DOCTORAL DISSERTATION

FDI and International Trade:

Comparative Advantage and Global Value Chain Analysis

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Abstract

This dissertation contributes to the literature regarding the role of export specialization as the determinant of FDI, in the following two aspects: comparative advantage and vertical specialization through global value chains. It also contributes to our understanding of the role of inward FDI in Vietnam's ascendancy in the electronics trade. This dissertation comprises three chapters.

In Chapter 1, we measured the revealed comparative advantage (RCA) but recalculated it using a newer, econometrically-derived measure. Vietnam is studied as the primary object, in comparison to either leading exporters at the global level or similar economies in ASEAN. Hence, our data include 25 exporters from the G20 group and the emerging ASEAN countries. The trade flows of commodities were at the two-digit level from 2005 to 2018, and data were derived from the United Nations Commodity Trade Database. These exports are regressed for 95 commodities from 70 destination countries. The results show that Vietnam's electronics industry had the highest RCA globally. After observing the relationship between RCA and detailed FDI in the local government data, we found that inward FDI can and does affect comparative advantage. For Vietnam, the FDI amounted to roughly 6% of Vietnam's GDP. The study emphasizes the factors that attract investment in the Vietnamese electronics sector. First, Vietnam is advantaged because of its proximity to China, Japan, and South Korea, and membership of ASEAN. These factors reduce the barriers to movement between the headquarters and its subsidiaries. Second, relatively cheap and abundant medium-skilled labor is advantageous in the production of finished electronics products. Third, Vietnam's stable political environment, and the promise of improved access to developed countries through the CP-TPP, are also posited as important factors. This may be an

example of the "pro-trade oriented FDI" proposed by Kojima (2000), which is independently and explicitly modeled as "export-platform FDI' in Ekholm et al. (2003). These factors are also characteristic of an industry located downstream in the global electronics production chain.

Chapter 2 reinvestigates the relationship between comparative advantage and FDI behavior, with a detailed focus on global greenfield FDI in manufacturing, and the newer, econometrically derived measure of comparative advantage. We generate comparative measures for 340 country-industry pairs (20 host countries and major 17 sectors) for the years 2003–2017. The greenfield FDI data are derived from the Financial Times' FDIMarkets, which are available at the two-digit ISIC level. Our results find that FDI is drawn to host countries with pre-existing comparative advantages in a selected sector. However, we also find that this implication holds only when the host county is a lower-income country, and fails for high-income countries. This powerful empirical observation may be used to confirm or reject certain theoretical models and guide policymakers seeking to attract more FDI toward "key" sectors. Moreover, empirically speaking, our findings suggest that a readily available measure (RCAs) is a significant explanatory variable for FDI flows and that it should be included in studies trying to predict and explain FDI flows. For policymakers, it is important to know if foreign firms that are breaking new ground with their factories, are intending to "fill a gap," or are drawn to existing talents and advantages of the host. We have found that, in recipient countries such as the US, Japan, and Germany, this aspect is unclear. However, for countries such as Indonesia and Brazil, policymakers should not attempt to incentivize inward FDI for sectors with no existing strength. Subsidies or other incentives offered by the government to entice FDI inflows, may fail and incur a great expense for the host country's taxpayers. At the same time, if certain sectors are perceived to have sufficiently

large spillovers from inward FDI to warrant subsidization, such efforts should be limited to sectors with an existing comparative advantage.

Chapter 3 provides insights into the relationship between greenfield FDI and trade through global value chains (GVCs) at the sectoral level. We utilize bilateral FDI data from the Financial Times FDIMarkets and GVC participation index, available in World Integrated Trade Solution. Our data spans from 2005 to 2015, covering 15 manufacturing industries for 64 host and 88 source countries. Overall, the coefficient of GVC participation is positive and statistically significant. This means that increased trade through GVCs will increase FDI inflows. This finding relies on disaggregated data at the industry level and is consistent with the existing results based on aggregated country-level data. Although we find that GVC participation, for backward and forward linkages, is positively associated with inward greenfield FDI, the effects are heterogeneous and sector- and region-dependent. Among all sectors, the "basic metals" industry has a strong positive impact on forward and backward linkages. If the host country is in the later stages of production in the basic metals and rubber and plastic industries, policymakers should attempt to incentivize inward FDI for these sectors. This action is strongly recommended when the country is located in Europe and Central Asia, East Asia and Pacific, and North America. Conversely, the machinery and equipment industry does not seem not to be a key sector for GVC-driven FDI policy. Although the electronics industry is one of the most active industries in the global production chain, its result is positive but statistically insignificant.

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Chapter 1: Vietnam's Ascendancy in the Electronics Trade and the Role of Inward FDI

1.1. Introduction

For more than two decades, Vietnam has integrated deeply and widely into the global economy. After acquiring membership in the Association of Southeast Asian Nations (ASEAN) in 1995 and the World Trade Organization (WTO) in 2005, Vietnam signed numerous bilateral and multilateral commitments with various partners including the mega-trade agreement CP-TPP of 11 countries. This trade liberalization process has brought a significant increase in the contribution of exports to Vietnam's Gross Domestic Product (GDP). By 2019, merchandise exports were as large as Vietnam's entire GDP (Source: World Bank).

While a large share of this trade is processing exports, with imported inputs coming from China and elsewhere, the export growth is real and is raising the incomes and reducing poverty in record levels. Since 2005, in which we start our sample, GDP per capita has risen 295% in nominal terms to $2,715 in 2019 (Source: World Bank). Poverty has fallen from nearly 21% in 2010 to just under 7% in 2018. (Source: World Bank. 'Headcount poverty headcount ratio at national poverty lines'.) While domestic industries and innate comparative advantage contributes to these exports, a large and perhaps growing share is due to huge investments into Vietnam by foreign multinationals, who are using Vietnam as an export-platform to high-income markets.[1] Most

[1] This effect will be more pronounced if the low-cost host country is a member of an FTA with access to another large, high-cost market, while the FDI host country is a non-member. Despite the US's withdrawal from the TPP pact, this was no doubt one large factor in LG and Samsung's calculations. Korea is not a member of TPP. Vietnam is. For a theoretical model of export platform FDI of this type, see Ekholm, Forslid and Markusen (2003).

notably, massive investment in the footwear industry by Nike (in 1995) and later by Adidas (in 2010) contributed to an upsurge in exports from Vietnam in that sector. More recently, South Korean giants LG and Samsung have poured billions of dollars into production and, importantly, research & development facilities, in the electronics sector in Vietnam. This in turn, has resulted in huge increases in the exports of electronics from Vietnam to the world (see Figure 1 below.) Electronics exports are more than one-third of all Vietnamese exports and that share is rising.

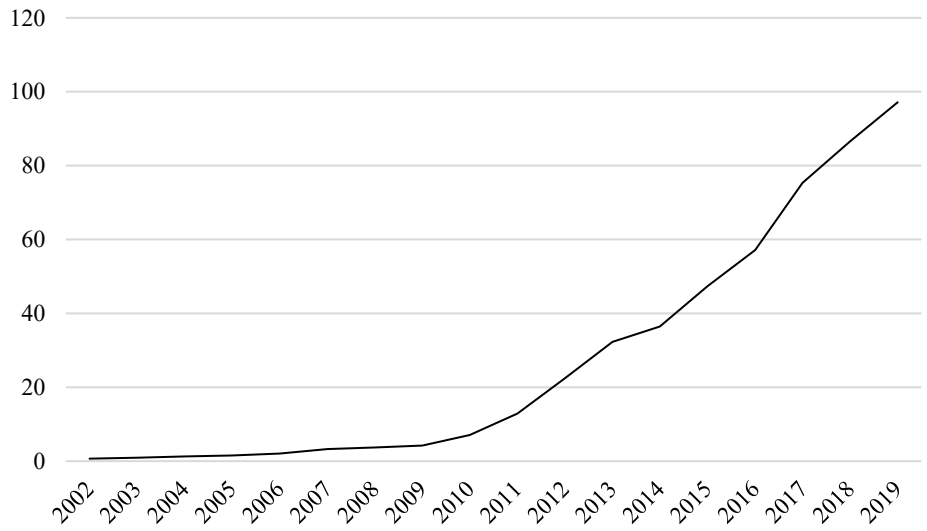

Figure 1: Vietnam's Exports of Electronics, HS 85 (Billions of US$).

Source: UN COMTRADE.

While it is clear from a quick glance at the trade data and the popular press that multinationals played a large role in these newfound exports, many questions remain.[2] **One question** is whether or not Vietnam's electronics industry is *truly* taking off relative to neighbors in Asia and the world, more generally. To answer this, we create original, econometrically-

[2] "Tech firms flock to Vietnam," *Wall Street Journal* by James Hookway Sept. 27th, 2013 online at https://www.wsj.com/articles/no-headline-available-1380253320; last accessed September 2020.

estimated measures of revealed comparative advantage (RCA) for a wide range of industries in Vietnam and 24 other countries in ASEAN and the world over the past 14 years (2005-2018). We confirm both Vietnam's ascendancy in electronics, but also the decline in comparative advantage in this sector elsewhere in Asia. Indeed, we find that Vietnam has the highest RCA in electronics in the world.

The second is a two-part question. Is this new world leader status primarily driven by only two firms, LG and Samsung? And if so, just how *much* new, greenfield investment has it taken for Vietnam to become a world leader (economic size-adjusted) in electronics? Using unique local-level government data together with other detailed FDI data, we arrive at our answer. The answer to the first part of the question is 'yes' and the answer to second part is '6% of GDP'. That is to say, the new greenfield investment, mostly by LG and Samsung, over the period of a few years was equivalent to approximately 6% of Vietnam's GDP. Almost entirely due to this investment, Vietnam has transformed from a country with no comparative advantage in electronics, to the having the highest comparative advantage in the world.

A third question is whether or not the electronics Foreign Direct Investment (FDI) (by LG and Samsung, but also to a lesser degree from Japan, Malaysia, the US and Taiwan) will continue in the near future, or whether such a surge in inward FDI is of a more 'footloose' nature.[3] The history of Nike and other footwear firms is a pattern of constant movement of production from one low-wage country to the next, as wages rise in the host nation (Japan, then to Korea, then to China, etc.). Secondly, and perhaps more importantly, Nike does not typically invest in *fixed assets* in the

[3] Note: The top 10 countries investing in electronics in Vietnam during 2003-2017 were: South Korea, Japan, Malaysia, United States, Taiwan, Singapore, Thailand, United Kingdom, China and France. (Source: www.unctad.org)

host country, but rather subcontracts to local or other multinational firms.[4] Thus, though it may be too early to tell, we may reasonably predict that while Vietnam is now a powerhouse in footwear exporting, it may not last. However, in contrast, there is massive investment in physical assets by LG, Samsung and others in Vietnam, and some of these assets are even engaged in R&D activity.[5] As such, the comparative advantage in electronics may be sustained in the foreseeable future.

The answers to the above questions yield important lessons for other countries who may be eager to move up the development ladder via greater inflows in hi-tech FDI.

The rest of the paper is organized as follows. Section 2 presents the review of the literature and explains the logic and strengths of the new, econometrically-estimated RCAs. Section 3 describes methodology. Section 4 then presents our original RCA estimates in electronics and 15 other sectors for Vietnam, other ASEAN countries, as well as historical electronics giants (Japan, Korea, and China) over the period 2005-2018. We also calculate RCAs for 24 other major exporters in the world for the most recent year of data. Here, we demonstrate that Vietnam has indeed broken away from the pack in electronics. Section 5 presents and discusses detailed, local-level government data on production and exports, where we confirm that Vietnam's rise in electronics is due to the presence of huge recent foreign investments in that sector. We also present other evidence on FDI activity which allows us to make a rough estimate as to how much inward FDI it took for Vietnam to become an electronics leader (at least in relative terms.) This section

[4] See chapter 4 in Otsubo (2016).
[5] See the November 30, 2017 article by Atsushi Tomiyama in the Nikkei Asian Review "Samsung readies Vietnam R&D center for appliances." Accessed on August 17, 2020 here: https://asia.nikkei.com/Business/Electronics/Samsung-readies-Vietnam-R-D-center-for-appliances

also considers other factors which contributed to Vietnam's success and asks whether this new position in global electronics is sustainable. Section 6 concludes.

1.2. Literature Review

1.2.1. Revealed Comparative Advantage

Ricardo demonstrated in 1817 that a country has a comparative advantage in a product if its *relative* production cost is lower than that of other countries.[6] The country will then specialize and export this product and import the other(s). Theoretically, the pre-trade relative price (or cost) of products is the determinant of comparative advantage. Thus, if we can observe autarky prices, we can determine comparative advantage. In reality, autarky prices are unobservable. Hence, economists have developed a proxy of comparative advantage by using *ex-post* observed trade data. Balassa (1965) introduced the so-called 'revealed comparative advantage index', or later simply the Balassa Index (BI). It is well-known and often used as a descriptive statistic in international trade.[7]

Simply put, the Balassa Index is the ratio of two ratios. In Japan's RCA in automobiles, for example, the numerator would be the share of auto exports by Japan of all Japanese exports. The denominator would be auto exports by *all* countries as a share of total world exports (i.e. all goods by all countries). As a rough representation of reality, let us say autos are 20% of Japanese exports and world auto exports are 10% of all goods exported globally. In this case, Japanese auto RCA

[6] Haberler (1930) was the first to re-frame Ricardo's Comparative Advantage into that of a question of lower opportunity costs. See Bernhofen's (2005) explanation.
[7] While Balassa made this measure well-known, it was preceded by a similar method by Liesner (1958).

would be 2. Anything greater than one is suggestive that Japan has a *revealed* comparative advantage in that good, as compared to other nations.

While easy to calculate from trade data, there are serious weaknesses with the Balassa Index. These are many and well-known. For example, the Balassa Index has a non-symmetric and non-normal distribution. While the mean is generally around 1, it can be, as low as say, 0.2 or as high as 15. The mean for any given country-product (say Japan's autos) is very unstable and can vary quite a bit from year to year. (See Hinloopen and Van Marrewijk 2001.) The many flaws of the BI and its variations have been known for some time, indeed, since its inception. To deal with the problems of the Balassa Index, a number of solutions have been proposed (again, refer to Hinloopen and van Marrewijk, 2001). These methods, however, solved only some of the statistical problems, and usually in an *ad hoc* fashion.

There is also still the fundamental problem that the ex-ante nature of Ricardian comparative advantage is not captured in these indices that used ex-post, observed trade flows.

Since all the previous studies on Vietnam used the Balassa Index or some variation, they suffer from the same shortcomings. (See Le (2010); Phan and Jeong (2012); Huynh and Nguyen (2017) inter alia).

1.2.2. Recent Empirical Advances

As such, this paper will use the recent method developed by Costinot, Donaldson and Konmujer (2012) and adapted by Leromaine and Orefice (2013) who used econometric regressions to isolate the exporter-product specific factors from the importer-product and country-pair specific

factors. Hence, the new RCA strips away confounding effects, and, in theory, leaves us with the relative productivities for each country-product pair which better captures the true nature of the Ricardian idea.

As briefly mentioned above, the new RCA has much better statistical characteristics (normal, symmetric distribution; mean of almost exactly one; much smaller variance) and superior ordinal ranking properties when compared to the Balassa Index (Leromain and Orefice, 2013). Another strength of the Costinot et al. measures is that they are derived from an underlying trade model. It can be derived from an Eaton and Kortum (2002) trade model, but also other standard models. Throughout this paper, the terms 'RCA' and 'new RCA' will refer to the RCA index developed by Costinot et al. (2012) and the original estimates of those RCAs by the authors and not the Balassa Index measures.

Whereas Costinot et al. (2012) and Leromain et al. (2013) mainly focused on G20 countries, in this paper, Vietnam is studied as the primary object in a comparison to either leading exporters at the global level or similar economies in ASEAN. Hence, not only the G20 group, but also the emerging ASEAN countries are included. The final sample includes 25 exporters: Argentina, Australia, Brazil, Canada, China, France, Germany, India, Italy, Japan, Republic of Korea, Mexico, Russia Federation, South Africa, Turkey, UK, US, Saudi Arabia, Spain, Netherlands, Thailand, Indonesia, Malaysia, the Philippines and Vietnam. These exports are regressed on 95 commodities to 70 destination countries.[8]

[8] To construct these new RCA for a single country-product, one needs to run regressions (see below) not only on the trade flows of the country in question (Vietnam), but for all other countries and products as

Our dataset consists of trade flows of commodities at the 2-digit level and uses the Harmonized System 2002 Classification (HS). The annual export values are from 2005 to 2018 and are taken from the United Nations Commodity Trade Database (COMTRADE). The category of industries corresponding to 2-digit codes are described in Table 1 based on the HS 2002 Classification by Section.

well. Ideally, one would use 180 or so exporters rather than just the 25 used here and elsewhere. However, even with 25 exporters, this pushes STATA's software capacity the maximum.

Table 1: Industry Description

Industry	Section in HS 2002	Description	HS-2 code
Animal Product	I	Live animals; Animal products	01-05
Vegetable Product	II, III	Vegetable products; Animal or vegetable fats, oil and waxes	06-15
Foodstuffs	IV	Prepared foodstuffs; Beverages and tobacco	16-24
Minerals	V	Salt; Sulphur; Earths and stone; Plastering materials, lime and cement; Ores, slag and ash; Mineral fuels, mineral oils	25-27
Chemicals	VI	Chemicals and allied industries	28-38
Plastics	VII	Plastics and Rubbers	39-40
Leather	VIII	Raw Hides; Skins; Leather and Furs	41-43
Wood	IX, X	Wood and products of cork, straw and wood; Paper and paperboard	44-49
Textiles	XI	Textiles and textile articles	50-63
Footwear/Headgear	XII	Footwear; Headgear; Umbrellas; Prepared feathers	64-67
Stone/Glass	XIII, XIV	Articles of stone, plaster, cement, asbestos, mica, ceramic, glass, pearls, precious metals	68-71
Metals	XV	Base metals and articles of base metal	72-83
Machinery	XVI	Nuclear reactors, boilers, machinery and mechanical appliances	84
Electrical	XVI	Electrical machinery and equipment; Television image, sound recorders and reproducers	85
Transportation	XVII	Vehicles, aircraft, vessels and associated transport equipment	86-89
Misc. Mfg.	XVIII, XIX, XX	Optical equipment; Arms and ammunition; Miscellaneous manufactured articles	90-96

1.3. Methods: A new Econometric-based Measurement of RCA

In implementing the Costinot et al. (2012) method, trade flows will be a good representation of exporter-product technology advantages if the country-pair specific and importer-product specific factors are controlled for. To control for this, Costinot et al. (2012) derived an econometric-based index from a world (m-countries producing and exporting n-goods)

trade model assuming a single factor of production (labor). Ultimately, they can express trade flows between exporter *i* to importer *j* in commodity *k* by the following:

$$ln(x_{ijk}) = \delta_{ij} + \delta_{jk} + \theta ln(z_{ik}) + \varepsilon_{ijk} \quad (1)$$

in which x_{ijk} is the bilateral trade value from exporter *i* to importer *j* in commodity *k*, wherein δ_{ij} is the country-pair fixed effect and δ_{jk} is the importer-product fixed effect. The term expressing the technological differences, $\theta ln(z_{ik})$, is assumed to be an exporter-product specific δ_{ik}

$$\delta_{ik} \approx \theta ln(z_{ik}) \quad (2)$$

The technological differences depend on two parameters. Firstly, the fundamental productivity z_{ik} of exporter *i* in commodity *k* is *ex-ante* unknown and interpreted as the technological coefficient of the Ricardo model. Hence, the Ricardian spirit is retained, and cross-country factors affecting the trade pattern such as climate, institutions, infrastructure and factor endowments are, in principle, captured. Secondly, the dispersion of productivity variable θ represents the intra-industry productivity heterogeneity across varieties with an industry. The value of this parameter has been estimated through econometric methods in Costinot et al. (2012) to be θ=6.53 using firm-level data in manufacturing. Other authors have found this parameter to generally be in this range. For our work, we follow Costinot et al. (2012) and assume θ is a constant value of 6.53 across all industries. While this is a big assumption, it is, alas, unavoidable. Having said that, assuming the theta was a bit higher or lower, would not change our conclusions and the relative nature and ranking of our derived RCAs.

The procedure to generate the RCAs is as follows:

Step 1: Estimate the exporter-product effect δ_{ik} by estimating equation (3):

$$(3)\quad ln(x_{ijk}) = \delta_{ij} + \delta_{jk} + \delta_{ik} + \varepsilon_{ijk} \qquad (3)$$

Step 2: Calculate the fundamental productivity based on δ_{ik} and θ, in which θ = 6.53:

$$(4)\quad z_{ik} = e^{\delta_{ik}/\theta} \qquad (4)$$

Step 3: Compute the RCA by a weighted index of the average of z_{ik} coefficients across all *m* exporting countries and *n* commodities (*m* = 25 and *n* = 95 in this paper):

$$(5)\quad RCA_{ik} = \frac{z_{ik}z_{mn}}{z_{in}z_{mk}} \qquad (5)$$

in which, z_{mn} is the average of all z_{ik} across all commodities and countries, z_{in} is the average of z_{ik} for the exporter *i* across all commodities and z_{mk} is the average of z_{ik} for the commodity k across all exporting countries. Equation (5) can be reformulated as: $RCA_{ik} = \frac{z_{ik}/z_{in}}{z_{mk}/z_{mn}}$ where the numerator indicates the ratio of productivity of country *i* for commodity *k* divided by the average of that for all commodities. The denominator denotes the ratio of average productivity in all countries for commodity *k* compared to the average of those for all commodities. If the numerator is greater than the denominator, production in commodity *k* in country *i* is relatively more efficient than production in commodity *k* in the other countries. Therefore, if RCA_{ik} takes a value of greater than 1, country *i* has a comparative advantage in commodity *k*. On the other hand, country *i* has a comparative disadvantage in commodity *k* when RCA_{ik} is less than 1.

The interpretation that an RCA of 'greater than unity implies comparative advantage' is also made in the original 1965 Balassa Index (BI). However, it is important to remember that the

interpretation in this new measure is based on a comparison of productivities across products and countries 'stripped', if you will, of the confounding factors. In Balassa, the decision to say that 'greater than unity implies comparative advantage', while reasonable, is entirely arbitrary. With the BI, it is rare, but not unheard of, to have a net *importer* of a product have a BI of greater than unity! (See Bowen, Hollander and Viaene 2012.) As we will see in the next section, these econometrically-derived RCAs have very reasonable values (no outliers) and are very consistent across countries and over time.

1.4. Results

Here, we present our new estimates of RCAs.

1.4.1. Regression-based RCAs for Vietnam

The values of RCA for all 25 countries in 2018 are reported in Table 2. The most interesting finding, which has not been reported in previous studies, is that Vietnam has the highest comparative advantage in the electrical industry at the global level in 2018 (as has maintained that for some time). In the past, this top position in the industry belonged to Japan and Korea.[9]

Additionally, annual RCA values of Vietnam from 2005 to 2018 are provided at the industry level in Table 3. First, we can see that Footwear and Headgear is also a leading Vietnamese industry. Next, we see that several of Vietnam's low-technology industries have a

[9] Reminder: when we say 'top position', we, of course, mean this in the comparative advantage sense, not an absolute sense. Total electronics exports from China, for example, are still far greater than that of Vietnam`s.

slight comparative advantage, such as Textiles, Wood and Vegetable Products. Sectors with an even weaker comparative advantage are, for example, Plastics and Leather. On the other hand, Vietnam has a clear comparative disadvantage in Chemicals and Transport. The turning point upwards for electronics seems to be in 2011. Also, there have been improvements in Metal and Machinery industries where the comparative advantage is approaching the tipping point of an RCA of 1. In contrast, Mining, Animal and Vegetable products gradually seem to be losing their advantage.

Table 2: RCA Index for 25 Countries at the Industry Level in 2018

Industry	Animal Product	Vegetable Product	Foodstuffs	Minerals	Chemicals	Plastics	Leather	Wood	Textiles	Footwear/ Headgear	Stone/ Glass	Metals	Machinery	Electrical	Transport	Misc. Manuf.
ARG	1.31	1.23	1.19	0.97	0.86	0.60	1.30	0.90	0.95	0.83	0.71	0.74	0.64	0.51	0.85	0.72
AUS	1.25	1.09	0.94	1.11	0.97	0.81	1.09	0.88	1.01	0.95	0.96	1.00	0.92	0.93	1.02	0.97
BRA	1.09	1.10	1.16	1.23	0.93	1.00	1.23	1.09	0.91	0.88	1.09	0.94	1.02	0.85	0.88	0.81
CAN	1.13	1.02	0.95	0.99	0.97	0.93	1.08	1.15	0.90	1.04	0.94	0.98	1.04	0.98	1.11	1.06
CHN	0.74	0.79	0.79	0.75	0.95	1.04	1.14	1.16	1.56	1.72	1.26	0.99	1.00	1.12	1.00	1.20
FRA	1.00	0.94	1.05	0.91	1.08	1.00	1.13	1.10	1.17	1.07	1.11	0.94	0.95	0.99	1.19	1.07
DEU	0.90	0.84	0.98	0.73	1.09	1.02	1.01	1.12	1.14	1.06	1.14	1.03	1.01	1.00	1.10	1.09
IND	0.69	1.11	0.83	0.92	1.00	1.06	1.17	1.07	1.53	1.02	1.28	0.97	0.90	0.93	0.88	0.90
IDN	0.79	1.05	1.09	0.80	0.87	1.18	0.94	1.27	1.24	1.42	1.04	0.90	0.84	0.98	0.80	1.13
ITA	0.82	0.90	1.00	0.76	0.96	0.97	1.41	1.09	1.40	1.23	1.27	0.95	1.02	0.92	1.01	1.12
JPN	0.76	0.72	0.78	0.83	1.08	1.27	0.71	0.98	1.21	0.93	1.22	1.09	1.26	1.17	1.13	1.18
MYS	0.68	0.85	0.97	0.88	0.99	1.29	0.91	1.03	1.04	0.99	1.06	1.11	1.06	1.24	0.90	1.10
MEX	0.98	1.04	1.05	1.03	0.96	0.95	1.06	0.84	0.96	0.85	0.99	1.06	1.02	1.07	1.03	0.86
NLD	1.07	0.99	1.12	0.85	1.07	0.95	0.92	0.98	0.98	1.02	0.88	0.93	0.97	0.98	0.93	0.97
PHL	0.84	1.07	1.21	0.73	0.97	0.99	1.06	1.20	1.17	1.23	0.99	0.88	1.06	1.15	0.89	1.16
KOR	0.59	0.65	0.82	0.79	1.06	1.38	0.93	0.86	1.36	1.05	1.08	1.14	1.17	1.27	1.13	1.12
RUS	0.88	1.02	0.94	1.50	1.01	1.09	0.94	1.20	0.83	0.74	1.03	1.00	0.91	0.91	1.17	0.88
SAU	0.89	0.85	0.89	1.04	1.11	1.26	0.97	1.22	1.15	1.00	1.11	1.08	0.84	0.72	1.12	0.95
ZAF	0.79	1.05	0.91	1.26	0.98	0.86	1.12	1.11	0.91	0.98	0.95	1.07	0.92	0.84	1.11	0.88
ESP	1.00	0.99	1.01	0.83	1.01	0.99	1.11	1.14	1.19	1.07	1.19	0.93	0.90	0.92	0.98	1.03
THA	0.78	0.99	1.17	0.64	0.90	1.39	1.07	0.96	1.28	1.16	1.35	0.93	1.19	1.17	0.98	1.04
TUR	0.76	0.92	0.99	0.97	0.88	1.06	1.17	0.91	1.51	0.96	1.29	0.94	0.91	0.91	0.91	0.98
GBR	0.92	0.81	0.98	0.82	1.06	0.97	1.05	1.10	1.25	1.12	1.15	1.03	1.01	0.97	1.13	1.10
USA	0.94	0.94	0.91	0.92	1.05	0.99	0.96	1.17	1.04	0.99	1.09	0.97	0.96	0.99	1.20	1.13

See table in Appendix 1 for list of country abbreviations.

This rapid increase in Vietnam's electronics industry appears to be another example of the so-called 'flying geese' model, widely known in East Asia and first put forth by Akamatsu in 1935 and 1937 and the translated into English in 1961 and 1962. Kojima (2000) expanded on this theme and posited that an industrial transfer starts, often through FDI, from a country like Japan as the

leader in Asia to 'follower' geese including NIEs - Newly industrializing economies (South Korea, Taiwan, Singapore and Hong Kong), ASEAN4 (Malaysia, Indonesia, Thailand, Philippines) and China. Kojima (2000) also predicted that the flying geese would spread further to the new ASEAN members (Vietnam, Cambodia, Laos, and Myanmar), India, Pakistan and even North Korea. Hence, consistent with this prediction, Vietnam appears to be a new leader in the electrical industry.[10]

Table 3: RCA Index for Vietnam at the Industry Level during 2005-2018

Industry	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Animal Product	1.08	1.07	0.98	1.05	1.08	0.96	1.02	1.01	0.94	0.98	0.97	0.89	0.97	0.92
Vegetable Product	1.31	1.2	1.16	1.19	1.15	1.1	1.13	1.09	1.09	1.06	1.12	1.00	1.10	1.09
Foodstuffs	0.98	1.01	1.03	0.98	1.02	0.95	0.99	0.98	0.96	0.99	0.99	0.93	1.03	1.03
Minerals	1.02	0.99	0.95	0.96	0.83	0.83	0.93	0.97	0.83	0.89	0.83	0.69	0.86	0.77
Chemicals	0.82	0.82	0.77	0.82	0.8	0.73	0.81	0.88	0.77	0.81	0.84	0.87	0.94	0.81
Plastics	1.07	1.14	1.08	1.01	1.05	0.98	1.04	1.07	1	1.04	1.11	1.07	1.13	1.14
Leather	1.1	1.02	1.04	1.13	1.18	1.07	1.07	1.09	1.09	1.1	1.17	1.03	1.18	1.26
Wood	1.17	1.13	0.93	1.05	1.07	1.03	1.06	1.14	0.99	1.1	1.28	1.03	1.09	1.11
Textiles	1.2	1.18	1.17	1.13	1.2	1.06	1.13	1.15	1.1	1.15	1.21	1.11	1.18	1.43
Footwear/ Headgear	1.5	1.57	1.42	1.4	1.43	1.36	1.37	1.4	1.35	1.45	1.51	1.38	1.41	1.59
Stone/ Glass	1.04	1.02	0.99	0.97	1.01	0.91	0.95	1	0.93	1.01	1.05	0.97	1.04	1.12
Metals	0.91	0.89	0.86	0.89	0.91	0.85	0.95	1.01	0.91	0.96	0.99	0.89	0.94	0.93
Machinery	0.74	0.79	0.79	0.76	0.83	0.75	0.85	0.98	0.91	0.97	1.01	0.93	1.01	0.97
Electrical	0.85	0.93	0.91	0.82	0.93	0.89	1.06	1.26	1.17	1.33	1.45	1.37	1.43	1.37
Transport	0.85	0.81	0.83	0.77	0.8	0.8	0.83	0.88	0.76	0.82	0.82	0.76	0.84	0.82
Misc. Manuf.	1.03	1.04	1.01	0.97	1.05	0.95	1.04	1.09	1.02	1.07	1.11	1.04	1.12	1.14

Vietnam's structural transformation can perhaps better be seen in Figure 2 above. Here, we see the dramatic increase in the growth of exports as a share of total exports in electronics and in

[10] Two of several empirical observations of the flying geese pattern are described below. A structural upgrading of textiles and related industries across Korea-Thailand-Malaysia-Indonesia from 1960 to 1990 was observed by Kosai and Tran (1994). Another example in machinery trade from 1975-1992 between Japan and other Asian countries (NIEs, ASEAN4 and China) was observed by Shinohara (1996).

some other sectors to a far lesser extent. We can also see which export sectors are shrinking, mineral exports being the most notable.

In Table 4, we show the ranking of our RCA measures for select commodities and compared to most of the world (our selection of countries covers over 90% of world exports.) We see that 'Footwear' and 'Fish', and quite a few other sectors are at the top, but now Vietnam's RCA in electronics is also number one as well.

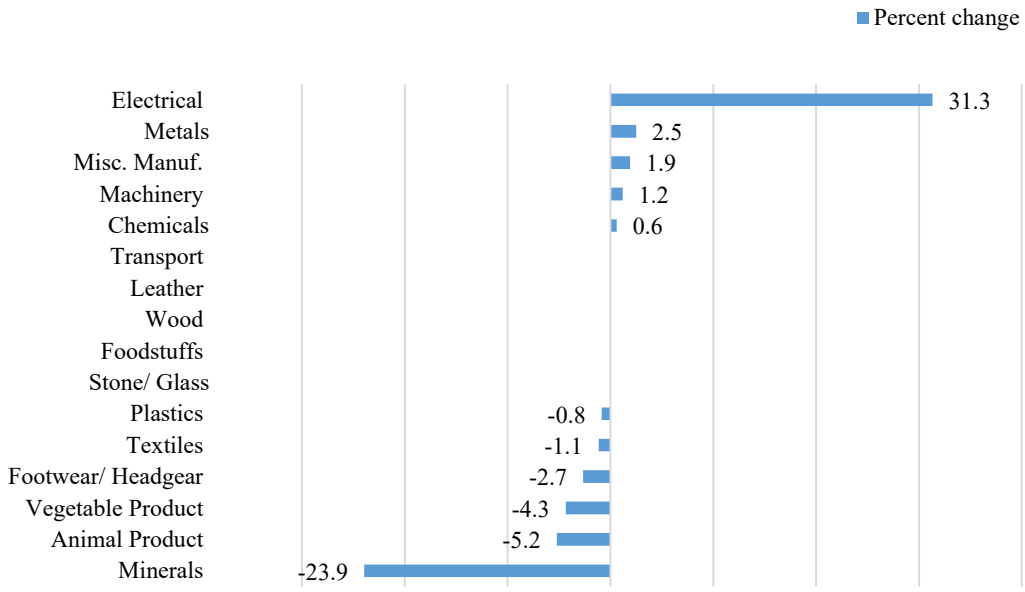

Figure 2: Changes in Vietnam's Export Share, 2005 - 2018

Source: Own calculation using data from UN COMTRADE

Table 4: Top 20 Products in Vietnam and its Global Ranking in 2018

HS Code	Product Description	RCA	Global Ranking
50	Silk	2.41	7
46	Manufactures of straw, of esparto or of other plaiting materials	2.18	1
64	Footwear, gaiters and the like; parts of such articles	2.15	1
9	Coffee, tea and spices	1.90	1
62	Articles of apparel and clothing accessories, not knitted or crocheted	1.84	1
3	Fish, crustaceans and other aquatic invertebrates	1.72	1
42	Articles of leather; saddlery and harness	1.72	1
61	Articles of apparel and clothing accessories, knitted or crocheted	1.68	1
16	Preparations of meat, of fish or of crustaceans	1.53	3
65	Headgear and parts thereof	1.52	1
55	Man-made staple fibers	1.47	6
63	Other made up textile articles; sets; worn clothing and worn textile article ...	1.44	3
60	Knitted or crocheted fabrics	1.42	4
94	Furniture; bedding, mattresses, cushions and similar stuffed furnishing	1.41	1
54	Man-made filaments	1.40	7
66	Umbrellas, sun umbrellas, walking sticks, seat sticks, whips, riding-crops	1.38	3
8	Edible fruit and nuts; peel of citrus fruit or melons	1.38	3
85	Electrical machinery and equipment and parts thereof; sound recorders and r ...	1.37	1
58	Special woven fabrics; tufted textile fabrics; lace, tapestries; trimmings; ...	1.34	7
67	Prepared feathers and down and articles made of feathers or of down	1.31	4

1.4.2. Vietnam Breaking Away for the ASEAN pack

Next, we contrast Vietnam's rising RCA in electronics to that of some of largest ASEAN neighbors in Figure 3. As our estimated RCAs have a fairly tight range, we started the vertical axis

at 0.70 to highlight the differences. It is clear that Vietnam has taken off in electronics, while its neighbors have not.

According to data from UNCTAD, FDI flows into 2019 to Vietnam were $16 billion as compared to Indonesia's $20 billion and Thailand's $4 billion. However, while there is some electronics investment in these and other ASEAN countries, it is tiny as compared to Vietnam. Most FDI into Indonesia is in 'renewable energy, mining, chemical, real estate, and metals'.[11] In Thailand, nearly half of the inward FDI is in manufacturing, some of which is in ICT sector.[12] However, inward FDI has fallen (it was $10 billion in 2018) and more generally has been quite erratic since the coup d'etat and change in government in 2014.

Malaysia has long been involved in ICT supply chains. Intel made its first investment there in 1972 and had invested nearly $4 billion in Malaysia by 2010.[13] Overall, Malaysia has had a fairly steady inflow of $7-$9 billion a year, but real estate, finance and insurance are the main recipient sectors. Manufacturing accounts for about 17% and electronics manufacturing alone about 5%.[14] Firms such as Dell and ON Semiconductors also have a presence in Malaysia and Malaysia has seen an uptick in investment plans from the US in the wake of the US-China trade war.[15] Despite Covid-19 concerns and the global slowdown, which may put most of those plans

[11] See a recent article by the Asian Development Bank at https://www.adb.org/news/op-ed/foreign-direct-investment-not-coming-indonesia-really-edimon-ginting.

[12] For more detailed data see the Bank of Thailand website as https://www.bot.or.th

[13] "Intel in Malaysia for the long haul" June 14, 2010 accessed Sept 17, 2020 at thestar.com.my

[14] For more detailed data see the Department of Statistics Malaysia website at https://www.dosm.gov.my/

[15] Das, Krishna "U.S. investment in Malaysia up sharply as trade row with China drags" on Sept 4, 2019, on Reuters.com; last accessed Sept 17, 2020.

on hold, Malaysia will likely continue to be a popular FDI host to wafer fabrication and other semiconductor-related industries in the foreseeable future.

The Philippines received about $4 billion a year in total FDI. There has been a downward trend since a peak of $10 billion in 2017. Nearly half of this is in manufacturing, but virtually none of it is in electronics production. (See Aldaba and Aldaba, 2010.) There is a thriving ICT sector in the Philippines, much of it financed by foreign firms, but this is mostly in 'call centers, computer processing, software development and multimedia content creation' (Dezan Shira and Associates, 2018).

Compare the above figures to the staggering fact (see section 4 below) that Samsung alone invested $17 billion in Vietnam in the last decade or so. In summary, it appears that Vietnam's position as a favored recipient of electronics FDI in the ASEAN region is assured for the near future.

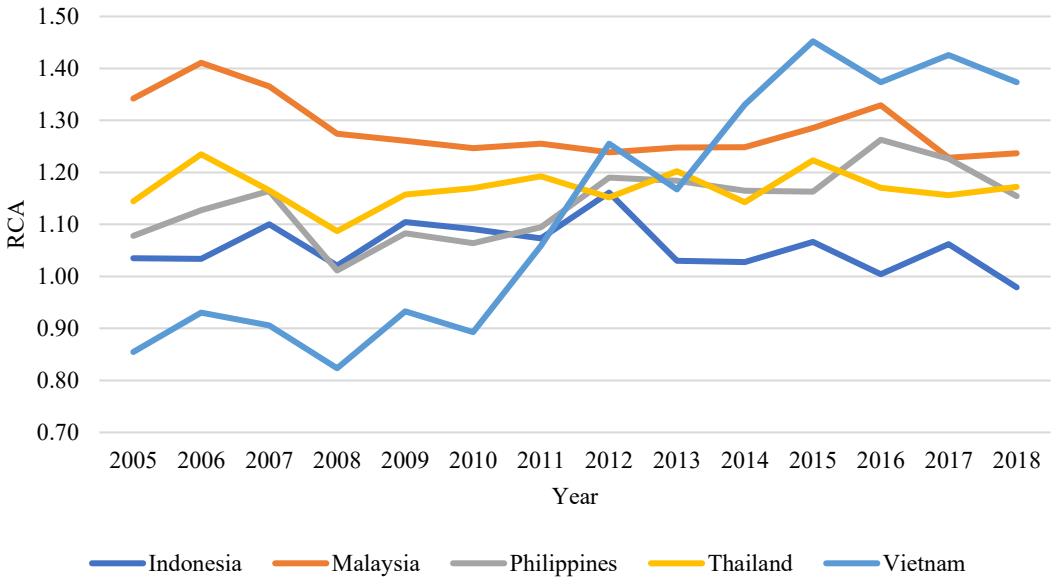

Figure 3: RCA in Electrical in 5 ASEAN Countries

1.4.3. Electronics Comparative Advantage Slowly Moving out of Northeast Asia

In Figure 4, we show that Vietnam rise in its Electronics' RCA is paralleled with either a flat or declining RCA in the three traditional East Asian giants in electronics, namely Japan, Korea and China.

In the next section, we identify why and confirm from exactly where this new trajectory of exports of electronics is coming.

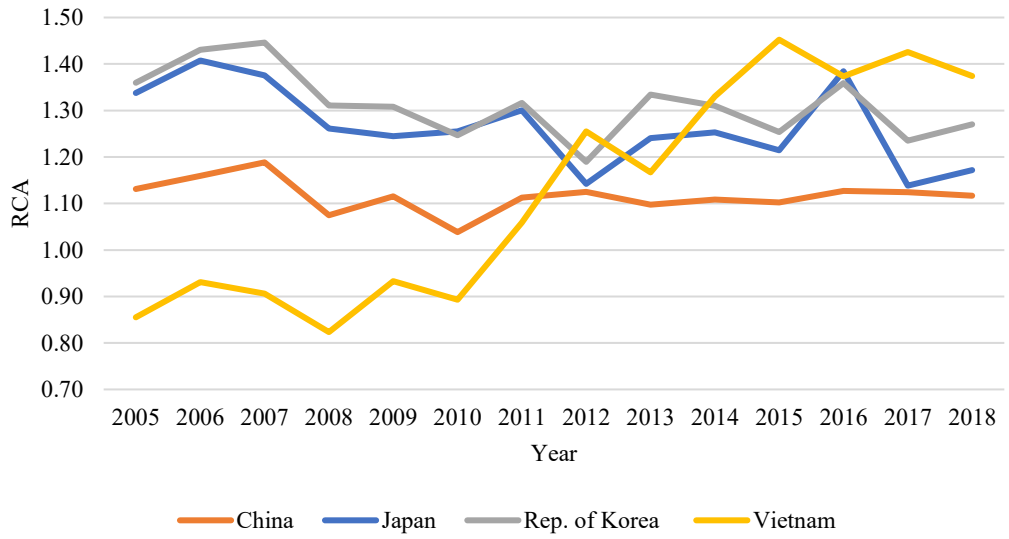

Figure 4: Electrical RCA in 4 Selected Countries

1.5. Discussion

1.5.1. Origins of New Electronics Exports: Evidence from Vietnamese Government Data

While it may be apparent that Vietnam's huge and sustained surge in electronics in exports is due to the relatively recent presence of inward FDI, one cannot confirm that by looking at trade data or firms' annual reports. That is to say, trade data alone cannot tell whether all those new

exports are being made by Samsung, or, though unlikely, some domestically owned Vietnamese firm. Detailed data both on production by foreign and local firms is needed.

By assembling detailed data from the government of Vietnam, we have confirmed the overwhelming contributions made by foreign firms. Table 5 below has been constructed from data available (in Vietnamese, but also in English) in the "Customs Handbook on International Merchandise Trade Statistics of Vietnam 2015".[16] The findings in Table 5 below were further confirmed by data at the provincial level. LG's operations are located mainly in the tiny province Bac Ninh, just northeast of Hanoi. Examining data from the statistics office of Bac Ninh province, we corroborated the fact that virtually all industrial electronics products were produced by 'FDI enterprises'.[17]

Specifically, we collected data on the main electronics groups in HS 85, namely: 'Computers, electrical products, spare-parts and components thereof; Telephones, mobile phones and part thereof; and Still image, video cameras and parts thereof'. The export values are presented in Table 5. The government data presents total exports out of Vietnam of these (and many other products) products, but also breaks out the amount exported by 'FDI enterprises' alone.

Exports by FDI enterprises (mainly by Samsung and LG) range from **98% to 100%** of total exports. This confirms that FDI has nearly single-handedly transformed Vietnam from a

[16] The entire handbook, in pdf form, was found at www.customs.gov.vn

[17] This data was accessed in October 2018 at the Bacninh Statistics Department website http://bacninh.gov.vn/ in a book called "Niên giám thống kê Bắt Ninh 2015" (which means "Bacninh statistical yearbook 2015"). They have since taken that book offline, but it is available in hard copy in the Statistics Library of Vietnam in Hanoi.

country with no comparative advantage (recall Figure 2 where RCA in 2005 was 0.85 but jumped to 1.37 in 2018) in electronics, to one of the world's leading exporters (size-adjusted).

As nearly all of the production at plants such as those in Bac Ninh is destined for exports, it is clear that this is export-platform FDI, at least for the time-being. But how can we nest this phenomenon in the theories of comparative advantage and FDI?

Ricardo's original comparative advantage is viewed as coming from some natural advantage (perhaps climate and soils conducive to wine such as Portugal's) or some other technology (British textile mills in the 19th century.) It is clear here that the transformation is due to the importation of technology or 'know-how' by foreign FDI. At the same time, most of the production is assembly (rather than, say, design) and so we can also ascribe a Heckscher-Ohlin view that firms are locating in Vietnam to take advantage of cheaper and relatively abundant semi-skilled labor as wages for that same labor rise in China, Korea and elsewhere. Again, it remains to be seen whether this newfound comparative advantage will take root in Vietnam or, instead, be more footloose, as has traditionally been the case in global footwear production. As mentioned in the introduction, because giants like LG and Samsung are bringing in fixed assets and even building R&D factories, our prediction is that it will be the former.

Table 5: Exports by Three Main Commodity Groups in HS85 Products

1. Computers, electrical products, spare-parts and components thereof				
	2014		***2015***	
	Total exports	FDI enterprises	Total exports	FDI enterprises
Value (Bil.US$)	11.43	11.3	15.61	15.32
Annual change (%)	7.9	8.4	36.3	35.49
Share in total exports (%)	100	98.9	100	98.13
2. Telephones, mobile phones and part thereof				
	2014		***2015***	
	Total exports	FDI enterprises	Total exports	FDI enterprises
Value (Bil.US$)	23.6	23.5	30.166	30.09
Annual change (%)	11.1	11.4	27.8	28.03
Share in total exports (%)	100	99.6	100	99.75
3. Still image, video cameras and parts thereof				
	2014		***2015***	
	Total exports	FDI enterprises	Total exports	FDI enterprises
Value (Bil.US$)	2.22	2.178	3.025	3
Annual change (%)	36.8	36	36.3	38
Share in total exports (%)	100	98.1	100	99.36

Note: Total exports means the number of exports by all kinds of ownership including state, non-state and FDI enterprises.

Source: General Department of Vietnam Customs

As mentioned earlier, this phenomenon may be likened to that espoused by Kojima (2000) and Ekholm, Forslid and Markusen (2003). Vietnam's abundance of low-wage, yet relatively educated labor force is ideal for the assembly of electronics in Vietnam. Thus, Vietnam becomes (and China slowly ceases to be) an exporter to third countries as well as to the home country (here, Korea) through FDI and the know-how brought in by Samsung and LG. As transportation costs for intermediate inputs from the FDI source (home) country fall, this process is accelerated. This basic shift in the location of comparative advantage is also leveraged with Vietnam's stable rule of law, and the promise of improved access to the US, Canada and elsewhere through TPP.[18] This

[18] Both Vietnam and the US joined the broadened TPP discussions in 2008 (the US in January 2008). LG and Samsung made massive investments and Samsung its first mobile phone factory in Bac Ninh (Vietnam) in 2007. Of course, LG and Samsung had made earlier, smaller investments in Vietnam in 2003. These

may be an example of what Kojima (2000) called 'Pro-trade oriented FDI' and which is independently modelled explicitly as 'Export-platform FDI' in Ekholm *et al.* (2003).

1.5.2. The Nature and Magnitude of Foreign Direct Investment Inflows in Electronics

What magnitude of FDI inflows in electronics were necessary to bring about this dramatic rise in Vietnam's comparative advantage in little more than a decade? A generally positive relationship between the promotion of FDI in certain sectors and an increase in that sector's comparative advantage has been found in at least one recent study. (See Harding and Javorcik, 2011).[19] However, the nature and magnitude of such promotion efforts and incentives is unknown. More importantly, how *much* increased FDI was necessary to bring about such an increase is also unknown. Here, we have constructed a very precise estimate of exactly that in this paper with the judicious combination of several sources of FDI activity in Vietnam.

Over the period from 2003 to 2017, $311 billion of new (greenfield) FDI has come into Vietnam purportedly creating some 1.3 million jobs. This includes direct investment in manufacturing, but also construction, mining, etc. Of this figure, $136 billion worth of this investment was in 'Manufacturing Activity' alone. This is as opposed to 'Construction, Business Services, Infrastructure' and other forms of FDI activity. Over 937,000 persons were to be employed in these activities. Of this $136 billion, $27 billion was invested in 'ICT' manufacturing activity alone and approximately 237,000 persons were employed. This works out to over

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were likely influenced by the normalization of trade relationships between the US and Vietnam in December of 2001. Vietnamese exports to the US skyrocketed following this agreement. Much later, the US signed the TPP agreement in February 2016. Although the US withdrew from the TPP in January 2017, at the time, Samsung and others made these investments clearly expecting a stronger and growing relationship with the US.

[19] The Harding and Javorcik paper, published in 2011, naturally used the older, classic, Balassa Index for its measure of RCAs.

$100,000 of investment in the ICT manufacturing activities per worker employed in those plants. Of this $27 billion, $14.5 billion, or half, was from South Korean firms alone.[20] Of this, $14.5 billion, $13 billion came from Samsung and LG.[21] From other journalistic sources, these figures have been confirmed and updated.[22]

Vietnam's entire nominal GDP was $224 billion in 2017 (Source: World Bank). Thus, the cumulative investment by Samsung and LG in new manufacturing plants in ICT alone was nearly *6% of GDP*. In summary, investments by only two firms, in little over a decade, amounted to 6% of the nation's entire GDP and increased Vietnam's RCA in electronics from 0.85 to 1.37.[23] Recall that this is new FDI stock and GDP is an annual flow. Presumably, the returns and sustained production and exports from these new investments will continue for many years to come.

How much is the LG and Samsung investment as a share of Vietnam's pre-existing stock of capital? Estimates of Vietnam's total capital stock in 2017 was approximately $1.7 trillion (in constant 2011 US dollars).[24] As such, *nearly 20%* of all existing capital stock in Vietnam came from new inward FDI since 2003. Recent investments by Samsung and LG have added roughly 1% to the entire capital stock in Vietnam.

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[20] From Tractus (2019).

[21] This data in this paragraph is taken from Parsons, Doytch and Feliciano (2020).

[22] 'Samsung invested about $17 billion in Vietnam, making it the country's largest overseas investor.' (Waring (March 2, 2020). This implies that another $4 billion has flowed in from Samsung in the last three years. Rumors that Samsung would move smartphone production out of Vietnam and into India have, thus far, been not been borne out. See Waring, "Samsung stands by Vietnam factories" Aug 19, 2020.

[23] While some of these investment projects have been added to in the years following, for the most part, this 6% figure is the sum of several huge lumps of investment over a period of years. That is to say, it is not 6% of GDP *every* year.

[24] Source: Feenstra, Inklaar and Timmer (2015).

We can clearly see that comparative advantage *can* change with a massive infusion of FDI. And this change can be fast, though not instantaneous. Investment started to take off in 2003, and then expanded with two major projects by Samsung and LG in 2007 and 2008. We do not see an uptick in Vietnam's RCA until 2011, when it jumps 15% higher than in its relatively steady value of around 0.9 from 2003 to 2010. It jumps again in 2012. This increase in RCA (brought out by a surge in new exports from Vietnam by LG and Samsung) was no doubt delayed by the Global Financial Crisis in 2007/2008 and the ensuing Great Trade Collapse. So, it could be said that massive inward FDI may take around three years to see a noticeable effect on RCAs. This is a certainly a very rapid shift in the location of comparative advantage (dubbed the 'kaleidoscope effect' by Bhagwati, 1998) if a certain firm is committed to certain export goals in specific sectors. Note also that despite the amount of inward investment in other sectors across Vietnam, only electronics has seen the sharp uptick in comparative advantage.

While we are not privy to whatever tax breaks and other auxiliary support the government of Vietnam promised to these and other firms to attract such FDI, it is fairly clear that attracting such massive investments would be the envy of many other countries in the region and the world.[25] But it also points to how *much* investment is needed to make such a radical change in export structure. Whether or not the tax breaks and other concessions given are worth this boon for the host country is another matter. But it does give us a benchmark with which to compare with other countries in future work.

[25] Most, if not all countries in the region, are taking very pro-active efforts to attract FDI. See 'Invest India' investindia.gov.in, or Thailand (https://thaiembdc.org/invest-in-thailand/ and Invest Indonesia (investindonesia.go.id), the Philippines (boi.gov.ph) just to name a few.

For some historical perspective, consider that Intel invested $1.3 billion in electronics in Vietnam in a two-year period in 2006-7. But the RCA for electronics remained essentially unchanged even in 2010 (see Table 3). At first, the facilities were used for simpler assembly and testing of semiconductor components.[26] In 2014, Intel started making CPUs in Vietnam. Nowadays, Intel's export revenue from Vietnam is about $1 billion per year. (Tractus, 2019). While $1 billion per year is impressive, Vietnam exported nearly $57 billion dollars of electronics exports in 2016 (Tractus, 2019). Approximately 50% of these electronics exports are telephones. 98% of these phones are produced by Samsung. (Tractus, 2019). So, this is clearly unprecedented, but how long will it last?

1.5.3. Is Vietnam's Position in Electronics Sustainable?

Will this leadership position be sustained, or will this superior RCA decline as LG, Samsung and others move on to lower wage countries as Vietnam's wages rise? Vietnam's current luck may well change, of course, but there are two reasons why this surge may just stick. First, as mentioned earlier, ICT firms such as LG are invested in *fixed assets*. This is very different from the subcontracting model of Nike and other footwear companies. Second, these ICT firms are investing in *R&D facilities* in Vietnam. Samsung employs 2,200 R&D staff in the country and began construction of a $220 billion R&D facility in Hanoi focusing on 5G network technologies (Waring, March 2, 2020). Japan's Renesas also built R&D facilities in Hanoi. Renesas is one of the largest producers of semiconductors for automobiles (Source: Tractus, 2019).

[26] Dezan Shira and Associates (June 4, 2015).

Again, contrast this with the footwear industry, where no R&D is taking place in Vietnam. Indeed, the large rents that are made in the footwear industry are derived the brand power that firms like Nike and Adidas have *and the brand names that they take with them* when production moves. With both production and R&D in ICT occurring in the country, the possibility that this comparative advantage may stick is far greater.[27] It may be too much to predict that Vietnam will generate its own version of the next 'LG' or 'Huawei' smartphone, as its domestic market is still small in GDP terms.[28] However, one can envisage Vietnam finding a permanent place in the international value chains in electronics, and gradually moving up it.

Another set of factors makes Vietnam a preferred venue for electronics giants such as LG, Intel, and the like. Vietnam has the advantage of proximity to China, Japan and South Korea and it is a member of ASEAN. Both of those facts reduce the barriers of movement in both parts and personnel between the headquarters and their subsidiaries. These are factors that are consistently found to influence location decisions. But as mentioned above, Vietnam does not yet have the appeal as a huge market, something India, a rival host for FDI, certainly has. As India will clearly play a larger role in hosting FDI from electronics giants from around the world, it is imperative that Vietnam make the most of the current position it has.

[27] There is a large domestic footwear industry in Vietnam that no doubt benefitted from the spillovers from the presence of Nike and Adidas. However, no Vietnamese brand has yet emerged in the world market.
[28] Vietnam's population is currently almost 100 million and is predicted to reach 106 million in 2030. By comparison South Korean has a population of 51 million. But South Korea's GDP per capita is over $30,000 while Vietnam's is about $2,000. (Source: World Bank.)

1.6. Conclusion

In this paper we accomplished three major goals with respect to Vietnam's recent emergence as a leading electronics exporter. First, through our original, econometrically-estimated measures of Revealed Comparative Advantage, we have confirmed that Vietnam now has the highest comparative advantage in the world and is far above its ASEAN neighbors. Likewise, RCAs in traditional electronic powerhouses Japan, Korea and China are flat or falling. Second, we identified, through the use of local government data, that nearly all (98-100%) of this newfound comparative advantage is from foreign enterprises based in Vietnam. The majority of this investment is by LG and Samsung. Third, we determined that that amount of inward investment necessary to produce this large increase in its comparative advantage amounted to roughly 6% of Vietnam's GDP over the period of a decade.

Although we only examined the case of Vietnam and electronics, we feel there are important lessons for other countries that aspire to become exporters in so-called higher-value goods and achieve greater integration into the global value chains in electronics. The main lesson is that it is possible, but it takes a massive amount of new (greenfield) FDI in manufacturing of the product. However, foreign firms presumably will only be willing to make such large, far-sighted investments if the host country's government is stable overall and predictable in its behavior towards foreign firms. Good infrastructure and steady electricity supply are also, no doubt, necessary requirements. Vietnam has become more attractive as a host for FDI from recently improved access and trade ties with the US (the US pull-out of TPP notwithstanding), and the EU (an EU-Vietnam trade agreement went into force in August 2020). Currently, Vietnam is also benefitting from current US-China frictions, as well as rising labor costs in China.

While the jobs created, influx in capital, and potential spillover effects to local firms from inward FDI (see Sjoholm, 1999) will almost certainly bring net benefits to Vietnam, countries must be wary of giving too much away in the form of excessive tax breaks, infrastructure subsidies and the like.[29] Lastly, such a huge inflow of funds may be a breeding ground for corruption, lax environmental standards, weak labor enforcement, political intervention by foreign firms, etc. While welcome the incoming FDI, emerging countries must remain vigilant in these areas.

We have argued in this paper that this FDI in electronics is not the 'footloose' type and may be here to stay and spur domestic electronics firms. However, as mentioned in the previous section, Vietnam is a medium size country, but still with very low purchasing power. One potential threat to Vietnam's current position is, of course, India. As mentioned in footnote 21, more and more firms are considering moves to India. India has a much larger pool of low-wage workers, many of whom have a good education and as such, India has more than enough 'absorptive capacity'. India also has its own vibrant, home-grown ICT industries. And, of course, it has a huge, yet still on average poor, domestic market. India has just started negotiations with the EU on a possible trade agreement. The US has also discussed the possibility, though the barriers to overcome seem large. India is already receiving $50 billion in FDI each year. Historically, most of that has been from the EU, but now the US and Japan are top source countries. It remains to be seen if firms like Samsung and LG and will continue to see Vietnam as one of their first choices. In the World Bank's Doing Business 2020 report, India surpassed Vietnam. Previously, India was 77th, but it has now jumped to 63rd, ahead of Vietnam at 60th. The government needs to continue

[29] See a report by the OECD (2003) which describes the various policies in which host countries government can implement in efforts to secure more inward FDI. The report also explains the costs and benefits of each of the various policies, some of which can be quite wasteful either to the recipient country and/or to world welfare overall.

to make Vietnam attractive for foreign businesses (safety for expats, less red tape, good infrastructure, higher transparency and less corruption in doing business, etc.). Also, Vietnam needs to leverage the position it has now in order to sustain or even enhance its export competitiveness in electronics by enhancing successful 'learning by doing' and other efforts to capture any potential spillovers from the inward FDI. Otherwise, there is still the chance that this may be a 'kaleidoscope comparative advantage' after all.

For future research, it would be very useful to identify similar experiences in other countries to confirm whether our 6% figure is a reasonable reference for other countries and industries. With the new methodology for estimating comparative advantage more accurately, as well as the increased availability of detailed FDI data, there is great potential here.

Appendix 1

List of 25 Exporting Countries and their Abbreviations

ARG = Argentina; AUS = Australia; BRA = Brazil; CAN = Canada, CHN = China;

DEU = Germany; ESP = Spain; FRA = France; GBR = United Kingdom; IDN = Indonesia;

IND = India; ITA = Italy; JPN = Japan; KOR = Republic of Korea; MEX = Mexico;

MYS = Malaysia; NLD = Netherlands; PHL = the Philippines; RUS = Russia Federation;

SAU = Saudi Arabia; THA = Thailand; TUR = Turkey; USA = United States; VNM = Vietnam;

ZAF = South Africa.

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Chapter 2: Revisiting the Relationship between Comparative Advantage and FDI using Global Greenfield Data[30]

2.1. Introduction

While the potential determinants of foreign direct investment (FDI) are many and the empirical literature on this topic is extensive, there is no definite answer to the question of what role does comparative advantage play in explaining these massive worldwide flows? A large body of theoretical work has examined the interplay between comparative advantage and FDI, but work on the empirical link is scarce. Early attempts to establish a link between comparative advantage and FDI were made in the 1980s and 1990s, with mixed results (e.g., Maskus and Webster, 1995). Some papers used Balassa's Revealed Comparative Advantage (RCA) measure together with FDI data for a handful of countries, while others explored the link with a factor proportions view of comparative advantage in mind. These attempts using varied methodologies and data, unsurprisingly, have yield varied and sometimes inconsistent results.

In this paper, we reinvestigate the relationship between comparative advantage and FDI behavior with a detailed global set of greenfield FDI in manufacturing and a newer, econometrically-derived measure of comparative advantage. Our results find that FDI is drawn to host countries with a pre-existing comparative advantage in that sector. We also find, however, that this only holds when the host county is a lower-income country and fails to hold for high-income countries. We feel this powerful empirical observation may confirm some and reject other

[30] I would like to thank Professor Craig Parsons, Professor Nadia Doytch, Professor Zadia M Feliciano for giving me the opportunity to participate in the research. In this joint research, I am honoured to contribute my efforts in the calculation of the global RCA index and part of the work of the conversion from HS to ISIC, as well as other contributions in the process of completing the article. I would like to express my sincere thanks to all of you who have approved me to present this joint research in my doctoral dissertation.

theoretical models, as well as guide those policymakers seeking to attract more FDI in 'key' sectors. Moreover, empirically speaking, our finding that a readily available measure (RCAs) is a significant explanatory variable for FDI flows suggests that it should be included more often in studies that try to predict or otherwise explain FDI flows.

Establishing a link between comparative advantage and FDI is difficult because of the complex and multifaceted nature of FDI. Some MNC activity is of the "market seeking" variety. Other MNC activity may be the "export-platform" type, bringing firm-specific know-how to a country with possibly lower labor costs, in the hopes to export back to the home country and/or to the rest of the world. And there are other reasons for MNC activity. We can also view drivers of FDI from the host country's perspective. A potential host country's relative productivity in a certain sector, no doubt, at least in part, affects the FDI decision. A multinational firm may be attracted to, and drawn to invest in, countries in which a comparative advantage already exists (the so-called "demonstration effects" may also be a part of this). Conversely, however, a firm may wish to enter a market (perhaps to sell in that market more easily, or to export from) that does *not* have a pre-existing comparative advantage. It is only natural to think that a firm may want to enter a market where it has a particular advantage and where existing domestic (i.e. the host country) firms do not possess such skill or know-how.

Attempts to disentangle the interplay between FDI and comparative advantage began in the 1970s with work by Buckley and Casson (1976) and Caves (1982) who reasoned that, in general, comparative advantage and FDI activity should have a *positive* relationship. That is, we should find that MNCs tend to invest in countries that already possess a comparative advantage in that particular industry. However, this prediction is contrary to what a factor-proportions view of trade would suggest. Indeed, in 1957 Mundell posited that if international capital was allowed to

be more internationally mobile, capital flows would be drawn to countries that were capital- scarce and, concomitantly, did not have an existing comparative advantage in that (capital-intensive) good. Thus, the 'factor' view suggests that incoming FDI would have a *negative* relationship with a host's comparative advantage. As documented later in the literature review, while both theory and some empirics have been applied to this question over the past 40 years or so, no convincing conclusion has been reached. This paper offers the first answer to this question on a global scale.

A larger question we might ask is, why are we interested in the relationship between FDI and comparative advantage, and how does this contribute to the literature? We feel there are several reasons why this question is important and that now is the time to re-examine it. First, though there are more than 40 years of opposing views, there is still no clear consensus, either empirically or theoretically. Moreover, the tests thus far were for only a handful of countries. Here, we use a global database. Second, there is an extensive empirical literature on the determinants of FDI. If comparative advantage is, indeed, a significant explanatory variable and it is readily available, it should be included. Third, a better understanding of the relationship can better guide policy. Does new inward FDI go into declining industries (with no comparative advantage) or into sectors with an existing or emerging comparative advantage? Does FDI "fill a gap" or, on the contrary, does FDI possibly augment or even displace "home" production in a sector with a comparative advantage? With the renewed interest in trade deficits, and the hollowing out of industry, at least in the US, the answers here should contribute to that debate. Lastly, and this follows from our results in this paper, there may be differences in the relationship across higher-income and lower-income countries. Again, theories can give conflicting views, and our use of a global database can help determine when and if important differences emerge.

2.2. Literature Review

While there is a multitude of possible motivations for Foreign Direct Investment (FDI), there has always been a larger question as to whether inward FDI in a particular sector is aligned with a particular comparative advantage in the host country. That is to say, is FDI attracted to countries with the *same* advantages or is it the *opposite*, i.e., is FDI filling a gap? Naturally, this depends on a number of factors, including whether or not the FDI is "efficiency seeking" or "market-seeking", but nonetheless, this is still a very open question with important implications.

This question dates back to at least the late 1970s and 1980s when Buckley and Casson (1976) argued that FDI was based on comparative advantage, while Caves (1982) argued that FDI was based primarily on absolute advantage. Later papers attempted to address this idea both theoretically and empirically. Maskus and Webster (1995) tried to determine if sectoral FDI was correlated with the comparative advantage of the host country based on relative factor endowments. They were only able to examine two countries, the UK and South Korea. And the data only covered a few years. As their study considered all sectors, including services and natural resources as well as manufacturing, results were mixed.

Ray (1989) looked at inward FDI in the US and found that most of the incoming FDI was in R&D intensive and technology-intensive sectors, presumably sectors where the US has a comparative advantage. Nachum, Dunning and Jones (2000) studied the link between outward FDI (using sectoral FDI stocks and flows) and comparative advantage using UK data from the 1950s until the 1990s. They found a *negative* association between the UK's outward FDI and its export-based relative comparative advantage from 1950 to 1970, but a positive relationship from the 1970s to the mid-1990s. Another paper by Nachum, Dunning and Jones (2001), also using UK data, found that since the 1960s, the UK's outward FDI and exports tend to move 'in tandem'.

While an important finding, it is only for a single country. Moreover, in this paper, we are interested in the comparative advantage of the *recipient* country.

Qiu (2003) lays out a simple two-country, two-sector model in which FDI (building a new factory in the other country) and comparative advantage are both explicitly included. His model is primarily aimed at trying to explain the so-called North-to-South FDI. His model predicts that inward FDI is more attracted to the country's comparative advantage sector than to the sector with the disadvantage. While the model is clear and intuitive, the paper offers only a few stylized facts to support its claims.

Robert Lipsey's (2000) work attempts to better understand FDI in East Asia and its relation to comparative advantage. Using data on US and Japanese affiliates' activity and Balassa-like measures of RCA, he found that, for example, both Japanese and US affiliates had a much higher comparative advantage than the host country in electrical machinery (i.e. filling a gap). However, for other sectors such as chemicals and non-electrical machinery, the results differed between the US and Japan. This seminal work was, however, based only on several broad industry groupings and restricted to two source countries and focused mostly on East Asia.

More recently, Feliciano and Lipsey (2017) and Brakman *et al* (2013) have examined the role of FDI activity and comparative advantage using firm-level data. The former examines only FDI activity in the US, while the latter uses a "G7 plus 3" sample. Both papers use M&A FDI as the main investment activity variable, though Feliciano and Lipsey also look at new foreign establishment ("greenfield") activity in the US. Feliciano and Lipsey found that while the *source* countries' comparative advantage is correlated with investment in that sector in the US, foreign firms tend to acquire US firms in sectors where the US has no comparative advantage in particular.

With respect to *greenfield* FDI in the US, those inflows statistically tend to be in industries where the US has a comparative *dis*advantage.

Brakman *et al* use M&A data comprised of high-income countries, "G7 plus three." They find similar results, i.e. foreign firms invest (M&A) in industries abroad where they have a comparative advantage in that industry at home.[31] Felicano and Lipsey and Brakman *et al* differ, however, in one important aspect. Brakman *et al* find weak evidence that foreign firms are buying firms abroad that already have an existing comparative advantage. Brakman *et al* do not single out the US alone, however, where, as mentioned above, Feliciano and Lipsey found the opposite to be true. One possible interpretation of this divergence in results could be that foreign firms bring know-how and expertise to industries in the US where it did not previously exist (as opposed to cherry-picking the best US firms, which they may be doing in the other "G7 plus" countries). Again, we note that Feliciano and Lipsey's work is limited to US inward investments. Also, while Brakman *et al* used a broader set of countries, they only examined M&A FDI. We would argue that the motivations for greenfield FDI are usually quite different from the various motivations for M&A FDI (e.g. eliminating local competition, or obtaining economies of scale, gaining access to local distribution networks, etc.). As such, while the work of Brakman *et al* is somewhat global (ten high-income countries) in scale, it is examining very different behavior.

Finally, and just as important in our view: the two studies above use the classic Balassa (1965) Revealed Comparative Advantage index, rather than the econometrically-estimated comparative advantage from the Costinot *et al* (2012) method (which we refer to as the CDK

[31] Waldkirch (2011) looks at industry-level data for the case of Mexico and finds support for comparative advantage-led FDI. In other words, sectoral comparative advantage, based on a factor proportions model, drives inward FDI to Mexico.

method). We feel that by exploiting the superior properties of the CDK measures (detailed below) we offer a more accurate picture of the relationship between FDI and comparative advantage across countries, sectors and time.

Alviarez (2019) uses a 32-country data set of bilateral sales by foreign affiliates to investigate a related question. In the first half of her paper, she finds that inward multinational production shares are disproportionately higher in industries where local producers are relatively less efficient. [32] At the same time, she finds that outward FDI is higher in sectors where local firms have a comparative advantage. She distinguishes between what she calls 'fundamental' and 'effective' comparative advantage. The former is the comparative advantage generated by the domestic firms alone. The latter is the comparative advantage that results from the activities of both domestic and foreign firms in the 'home' country. As important as this work is, it does not address the broader question at hand in this paper, namely, traditional country-level comparative advantage. Moreover, the data used is primarily European and does not include most of Asia (except Japan).

As such, we are revisiting the older and broader debate of whether or not FDI is attracted to existing comparative advantage or, instead, drawn to countries in which it is lacking. This is the first paper that takes this question to the data on a global scale.

[32] For example, 52% of Chemicals production in Italy is conducted by 300 or so foreign firms such as Switzerland's Roche, or France's Sanofi Aventis.

2.3. Data, Methodology and Model

2.3.1. Structure of the Data Set

Our two main variables of interest are a measure of comparative advantage and FDI activity. The comparative advantage measures are created from our original econometric estimates of the 2-digit CDK-style measures (2012) following the weighting scheme of Leromain and Orefice (2014). We generate comparative measures for 340 country-industry pairs (20 host countries and major 17 sectors) for the years 2003-2017.[33] The twenty 'host' countries are: Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Korea, Japan, Mexico, the Netherlands, Russia, South Africa, Spain, Turkey, UK and the US (see Appendix Table 11). These are the same twenty countries Leromain and Orefice (2014) included in their study.[34]

To begin, we ran the CDK-regressions on 2-digit HS trade data (from UN Comtrade). Then, we converted the HS-based RCAs into 2-digit ISIC codes to match with our FDI data which is in ISIC (rev. 4). The concordance between HS and ISIC4 (rev 4) can be seen in Table 12 in the Appendix.

FDI data are taken from the Financial Times' "FDIMarkets", a database of over 211,630 transactions of all greenfield investments which occurred around the world from 2003-2017 and are available at the 2-digit ISIC level. The individual transactions have been aggregated by (ISIC rev. 4, 2-digit) industry for each country.[35] For example, there may have been three new

[33] Leromaine and Orefice's (2014) data ends in 2010. As such, our original estimates are far more recent than those in Leromaine and Orefice (2014.) Our regressions are also estimated on a broad sample of 20 exporting countries and their trade with 70 destinations (trade partners).

[34] Estimating CDK-style RCAs is data and time intensive. These twenty countries and industries cover about 80% of all manufacturing FDI, so we are satisfied with the coverage.

[35] The original FT database had its own industry codes which were, in turn, converted into ISIC codes by *insert name here. See (cite delated to maintain anonymity) for more details.*

investments into Brazil in the "Manufacture of Motor Vehicles, etc." sector in a particular year. The values of the three transactions are summed so that we have a country-industry pair unique to that year, i.e. all the greenfield FDI into Brazil in that sector in that year. The timespan for the Financial Times data and our constructed RCA measures are both 2003 to 2017. Though we have cross-sections of data over fifteen years, as we have zero values for some country-industry pairs in some years, we do not have a balanced panel. Also, as explained below, we have chosen to include host country, industry and year dummies rather than set it up as a panel with fixed effects.

Furthermore, note that only those transactions in which the FDI's "Industry Activity" was "Manufacturing" were included. Thus, for example, a new Denso (a Japanese auto parts maker) plant in the US (Ohio) may have an ISIC code of 29 "Manufacturing of Motor Vehicles, etc.", but the *Industry Activity* is "Sales, Marketing and Support", not "Manufacturing". As a result, such transactions have been omitted. Our study is only looking at greenfield factories *that make goods.*

Ultimately, we examine 20 host countries across 17 industries. Ideally, more sectors would be examined, but our sample is reduced to this number for the following reasons. First, of the numerous ISIC 2-digit categories, we only focus on 17 manufacturing activities (again, refer to Appendix Table 12 for the industry coverage). As such, we exclude ISIC categories that are in the Financial Times database but do not easily match with traditional concepts of trade. This is especially true for the services trade, for example, hotels, banking, etc. This also overlaps with the other constraint we have, namely: values for comparative advantage. Our estimates of comparative advantage measures are derived from trade data. For this reason, only products which are in the trade (in goods) data can be used. These are many, but not all, traded goods. We exclude some

goods in agriculture and farming, (e.g. "Live animals" and some other agricultural goods).[36] In the end, we feel the 17 sectors capture a wide swath of manufacturing goods and account for the majority of manufacturing FDI and export activity.

The full Financial Times database has 175 source and destination countries. In this paper, we ultimately include 102 source countries. See Appendix Table 13 for the list of source countries. We excluded many smaller countries because there was no FDI activity originating for those years and/or industries. However, on the FDI destination side, we examine a sample of twenty (20) major recipient countries. While this means that our dataset is not truly global, we still believe that it is very representative. The reason for the somewhat restrictive set of only 20 recipient countries is that estimating and calculating CDK-style RCAs is very data and time-intensive, even for a single country and a single year. However, these twenty countries account for over 80% of world output (based on nominal GDP data in 2017 from the World Bank) and have a very balanced mixture of higher-income and lower-income countries. The higher-income group of countries is comprised of Australia, Canada, France, Germany, Italy, Japan, the Netherlands, South Korea, Spain, the UK, and the US. The lower-income group is very diverse and includes Argentina, Brazil, China, India, Indonesia, Mexico, Russia, South Africa, and Turkey.

A final consideration is that for many of the other 155 possible recipient countries, there is little or no investment in certain sectors and, as such, would result in many 'zeroes.' In our sample, there are some countries that do not have the incoming investment in certain sectors and/or in

[36] As mentioned above, walking-over the comparative advantage from HS to ISIC was not easy, and in some cases, simplistic assumptions and weights would have to be made. In cases where we felt there was not a clear concordance, we dropped those sectors.

certain years. Ultimately, we have slightly more than a third of the country-industry pairs with zero values.[37] As such, we are confident this captures the essence of global greenfield investment.

Figure 5 shows the total inward FDI by all 20 host countries over time, separated into the higher and lower-income subsamples. Two observations immediately come to mind. First, the greenfield FDI in manufacturing is quite steady over time, albeit with a decline in the last two years in the lower-income subsample. Also recall that these are, by definition, new investment projects each year, so that if we were to look at capital stock of FDI over time, it would be steadily rising in nominal dollar terms. The second observation is that the inward FDI to the lower-income group of nine counties is higher in nearly every year than the FDI going into the eleven higher-income countries. This is despite the fact that the higher-income countries' combined GDP is several times larger than that of the lower-income countries.

The Financial Times database is very detailed with many additional characteristics. There are 27 variables in total including name of firm, city of UBO (ultimate beneficial owner), the month that the project was started, etc.)

[37] While using Poisson Pseudo-Maximum Likelihood (PPML) methods was considered, we did not conduct PPML regressions for the following reasons. First, the original PPML was developed for a single-cross section of (gravity) data. Recently, panel PPML estimators have been developed, but our sample is not, strictly speaking, a panel, nor is it the typical 'country-pair' gravity model setup. We follow the few papers in this area and have a cross-section of data over 15 years. Second, while estimates in gravity models using PPML tend to give different parameter estimates, the sign, magnitude and level of significance do not change (see Table 3 in Santos Silva and Tenreyro, 2006) when PPML is used. As our results are very robust across shorter samples, and several specifications, we did not see the need to attempt this here.

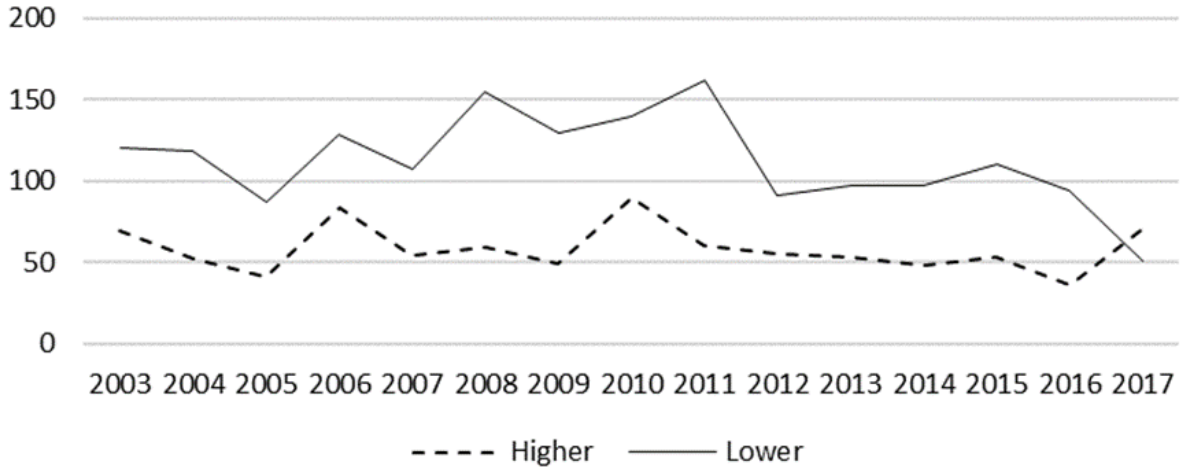

Figure 5: Total Inward Greenfield FDI by Higher and Lower Income Countries in Sample (2003-2017) in billions of US$

However, the main characteristics used here are: "Capital Investment" (in $US) of the greenfield FDI enterprises[38] ; An Industry Code (converted to ISIC 2-digit); "Industry Activity" ("Manufacturing", "Business Services", "Retail", etc.); and the Destination (Host) Country.[39]

Figures 6 and 7 show the composition of greenfield FDI by Source country and Host country. It is no surprise that the US (18%), Japan (13%), and Germany (10 %) are the largest sources of outward greenfield FDI. But also note that China (5%) and India (3%) are in the top 10 (See Figure 6.)

[38] Note: "Jobs Created" also available.
[39] Source (Home) country also available.

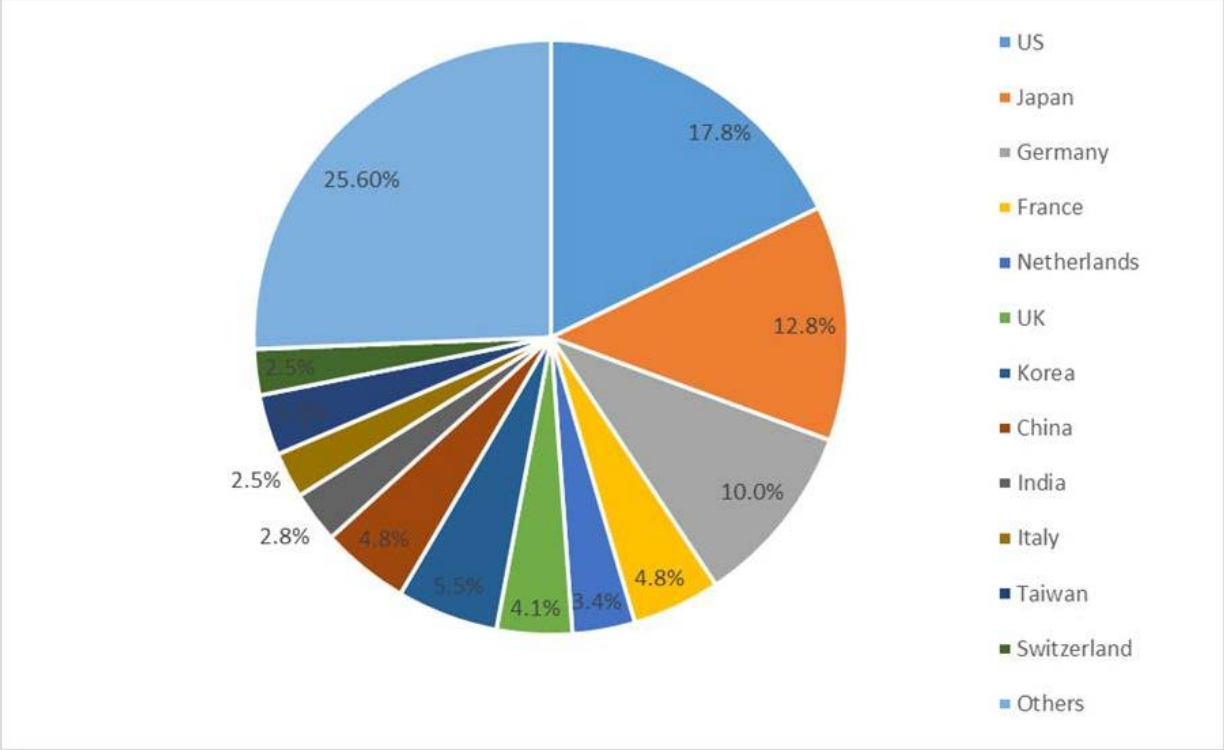

Figure 6: Percent of Outward FDI by Source Country (Cumulative 2003-2017)

In Figure 7, we show the shares of inward FDI. Note that this is not for the whole sample, but for the 20 Host countries in our sample. This still represents over 80% of manufacturing greenfield investment and all major recipient countries. China dominates, but we also see that higher-income countries such as the US and Canada are major host countries. India, Indonesia, Mexico, Russia, and Brazil are also significant locations for investment, each accounting for 6% of our sample.

Table 6 shows the distribution of FDI activity by the industrial sector.[40] Motor vehicles (and parts), chemical, and metal products are the dominant sectors. Manufacturing of machinery, rubber, and plastic products are also important sectors.

[40] Note too, that this is only limited to the 17 sectors in our data set. As described elsewhere in the paper, this excludes service FDI (hotels, finance, etc.), energy, natural resources, and various agricultural and food products.

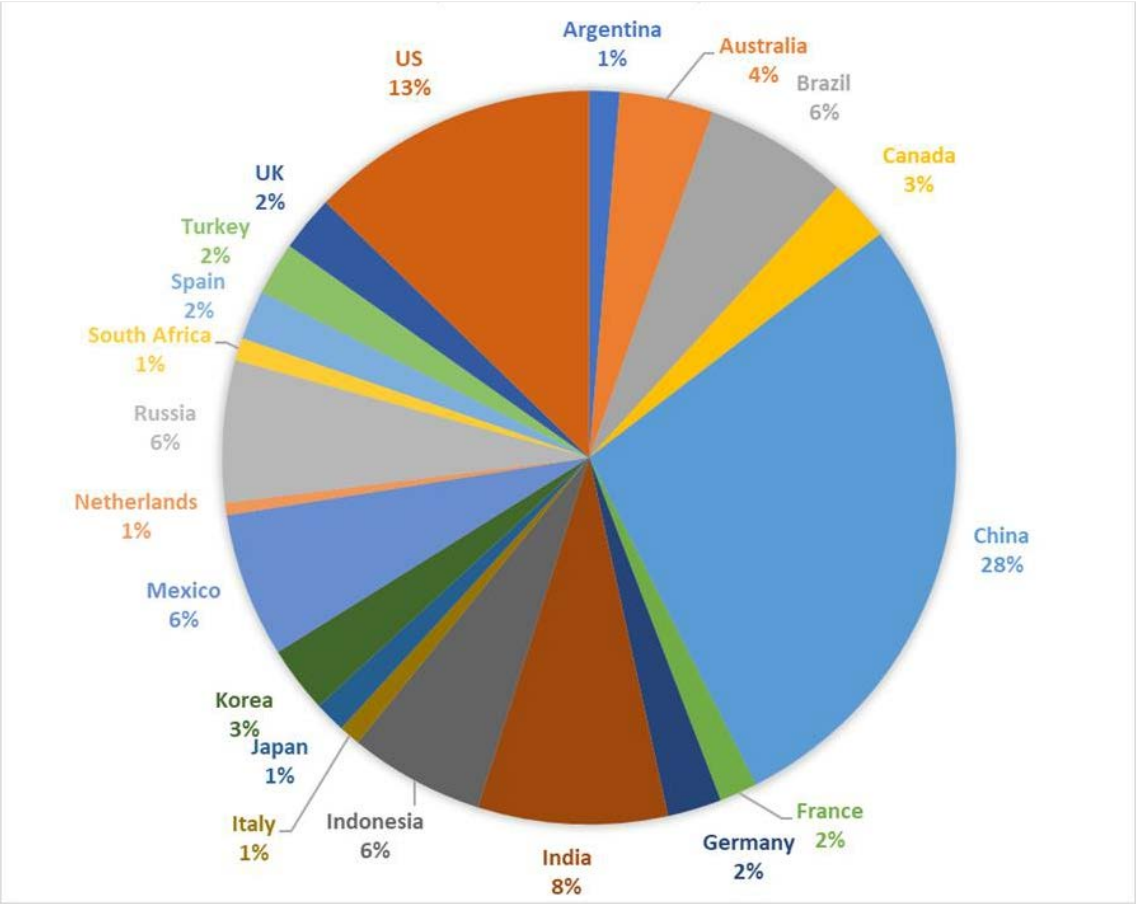

Figure 7: Percent of Inward FDI (Capital Inv) across 20 Host Countries (cumulative 2003-2017)

Table 6: Inward FDI Shares by ISIC Industry

ISIC	Description	Percent share
7	Mining of Metal ores*	0.9
8	Other mining*	0.1
13	Textiles	1.7
14	Apparel	0.2
15	Manufacture of leather and related products	0.1
16	Manufacture of wood and of products of wood and cork, except furniture	1.3
17	Manufacture of paper and paper products	4.7
20	Manufacture of chemicals and chemical products	21.0
21	Manufacture of pharmaceuticals, medicinal chemical	3.8
22	Manufacture of rubber and plastics products	8.4
23	Manufacture of other non-metallic mineral products	5.6
25	Manufacture of fabricated metal products, except machinery and equipment	6.4
28	Manufacture of machinery and equipment, n.e.c.	8.8
29	Manufacture of motor vehicles, trailers and semi-trailers	33.8
30	Manufacture of other transport equipment	1.8
31	Manufacture of furniture	0.2
32	Other manufacturing (jewelry, musical instruments, etc.)	1.2

* Only includes Manufacturing Activities, not 'Extraction' activities in these two sectors.

These are shares of the 17 sectors included in our sample, not all FDI activity in all ISIC sectors.

2.3.2. Weaknesses of Balassa RCA Indices

Before we proceed to the methodology, some brief comments as to the superiority of the CDK RCAs are in order. As discussed in Leromain and Orefice's and elsewhere, the deficiencies of the Balassa Index are well-known. The CDK comparative advantage measure addresses many of these deficiencies. Following Bowen *et al* (2012), the Balassa Index is often calculated as follows (or something mathematically identical):

$$RCA = \frac{\frac{X_{ij}}{X_{wj}}}{\frac{X_{i*}}{X_{w*}}}$$

Where X denotes "exports". X_{ij} represents exports by country i of good j. W denotes "world" so that X_{wj} would be total good j exported to the world by all countries.

First, the Balassa Index, while roughly consistent with our intuition of comparative advantage, is, in fact, quite *ad hoc*. In contrast, the CDK measure can be derived from an Eaton and Kortum (2002) model explicitly.[41] Second, while it is often asserted or implied that a Balassa Index of greater than 1 indicates comparative advantage, and in most cases probably does, there is no reason that this is necessarily the case. Indeed, it is quite possible to find net exports to be *negative* in a commodity yet have a Balassa Index greater than 1 (Bowen *et al*, 2012). The CDK measure, however, has a mean of one, and indeed, having a value of greater than one does indicate (based on the underlying model) that the country has a comparative advantage in that sector.

While the Balassa Index's mean is often close to 1 (see Leromaine and Orefice), the CDK measure, which is first econometrically derived, always has a mean that is very close to 1. Its median is also close to one and its distribution is very close to normal. This is in contrast with the Balassa Index, which is heavily skewed downward, and yet has a very long, flat right tail. Balassa Index values can be high, in some cases up to 20. Leromain and Orefice (2014) also found that for ranking across sectors and countries, the CDK measures are more highly correlated than those calculated using the Balassa Index. Lastly, and perhaps most important, CDK comparative advantage measures are far more stable over time. Since the estimation of CDK includes fixed

[41] Of course, the Eaton and Kortum-style models and the CDK measure make several large assumptions to achieve this.

effects (for example, importer-good fixed effects), the CDK measures account for demand shifts and other shifts over time. Table 7 shows a sample of some of the comparative advantage values used in this paper.

Table 7: Selected CDK-style RCAs for Major Host Countries and Industries (ISIC code)

	2010	2011	2012	2013	2014	2015	2016	2017
China								
20	0.899	0.922	0.922	0.883	0.923	0.892	0.907	0.904
25	0.953	0.945	0.966	0.915	0.954	0.914	0.946	0.946
29	0.831	0.836	0.852	0.800	0.825	0.789	0.835	0.799
US								
20	0.969	1.031	0.990	1.003	0.949	0.990	0.980	1.010
25	0.974	1.014	0.972	0.985	0.942	0.980	0.976	1.048
29	0.991	1.020	1.032	1.022	0.981	1.008	1.053	1.032
India								
20	0.977	1.021	1.007	0.949	0.957	0.935	0.964	0.964
25	0.942	0.972	0.947	0.904	0.936	0.898	0.948	0.938
29	0.964	0.971	0.994	0.902	0.919	0.898	0.969	0.913
Brazil								
20	0.952	0.974	0.970	1.016	0.984	0.985	0.992	0.906
25	1.031	1.017	1.003	1.070	1.066	1.054	1.059	0.996
29	0.912	0.889	0.878	0.880	0.852	0.837	0.922	0.839
Canada								
20	0.937	0.980	0.943	0.973	0.961	1.003	0.948	0.973
25	1.031	1.042	1.020	1.054	1.041	1.080	1.055	1.139
29	0.932	0.942	0.929	0.935	0.916	0.993	1.006	0.991
Japan								
20	1.019	1.081	1.027	1.092	1.053	1.080	1.092	1.162
25	1.014	1.064	1.011	1.070	1.025	1.056	1.046	1.137
29	1.464	1.500	1.446	1.516	1.469	1.499	1.564	1.588

Source of data: Authors

Other notes:

ISIC codes 20, 25 and 29 are: Manufacturing of Chemicals; Fabricated metals, except machinery and equipment; and Motor Vehicles, trailers and semi-trailers, respectively. This selection is for illustrative purposes. The full data set of RCAs is available upon request.

2.3.3. Empirical Model

We estimate a series of regressions of greenfield FDI on comparative advantage measures using several alternative specifications. We estimate regressions on the full sample of 20 countries as well as subsamples of higher-income and lower-income countries. Appendix Table 11 shows countries included in the higher-income and lower-income categories.[42] Lastly, while the time series is of a moderate length, only 15 years, we must consider possible endogeneity, wherein inward FDI may change the host's comparative advantage over time. We address this concern in the last set of regressions. Similar to Feliciano and Lipsey (2017), the general form of the regressions is as follows:

$$RFDI_{ijt} = \alpha + \beta_1 RCA_{ijt} + \beta_2 GDPGrowth_{jt} + I_i + H_j + Y_t + e_{ijt}$$

where:

RFDI is the sum of all of greenfield transactions in Industry *i* into Host country *j* in Year *t* from the 102 source countries of the world (source: FT database). Originally, the data is in dollars, but it is deflated by the US CPI.

RCA are our econometrically derived CDK-style comparative advantage measures which are specific to the host country-industry pair.

GDPGrowth is the real growth rate of the host country in local currency (Source: World Bank). Growth of the host country's GDP as well as the size of the host country's GDP are considered to be the main driving factors in attracting FDI (Faeth, 2009). H_j is a host country dummy which captures market size. The variable I_i is an industry dummy. Y_t is a year dummy.

[42] There was large and clear gap between the GDP per capita of the two groups. South Korea had the lowest per capita income of the high-income group at roughly $32,000 according to World Bank data. The wealthiest of the so-called "low-income" group was Russia, with a per capita GDP of $11,600. We used this break as our criterion.

Coefficient β_1 is our main parameter of interest. All variables are in their natural log transformation.

The results of the two sets of regressions of OLS as well as instrumental variable (IV) estimates are presented in the following section.

2.4. Empirical Results

2.4.1. Main Results

Table 8 presents the OLS results for the full sample, the lower-income country subsample and the higher-income subsample.[43] The left-hand side variable is the (natural) log of Real FDI in levels. The log of the RCA measure and the log of the Real GDP growth rate of the destination (Host) country are the main right-hand side variables along with Host country and Industry dummies.[44] In the full sample of 20 destination countries, the RCA coefficient is positive and significant at a greater than 1% level of significance (column 1). Real GDP growth of the Host country is also, not surprisingly, found to be positive and significant as well. Industry and Host country dummies are also significant but were not presented in the tables.

[43] See Table 11 in the Appendix for the delineation of "higher" and "lower". Estimations were also run allowing for robust standard errors and also errors clustered around the host country. Results were nearly identical with no change in the levels of significance.

[44] Time (year) dummies were included as well but were found to be insignificant. Furthermore, their inclusion and exclusion did not change the results and so they were dropped from the final estimations.

Table 8: Effect of Host Country's Comparative Advantage on Greenfield FDI (OLS)

	(Full Sample)	(Lower income)	(Higher income)
Dependent Variable	lnRFDI	lnRFDI	lnRFDI
	(1)	(2)	(3)
lnRCA	0.653***	0.835***	0.329
	(0.189)	(0.217)	(0.405)
lnRGDPGrowth	0.112***	0.119**	0.100**
	(0.040)	(0.061)	(0.049)
Observations	2532	1288	1244
Adj R-sq	0.507	0.557	0.475
Host Country effects	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Constant term included but omitted above. Results unchanged with or without time dummies. Results here are without time (year) dummies. Estimates were also done with errors clustered on the host country with no change in the results.

In column 2, we again find the *RCA* coefficient is positive and significant at the 1% level for lower-income countries. *GDPGrowth* is again positive and significant.

Column 3 shows results for higher-income countries. In contrast to the results for the whole sample and lower-income countries, the *RCA* coefficient is insignificant, even at a 10% level. Overall, these results suggest that the 'firm-specific' view applies very well to lower-income countries and not at all to the higher-income countries. We posit that this is mostly driven by the fact that FDI into lower-income countries is a result (mostly) of MNCs bringing new, superior, firm-specific capital to a country which already excels in that sector. This is consistent with Qiu's (2003) model of FDI and trade. There may also be agglomeration effects and 'demonstration effects', i.e. once some MNCs are successful in a country in an industry, others follow. For the higher-income countries, however, there may be no single dominant reason for FDI. Some could be targeting countries with existing comparative advantage in that industry (for example, VW

building cars in the US) but other reasons for investment may be to serve that (typically wealthier) domestic market more easily (i.e. "market-seeking" FDI) or to avoid tariffs (i.e. "tariff jumping"). As such, we see no clear correlation between the host's RCA in that sector and inward FDI. It is important not to forget that we are looking at new, greenfield investment and only FDI in the production of manufactured goods.

Table 9: Effect of Host Country's Comparative Advantage on FDI (OLS)

	(Full Sample)	(Lower income)	(Higher income)
Dependent Variable	Ln(FDI/FDIw)	Ln(FDI/FDIw)	Ln(FDI/FDIw)
	(1)	(2)	(3)
lnRCA	0.114***	0.138***	0.070
	(0.025)	(0.028)	(0.051)
lnRGDPgr	0.008	0.004	0.011*
	(0.005)	(0.008)	(0.006)
Observations	2532	1288	1244
Adj R-sq	0.344	0.384	0.317
Host Country dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Constant term included but omitted above. Results unchanged with or without time dummies. Results here are without time (year) dummies. Estimates were also done with errors clustered on the host country with no change in the results.

In Table 9 we adopt a considerably different method of control. On the left-hand side, we now have the log of the level of FDI as a ratio of the total world FDI in that sector. So, for example, we have the inward FDI in "Manufactures of Furniture" in Indonesia divided by the total FDI throughout the world in "Manufactures of Furniture". The results are again similar and support the firm-specific view, but only for the lower-income countries.

Table 10: Effect of Host Country's RCA on FDI (one year lag of RCA as IV, 2SLS)

	(Full Sample)	(Lower income)	(Higher income)
Dependent Variable	lnRFDI	lnRFDI	lnRFDI
	(1)	(2)	(3)
lnRCA	0.588***	0.774***	0.196
	(0.217)	(0.250)	(0.508)
lnRGDPGrowth	0.120***	0.131**	0.100
	(0.043)	(0.063)	(0.056)
Observations	2344	1193	1151
R-sq	0.514	0.561	0.489
Host Country dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Constant term included but omitted above. Results unchanged with or without time dummies. Results here are without time (year) dummies. Estimates were also done with errors clustered on the host country with no change in the results.

In Table 10, we address the concern of possible endogeneity. That is, over time, inward FDI may change the country's comparative advantage in that sector. While we feel this is certainly a possibility, we also think this would likely take a long span of time, usually longer than the 15 years of our study, and would not be true for most country-industry pairs.[45] Nonetheless, we address this possible concern by running instrumental variable (IV) regressions with a one-year lag of RCA for the country-industry pair as the instrument. We use the first specification (RFDI in levels with real GDP growth on the right-hand side as in Table 8). Again, we find the same results. Overall, the RCA and GDP growth coefficients are positive and significant, but when we estimate

[45] In a global data set, there are, of course, exceptions. Vietnam, for example, in the mid-2000s, saw a clear upward tick in the comparative advantage in its electrical sector (Vu and Parsons, 2018), though no clear trend in all other 15 sectors over the 15-year period. This uptick in comparative advantage was clearly driven by the massive inward investment, especially by Samsung and LG. In any case, Vietnam is not one of our 20 host countries in this paper. We also did not observe any huge changes in the measures of comparative advantage we used over this time period.

regressions for the two subsamples separately, we see the positive result is driven entirely by the strong positive and significant RCA in the nine host countries with lower incomes. Neither the firm-view nor factor-view seems to hold for higher-income countries in these IV estimations as well.

2.4.2. Further Robustness Checks

To check the robustness of these results, we do three things. First, we drop China as a host country, to account for the fact that China's sheer size and importance in global value chains could be influencing our results. When we drop China, nothing changes. Second, as our time series encompasses the Global Financial Crisis and Great Trade Collapse of 2008-2009, we run the regressions again with 2008 and 2009 omitted. Again, nothing changes, except for slight changes in the size of the estimated coefficients. Lastly, we do a somewhat *ad hoc* removal of an outlier sector. In particular, we drop 'Mining' (ISIC 7), because there are very few observations of manufacturing activity in this sector (most is coded as 'Extractive' and is not included in our sample). However, the results are unchanged.[46]

2.5. Conclusion

In this paper, we have conducted the first test of the relationship between greenfield FDI and a host country's CDK-style RCAs on a global scale using a rich data set from the Financial Times. Our results have helped answer a question that has lingered in the empirical trade literature for more than 40 years.

[46] Lastly, it is possible that FDI from higher income countries differs from that of FDI from lower income countries (such as China or India). We therefore re-aggregated the transactions data including only the ten largest source countries. While these ten countries account for a large fraction of FDI in dollar terms, it is far less representative than our preferred sample derived from 102 source countries. No discernible pattern emerged in this narrow sample, so the results are not reported here.

In short, we find that the "firm-specific" view, espoused by Caves *inter alia*, is overall supported by our estimations. That is, new FDI is generally attracted to existing comparative advantages in the host country rather than the view that capital goes to where comparative advantage is initially lacking (the factor-proportions view by Mundell, 1957).

However, importantly, when we divide the sample into higher-income and lower-income countries, the differences are stark. While in lower-income countries the positive, firm-specific view holds at a greater than 1% level of significance and across a variety of specifications, for higher-income countries, there is no statistically significant relationship. This is very likely due to the wide variety of motivations for investing in wealthier markets, some for access to the larger market, other times as an export platform to nearby markets, and also for separate reasons altogether. These findings highlight the need to further investigate this question with different data sets and methods.

The question raised in this paper is quite broad in scope: "What is the relationship between FDI and comparative advantage?" While we know that reasons for FDI are complex and numerous and that they differ widely across countries and sectors, it is useful to know the general patterns of FDI with respect to a country's skills. This can help better inform economists working to explain the patterns of trade, increasingly dominated by MNCs. But also, for policymakers, it is important to know, in general, if foreign firms that are breaking new ground with their factories are there to "fill a gap", or are, instead, drawn to existing talents and advantages of the host. We have found that for recipient countries like the US, Japan and Germany, it is not clear. But for countries like Indonesia and Brazil, policymakers may be well-advised not to attempt to incentivize inward FDI into sectors where there is no existing strength. Subsidies or other incentives by the government to entice such FDI may be destined to fail and at great expense to the host country's taxpayers. At

the same, if certain sectors are perceived to have large enough spillovers from inward FDI to warrant subsidization, such efforts should be limited to those sectors in which the country already has an existing comparative advantage.

Appendix 2

Table 11: Higher and Lower Income Host Countries

"Higher"	"Lower"
Australia	Argentina
Canada	Brazil
France	China
Germany	India
Italy	Indonesia
Japan	Mexico
Netherlands	Russia
South Korea	South Africa
Spain	Turkey
UK	
US	

Note: recipient (host) countries are grouped by GDP per capita as described in the text.

Table 12: Two-digit ISIC v.4 and HS Concordances

ISIC	Description	HS Code
7	Mining of Metal ores*	26
8	Other mining*	25
13	Textiles	50 through 58
14	Apparel	61, 62, 65
15	Mfg. of leather and related products	41, 42, 43, 64
16	Mfg. of wood and of products of wood and cork, except furniture	44
17	Mfg. of paper and paper products	47,48
20	Mfg. of chemicals and chemical products	28, 29, 31 through 40, 54
21	Mfg. of pharmaceuticals, medicinal chemical	29,30
22	Mfg. of rubber and plastics products	39,40
23	Mfg. of other non-metallic mineral products	25, 68, 69, 70
25	Mfg. of fabricated metal products, excl. machinery and equipment	73,74,82,83,84,93
28	Mfg. of machinery and equipment, n.e.c.	84,87
29	Mfg. of motor vehicles, trailers and semi-trailers	87
30	Mfg. of other transport equipment	84,86,87,88,89
31	Mfg. of furniture	94
32	Other manufacturing (jewelry, musical instruments, etc.)	66, 67, 71, 90, 91, 92, 95,96

* Only includes Manufacturing Activities, not 'Extraction' activities in these two sectors.
In any case, observations are only a handful and results do not change at all with their omission.

Table 13: Source Country

Angola	Egypt	Lithuania	Serbia
Argentina	Estonia	Luxembourg	Singapore
Armenia	Finland	Macedonia FYR	Slovakia
Australia	France	Malaysia	Slovenia
Austria	Germany	Malta	South Africa
Azerbaijan	Greece	Mauritius	South Korea
Bahrain	Guatemala	Mexico	Spain
Barbados	Hong Kong	Monaco	Sri Lanka
Belarus	Hungary	Morocco	Sweden
Belgium	Iceland	Myanmar	Switzerland
Bermuda	India	Netherlands	Syria
Bosnia & Herzegovina	Indonesia	New Zealand	Taiwan
Brazil	Iran	Nigeria	Thailand
Bulgaria	Ireland	Norway	Trinidad & Tobago
Canada	Israel	Oman	Tunisia
Cayman Islands	Italy	Pakistan	Turkey
Chile	Japan	Peru	UAE
China	Jordan	Philippines	Uganda
Colombia	Kazakhstan	Poland	Ukraine
Congo (DRC)	Kenya	Portugal	United Kingdom
Costa Rica	Kuwait	Qatar	United States
Croatia	Kyrgyzstan	Romania	Uruguay
Cyprus	Latvia	Russia	Venezuela
Czech Republic	Lebanon	Samoa	Vietnam
Denmark	Liechtenstein	Saudi Arabia	Zimbabwe
Dominican Republic			
Ecuador			

HS to ISIC Mapping

The CDK method involves first estimating export volumes (OLS) on an enormous set of specific dummies. Then, a key parameter estimate is extracted from those estimates to construct (though various sums and averaging) the RCA measure. Trade data available online (e.g. through UN Comtrade) can be downloaded in either HS or SITC code. Our FDI data, however, is in ISIC codes. As such, we have no choice but to use concordance tables to do a mapping from HS to ISIC. The document we used for the mapping was WITSJobID-48_Concordance_H3_to_I3.csv available on the WITS website.

The challenge, of course, is that a single ISIC may be comprised of goods that fall into several HS categories (and vice versa). Some are fairly straightforward. 'Wood, excluding Furniture' is HS 44, and is generally contained in ISIC 16. Also, 'Furniture' is essentially HS 94 and ISIC 31. Many other categories are far more challenging. 'Textiles' for example, is ISIC 13, but various yarns, ropes, carpets and other textiles span all 11 HS categories from 50 to 60 and also 63. Furthermore, it may be that the bulk of what is considered 'Textiles' may be in say, HS52 ("Cotton incl yarn") and very little (in trade value terms) in, say, HS59 "impregnated etc. text fabrics; tex art for industry" (part of which is also contained in ISIC 22 in addition to ISIC 13). Naturally, these weights would differ across countries and from year to year. As such, we took a simple approach. Noting the main (as determined by frequency) HS codes contained in each particular ISIC code, we took a straight average of those codes. Some categories which we determined were too difficult to map or too complex to be satisfied with a simple average were dropped. This heuristic method is no doubt imperfect. We do feel, however, that any improvements that can be made to this mapping would not alter the results of our findings, which are already quite robust across various perturbations.

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Chapter 3: Effect of GVC Participation on Greenfield FDI: An Industry-level Analysis

3.1. Introduction

In the past four decades, MNEs have played a leading role in shaping foreign direct investment (FDI) decisions and global value chains (UNCTAD, 2013; Helpman, Melitz, and Yeaple, 2004). Therefore, international trade fragmentation has intensified in the past two decades, with a rise in FDI flows. While many studies have examined FDI as a determinant of global value chain (GVC) participation, research in the opposite direction is scarce. However, upon examining the anecdotal evidence, it is apparent that some firms are enticed to invest in countries that are more integrated into GVCs. This may not be the case in all sectors, and even if GVCs draw in more inward FDI, the benefits may be either long-lasting or short-lived. Amendolagine *et al.* (2018) write that,

"…achieving high levels of GVC involvement is not a guarantee of attracting FDI with high sourcing potential. Countries and sectors with high GVC involvement may attract footloose investments, should they offer foreign investors low-cost inputs and other export incentives."

Therefore, it is important to identify whether or not greater GVC participation leads to increased FDI. If it does, it is important to determine the particular industries. Few studies have considered GVC participation as a motivator of FDI at an aggregate (country) level. To the best of our knowledge, no industry-level investigation has been conducted to determine the degree to which GVC participation is a determinant of increased FDI.

Various studies investigate the determinants of FDI by studying numerous gravity-type variables and financial and institutional variables, which differ across countries (see Chakrabarti

(2001), Di Giovanni (2005), Blonigen and Piger (2014) *inter alia*). These studies are based on cross-country analysis, which generally confirms their hypotheses. However, this aggregate approach may overlook the heterogeneity of industry and firms because it is MNEs that make investment decisions and not countries.

There are many reasons for MNEs to undertake investment activity. Certain activities generate "horizontal" FDI with the goal of increasing the MNE's sales in a new foreign market (i.e., "market-seeking"). Alternatively, "vertical" FDI or "export-platform" FDI represents efficiency-seeking activities that intend to minimize costs by exploiting the lower input costs of FDI-recipient countries. The manufactured products are then shipped back to their home countries, or exported to a third country. This efficiency-seeking investment is intertwined with the notion of "global value chains" (GVCs) which involve multi-border international trade of intermediate products. Antràs (2020, p. 5) defined GVCs as consisting "…of a series of stages involved in producing a product or service that is sold to consumers, with each stage adding value, and with at least two stages being produced in different countries. A firm participates in a GVC if it produces at least one stage in a GVC." Hence, we can consider drivers of FDI from a GVC perspective, in addition to the traditional determinants. Therefore, MNEs decide where to locate their investment activity after considering the value-added activities comprised in a GVC (UNCTAD, 2013; World Bank, 2017).

Establishing a link between GVC participation and FDI is difficult not only because of the reverse causality between GVC participation and FDI, but also the complex nature of inward FDI. MNEs can gain access to new foreign markets by manufacturing locally, setting up new plants (Greenfield), or acquiring existing facilities (Merger & Acquisitions [M&A]). As documented in

the literature review, GVCs generally play a more important role in greenfield FDI than in M&A. Therefore, our study analyzes greenfield FDI.

Despite the absence of a comprehensive theoretical and empirical framework, it can be hypothesized that a country's degree of GVC participation may either facilitate or hinder FDI. First, we consider a potentially positive link, according to which, a country with higher GVC participation attracts more FDI. First, MNEs can take advantage of the host country's resources for production with a possibly lower cost of labor and inputs, to produce a certain intermediate product. The export of these cheaper intermediate products can bring higher profits for MNEs, thereby, motivating MNEs to invest in the host country. Second, in addition to minimizing production costs, a host country with a high level of GVC participation can provide potential access to a greater number and variety of export partners for the MNE, ultimately granting greater access to the global market. This added benefit could also attract more MNE investment.

Conversely, deeper involvement in GVCs may also reduce inward FDI. For example, if the host country has a high GVC participation level but is operating in the early stages of the production process, it has an upstream position where its exports will become the intermediate input for subsequent production. Such kinds of intermediate inputs may originate from locally sourced raw materials. Conversely, the inputs may be highly technological and/or based on proprietary know-how. Consider the case of a world leader in automobiles or electronics exporting high-end inputs. The host country's government may implement policies that dissuade foreign investment in these industries to protect the country's technical knowledge and talent. In the case of natural resources, government intervention aims to prevent foreign exploitation of the resource. These conditions may explain why a host country has a high degree of forward GVC participation but no increase in foreign investment. Recently, several empirical and theoretical attempts have

been made to address the question of how GVC participation affects FDI (e.g., Martinez-Galan and Fontoura, 2019; Carril-Caccia and Pavlova, 2020; George *et al*, 2021), but no robust conclusions have been reached. This article answers this question at the industry level.

In this article, we address the following two concerns: (1) whether an empirical analysis relying on disaggregated data at the industry level is consistent with the existing results based on aggregate country-level data, and (2) how does GVC participation affect FDI across industries and regions? To answer these questions, we do not consider firm-level decisions; instead, we consider a country-level perspective using data at the industry level to examine the importance of GVC participation as the location determinant of inward bilateral greenfield FDI. Our results have several policy implications, which are laid out in the conclusion.

3.2. Literature Review

In the context of deepening globalization, MNEs have to decide the best approach to serve foreign markets. MNEs may opt to export or produce goods in the recipient country through FDI. If MNEs decided to invest, they opt for the following two channels: establishing a new firm (greenfield investment) or acquiring an existing firm (M&A). The choice between FDI channels is heterogeneous across the world. Nocke and Yeaple (2007) present a model in which the decision regarding foreign market access, depends on how firms differ in their internationally "mobile" (technology or perhaps organizational structure) or "non-mobile" capabilities (e.g., home market know-how). Therefore, firms with different capabilities choose different channels to access foreign markets. According to the World Bank (2020), M&A is the main channel preferred by developed countries, and EU-15 represents 69% of the total inward FDI volume. However, in the past decade, greenfield investment has comprised 85% of the FDI inflows to lower-income countries. Further,

we attempt to determine the most significant investment channel in GVCs. Head and Ries (2008) argue that firms seeking to gain corporate control, opt for M&As, while vertical FDI is preferable for firms seeking to relocate production and export the manufactured products to the home county or rest of the world. Braconier *et al*. (2005) emphasize that MNEs slice up the value chain through vertical FDI, exploiting the skilled and unskilled labor endowment differences across countries. ADB (2016) finds that, in the case of lower-income countries, greenfield FDI tends to be more GVC-linked than M&A. This may be because M&As are relatively more market-seeking. Accordingly, we focus on greenfield FDI. Additionally, our FDI data solely comprises greenfield FDI, as will be detailed later.

In investigating the degree to which GVCs attract FDI, the analysis is clouded by the presence of likely reverse causality. A growing body of literature is investigating the expansion of GVCs as a consequence of FDI. Several studies, including Lopez Gonzalez (2016) and UNCTAD (2013) *inter alia*, find evidence that more FDI can bring about further participation in GVCs. Domestic firms can produce higher-quality or more complex products by increasing their interactions with MNEs, continuing to learn from them, and promoting increased labor mobility from MNEs to domestic firms (i.e., FDI spillover effects. In turn, the overall firm performance and capacity for export improve. Accordingly, the host country becomes more integrated into GVCs. Controlling for this reverse causality to isolate the effect of GVC on greater FDI, is of paramount concern in this study.

Few studies examine the potential effect GVCs on inward FDI. While Martinez-Galan and Fontoura (2019) focus on aggregated inward FDI stocks and Carril-Caccia and Pavlova (2020) focus on M&A. George *et al.* (2021) focus on greenfield FDI. All of these studies suggest that higher GVC participation is associated with higher inward investment. While an important finding,

all of these papers use country-level data. Therefore, their results may be biased because they suffer from the heterogeneity of industries. In this study, we hope to obtain more definitive results using disaggregated industry-level data. Moreover, the three abovementioned studies use the GVC participation index by Koopman et al. (2014), which has several drawbacks. Thus, using the superior properties of Borin's (2019) GVC participation measures, which are documented in the data description section, we attempt to provide a more accurate picture of the relationship between bilateral FDI and GVC across countries, sectors, and regions.

A country with a high level of GVC participation is deeply involved in international production through exports and re-exports. It may have some of the following characteristics: a) a labor force specializing in distinct activities in the GVC(s), b) lower production and labor costs, c) technological know-how, and d) relatively easy access to international markets or certain partners. To be specific, Braconier, Norback and Urban (2005) highlight that countries with a higher capacity for producing intermediates goods are likely to attract vertical FDI because these goods can be used in later stages of production. Medvedev (2012) found that countries with a larger number of export partners can better attract export-platform FDI. Therefore, motivated by vertical and export-platform FDI, MNEs opt to invest by building new affiliates in such countries, facilitating access to global markets and economic integration. Although Braconier, Norback and Urban (2005) and Medvedev (2012) provide evidence that countries with the abovementioned characteristics attract more FDI, these papers do not directly quantify the impact of GVC participation on FDI.

Carril-Caccia *et al*. (2020) show that there are two cases in which countries with higher GVC participation show lower inward M&A. First, M&A inflow from developed countries to developing countries, is easily hindered by foreign competition in final products. Second, if the

host and source countries involved are developed, M&A will be easily hindered by competition, through the import of intermediate goods. This is because the intermediate imports from different countries lead to higher competition and subsequently lower expected profits. However, no studies have found that GVC participation mitigates or reduces greenfield FDI. This may be because it only occurs in some industries and cannot be seen at the aggregate level.

The regionality of the FDI may also have an effect. Baldwin (2011) argues that GVCs are not a global phenomenon but are instead located in one of only three regions without any considerable connection between them. These regions include Europe, North America, East Asia, and the Pacific. Although this is an important observation, there are no empirical studies analyzing how the effects of GVCs' involvement on FDI vary by region. Carril-Caccia and Pavlova (2020) analyzed the relationship across different levels of income (i.e., developed or developing country) while George *et al.* (2021) focused on emerging economies. However, our research investigates the relationship across the three regions, as delineated by Baldwin (2011).

3.3. Data and Methodology

3.3.1. Data

The two main variables analyzed in this study are FDI activities and the measure of participation in GVCs. Our data span from 2005 to 2015, covering 15 manufacturing industries, as shown in Table 14. Table 15 lists the 64 host countries with 36 OECD and 28 non-OECD countries. There are 88 source countries in our sample (see details in Appendix 4, Table 24).

Regarding the FDI variable, we utilize bilateral FDI data from the Financial Times "fDi Markets." It includes data regarding worldwide greenfield investment transactions that took place between 2003 and 2017. The main characteristics of the database include "capital investment" in

US dollars, “jobs created,” and “industry activity” (e.g., “manufacturing,” “business services,” “retail,” and “extraction”). Additionally, the database also contains information regarding the following aspects: name of firm, industry code, host country, and source country. In this study, we aggregate all transactions and firms to an industry level, under ISIC 2-digit categories.[47] From the various types of “Industry Activities,” we retain only the FDI projects related to "manufacturing." This is done to ensure that the focus is on greenfield firms that produce goods related to international production networks. However, we drop other activities, including “Retail,” “Business Services,” and “Sales.” FDI activity, measured in dollars, indicates the capital as a share of GDP. The countries’ GDP rates are collected from the World Development Indicators.

Table 14. Industry Category

Industry	ISIC Rev. 4-2digit
Food products, beverages and tobacco	10, 11, 12
Textiles, wearing apparel, leather and related products	13, 14, 15
Wood and products of wood and cork	16
Paper products and printing	17, 18
Chemicals and pharmaceutical products	20, 21
Rubber and plastic products	22
Other non-metallic mineral products	23
Basic metals	24
Fabricated metal products	25
Computer, electronic and optical products	26
Electrical equipment	27
Machinery and equipment, nec	28
Motor vehicles, trailers and semi-trailers	29
Other transport equipment	30
Other manufacturing	31, 32, 33

[47] The original FT database showed the industry codes, which were, converted into ISIC codes. See Valacchi, Doytch and Yonzan (2021) for more details. The FT database has its weaknesses, but it also has an incredible level of detail, with extensive global coverage and a reasonably long time series. For a good evaluation of its pros and cons, see Belderbos *et al.* (2016).

To account for a country-sector's GVC participation, we use the database provided by Belotti, Borin and Mancini (2020)[48]. These data are computed using the methodology discussed in Borin and Mancini (2019). These data are now available in the World Integrated Trade Solution (WITS). The calculated data rely on the 2018 version of ICIO OECD, which spans from 2005 to 2015. Our study utilizes only the GVC participation index to measure international fragmentation in production sharing. Therefore, we consider the manufacturing industries only and exclude agriculture-related industries and services.

[48] We downloaded the data using the Stata command icio.

Table 15. List of Host Countries

	OECD countries		Non-OECD economies
AUS	Australia	ARG	Argentina
AUT	Austria	BRA	Brazil
BEL	Belgium	BRN	Brunei Darussalam
CAN	Canada	BGR	Bulgaria
CHL	Chile	KHM	Cambodia
CZE	Czech Republic	CHN	China (People's Republic of)
DNK	Denmark	COL	Colombia
EST	Estonia	CRI	Costa Rica
FIN	Finland	HRV	Croatia
FRA	France	CYP	Cyprus [2]
DEU	Germany	IND	India
GRC	Greece	IDN	Indonesia
HUN	Hungary	HKG	Hong Kong, China
ISL	Iceland	KAZ	Kazakhstan
IRL	Ireland	MYS	Malaysia
ISR	Israel [1]	MLT	Malta
ITA	Italy	MAR	Morocco
JPN	Japan	PER	Peru
KOR	Korea	PHL	Philippines
LVA	Latvia	ROU	Romania
LTU	Lithuania	RUS	Russian Federation
LUX	Luxembourg	SAU	Saudi Arabia
MEX	Mexico	SGP	Singapore
NLD	Netherlands	ZAF	South Africa
NZL	New Zealand	TWN	Chinese Taipei
NOR	Norway	THA	Thailand
POL	Poland	TUN	Tunisia
PRT	Portugal	VNM	Viet Nam
SVK	Slovak Republic		
SVN	Slovenia		
ESP	Spain		
SWE	Sweden		
CHE	Switzerland		
TUR	Turkey		
GBR	United Kingdom		
USA	United States		

In this study, we use three GVC-related trade indices, namely, GVC participation, GVC backward participation, and GVC forward participation, to indicate the share of total exports by FDI recipient countries. As depicted in Figure 8, total exports consist of two the following main

components: GVC participation and traditional-style trade (i.e., trade that only crosses one border. Here, GVC participation is the sum of GVC backward and GVC forward participation.

The first measure, GVC participation, accounts for value-added that crosses at least two stages of production in different countries. Therefore, it indicates the products that have been re-exported at least once before being absorbed into the final demand.

Borin *et al.* (2019) extended the decomposition of Koopman et al. (2014) by creating a new component, namely, value-added directly absorbed by the importing country without any re-exports or $\mathrm{DAVAX_{sr}}$ (as shown in Figure 8). It captures the "traditional type of trade" across a single border. Thus, this new component captures the value-added generated in a country. This value is directly absorbed by the importing country without any further re-export or treatment at home. This measure cannot be obtained from the decomposition method proposed by Koopman *et al*. (2014) or using similar breakdowns of bilateral exports presented in the literature (e.g., Wang *et al.*, 2018). Therefore, there are two ways to compute GVC participation based on the Borin method. First, GVC participation is the sum of all value-added traded across at least two borders. It consists of domestic double counted ($\mathrm{DDC_{sr}}$), foreign value-added ($\mathrm{FVA_{sr}}$), foreign double counted ($\mathrm{FDC_{sr}}$), indirectly absorbed VAX, and reflection ($\mathrm{REF_{sr}}$). The second approach eliminates products traded using the traditional-style ($\mathrm{DAVAX_{sr}}$) from total exports ($\mathrm{E_{sr}}$). Appendix 3 provides the equations of the mathematical framework, representing the decomposition of bilateral and sectoral gross exports. The details regarding each term are given in Figure 8, and the corresponding equations are provided in Table 23 of Appendix 3.

Secondly, following the framework proposed by Hummels et al. (2001), we measure vertical specialization. Borin *et al.* (2019) prove that the GVC backward participation component

corresponds to the import content of exports. Therefore, the exporting country is shown to be in a later stage of production.

Third, the forward GVC component measures the domestic goods that are not fully absorbed by the importing country. Instead, these products are processed and re-exported. Hence, the exporting country is considered to be in the early stage of production.

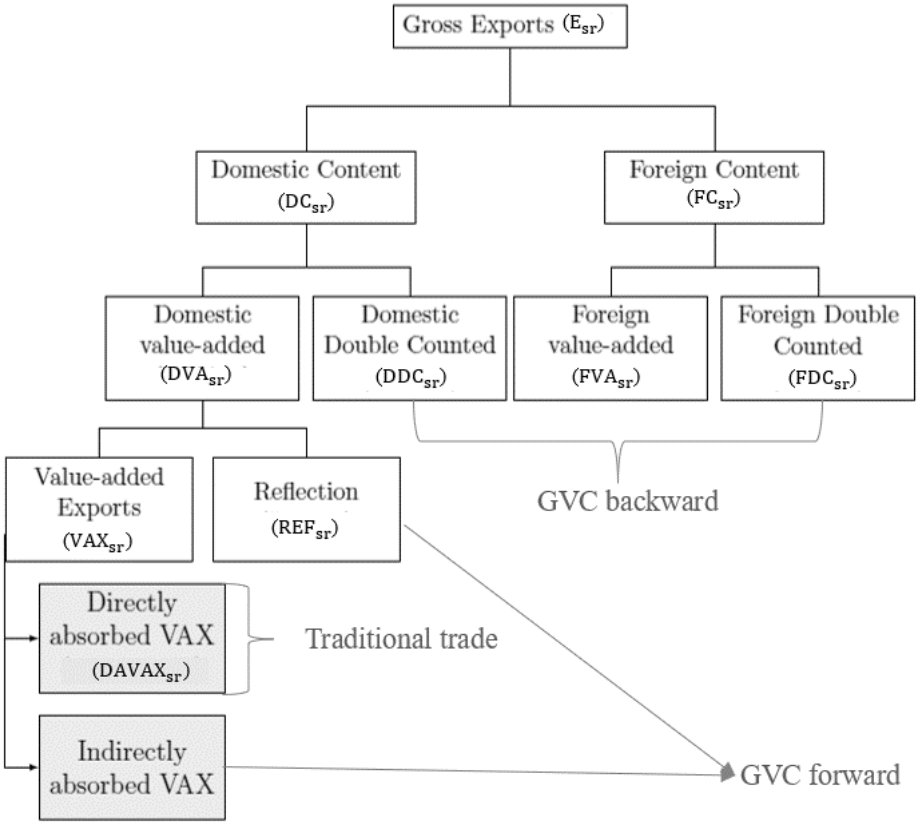

Figure 8. Value-added Decomposition of Total Exports based on Koopman et al (2014), Extended by Borin and Mancini (2019)

Borin et al.'s (2019) method is utilized to accurately capture GVC participation. First, by modifying the inverse Leontief matrix, GVC participation is quantified using a consistent, end-to-end source-based approach. However, studies such as Koopman et al. (2014) and Wang et al. (2018) combine the "sink" and "source" approaches. Furthermore, Borin's allocation approach for

value-added across countries is used to analyze total exports decomposition. Therefore, it differs from the approaches of Koopman et al. (2014) and Wang et al. (2018). Specifically, whereas Koopman et al. (2014) and Wang et al. (2018) define double-counting through a global perspective, defining it as value-added that crosses borders more than once, Borin et al. (2019) use various approaches, including the global, national, and bilateral perspectives (Miroudot and Ming, 2020). Their national perspective approach defines double-counting as value-added that crosses the borders of the exporting country more than once. As we address the research question from a national perspective, more specifically from the perspective of the exporting country receiving FDI, Borin et al.'s (2019) country-perspective approach is more appropriate in our case.

As Borin et al.'s (2019) method uses an ICIO table, similar to other measures, it suffers from the strong assumption that all output within a country-industry is produced using the same input mix (Antràs, 2020). Consequently, this limits the heterogeneity in production and trade.

Figure 9 shows the cumulative distribution of FDI activity and GVC participation by industrial sectors, from 2005 to 2015. "Chemical products" is an important sector for FDI activities and GVC-related trade. "Motor vehicles" is the dominant sector receiving the most FDI, while "rubber and plastic" is one of the most active sectors in GVCs.

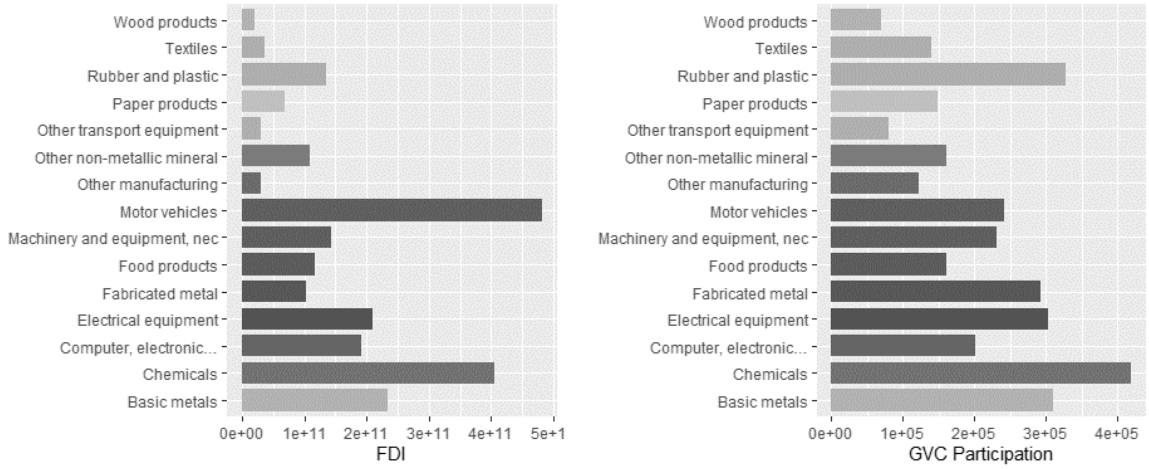

Figure 9. FDI and GVC by Industry, cumulative from 2005-2015

3.3.2. Methodology

Further, we proceed with the methodology. Similar to other studies examining the relationship between FDI and trade, we use a gravity-style model with fixed effects to study the determinants of FDI. There are numerous variations of fixed effects in a gravity model because this framework considers not only time-invariant multilateral resistance terms (MRT) but also time-varying MRTs (Anderson and van Wincoop 2003). Baltagi, Egger and Pfaffermayr (2003), and Baier and Bergstrand (2007) suggested that the structural gravity equation should be estimated using a full set of fixed effects, including bilateral-pair, source country-time, and host country-time fixed effects. This is because they control for all unobserved heterogeneities. Blonigen *et al.* (2020) present an industry-level study using cross-section data. This study comprises the following set of fixed effects: country-pair, source country-by-industry, and host country-by-industry fixed effects. To accommodate for our industry-level analysis using panel data, we include country-pair, sector-specific, and time-specific fixed effects. Additionally, we extend our analysis using multi-dimensional fixed effects, namely, country-industry-time fixed effects.

Given that we use industry-level bilateral FDI data by year, there arises an issue as many pairs of countries do not generate FDI flows in certain years. This is because MNEs may invest for several years. Therefore, zero values are entered for these observations. Santos Silva and Tenreyro (2006) proposed that a gravity equation can be estimated in its multiplicative form using the Poisson Pseudo-Maximum Likelihood (PPML) estimator. This estimator addresses the presence of zero values. Moreover, an OLS would be inconsistent if the error term contains heteroskedasticity, which is especially likely in the case of sectoral data. The PPML estimator overcomes this problem (Lee and Ries (2016); Martínez-Zarzoso *et al.* (2020)). Therefore, our baseline specification for the gravity-style model of FDI uses the PPML estimator as follows:

$$\boldsymbol{GrFDI_{ijkt} = exp[\beta_0 + \beta_1 PartGVC_{jkt-1} + \varphi_{ij} + \delta_{ikt} + \gamma_k + \theta_t] * \varepsilon_{ijkt}} \quad \text{(Eq. 1)}$$

where *k* is the manufacturing industry, *i* denotes FDI source country, *j* denotes the FDI recipient country, and *t* denotes the years between 2005 and 2015. $\boldsymbol{GrFDI_{ijkt}}$ is measured in capital as a share of GDP, for the FDI recipient country *i* and the destination country *j* in industry *k* for year *t*. $\boldsymbol{PartGVC_{jkt-1}}$ measures the engagement degree of the recipient country *j* in industry *k* in the cross-country production network. We lag the GVC variable for one period, to mitigate the likelihood of endogeneity.

Regarding fixed effects, the country-pair fixed effects ($\boldsymbol{\varphi_{ij}}$) control for the time-invariant gravity variables, such as transaction costs for investing, the distance between two countries, whether two countries have a common border, whether the two countries speak a common language, and whether a country is landlocked. Therefore, we do not include these conventional

time-invariant gravity variables in our specification. Moreover, as argued by Baier and Bergstrand (2007), country-pair fixed effects also mitigate endogeneity. The year dummies ($\boldsymbol{\theta_t}$) control for all common shocks to all country pairs and industries, such as changes in world demand, technological change, and oil price shocks. The sector-specific fixed effects ($\boldsymbol{\gamma_k}$) account for global trends varying by sector. The source-country-industry-time fixed effects ($\boldsymbol{\delta_{ikt}}$) control for time-variant changes, such as policy changes, market shocks, and level of GVC participation, in a specific industry in the source country.

Alternatively, we also examine $\boldsymbol{BackGVC_{jk,t-1}}$ and $\boldsymbol{ForGVC_{jk,t-1}}$ given in Equation 2, to measure the effects of country-industry GVC backward and forward participation, respectively. The elasticity of these two variables indicates how a country's position in a GVC, affects investment.

$$\boldsymbol{GrFDI_{ijkt} = exp\left[\begin{matrix}\beta_0 + \beta_1 BackGVC_{jk,t-1} + \beta_2 ForGVC_{jk,t-1} \\ + \varphi_{ij} + \delta_{ikt} + \gamma_k + \theta_t\end{matrix}\right] * \varepsilon_{ijkt}} \quad \text{(Eq. 2)}$$

3.4. Empirical Results

3.4.1. Full Sample

Table 16 presents the PPML results for the full sample. The left-hand side variable indicates FDI in capital as a share of GDP. The main right-hand side variable indicates the GVC participation measure, along with country-pair and source country-industry-year fixed effects, and industry and year dummies (column 1 for Eq.1). Overall, the coefficient of GVC participation is positive and statistically significant above the 1% level of significance. This means that increased trade through GVCs will increase FDI inflows. This result is consistent with those of existing

studies (e.g., Martinez-Gala *et al.* (2019), Carril-Caccia and Pavlova (2020), George *et al.* (2021)) using country-level data.)

In column 2, we present separate results for forward and backward GVC types. The GVC forward participation has greater elasticity than the backward GVC participation. This suggests that a country that is in the earlier stages of production, appears to attract more FDI.

Table 16. PPML Results for Whole Sample

	PPML	
Variable	(1)	(2)
$PartGVC_{jk,t-1}$	0.0506***	
	(0.00984)	
$ForGVC_{jk,t-1}$		0.0952***
		(0.0268)
$BackGVC_{jk,t-1}$		0.0547***
		(0.0116)
Constant	15.35***	14.50***
	(0.607)	(0.894)
Country-Pair FE	Yes	Yes
Source country-Industry-Year FE	Yes	Yes
Industry FE	Yes	Yes
Year FE	Yes	Yes
Observations	54,890	54,890
Pseudo R-squared	1.000	1.000

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

3.4.2. Industry-specific Results

Further, we investigate the effect of GVC as an FDI determinant by industry. We divide the sample into fifteen sub-samples, corresponding to the fifteen industries. For each industry, we apply Equations 1 and 2.

Tables 17 and 18 report the results of the two main equations using the PPML estimator for each of the fifteen industries in our sample. The estimation includes country-pair, year, and

source country-year fixed effects. The results are heterogeneous and vary based on the sector. For the "basic metals," "rubber and plastic," and "other manufacturing" industries, the elasticity of GVC participation is significantly positive. The "other manufacturing" industry demonstrates the largest elasticity. However, the variable for "machinery and equipment" is significantly negative. For other sectors, GVC-related trade does not significantly impact greenfield FDI.

Table 17. PPML Results by Industry

	Food		Textiles		Wood		Paper products		Chemicals		Rubber and Plastic		Other non-metallic mineral		Basic metals	
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
$PartGVC_{jk,t-1}$	0.0141		-0.0309		-0.0602		0.00690		0.0109		0.242*		0.0423		0.0912**	
	(0.0446)		(0.0381)		(0.0857)		(0.0487)		(0.0262)		(0.136)		(0.0447)		(0.0361)	
$ForGVC_{jk,t-1}$		-0.188		-0.198		0.00779		-0.0823		0.0108		0.133		-0.00496		0.107*
		(0.300)		(0.151)		(0.190)		(0.0923)		(0.0258)		(0.316)		(0.0815)		(0.0626)
$BackGVC_{jk,t-1}$		0.00900		-0.0347		-0.0548		0.0101		0.0121		0.224*		0.0453		0.0864**
		(0.0428)		(0.0383)		(0.0848)		(0.0494)		(0.0571)		(0.125)		(0.0454)		(0.0364)
Constant	17.04***	18.21***	-1.492	-0.0873	-0.402	-1.512	-3.930*	-2.589	16.44***	16.38***	2.322	4.612	15.55***	15.78***	10.44***	10.47***
	(1.775)	(2.127)	(1.707)	(2.301)	(3.653)	(4.143)	(2.288)	(2.655)	(1.881)	(3.518)	(8.436)	(8.460)	(2.173)	(2.192)	(2.611)	(2.629)
Country-Pair FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Source Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,493	4,493	2,562	2,562	809	809	2,330	2,330	6,629	6,629	4,937	4,937	3,336	3,336	3,754	3,754
Pseudo R-squared	1.000	1.000	0.4073	0.4077	0.3558	0.3559	0.3169	0.3173	1.0000	1.000	1.0000	1.000	1.0000	1.0000	1.0000	1.0000

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 18. PPML Results by Industry (continued)

	Fabricated metal		Computer, electronic and optical		Electrical equipment		Machinery and equipment		Motor vehicles		Other transport equipment		Other manufacturing	
Variable	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)
$PartGVC_{jk,t-1}$	0.108		0.0149		0.0374		-0.370*		-0.0489		0.110		1.459***	
	(0.177)		(0.0470)		(0.0512)		(0.218)		(0.0601)		(0.0757)		(0.140)	
$ForGVC_{jk,t-1}$		0.0594		0.186		0.175		-2.344***		0.620		-0.315**		-1.645
		(0.203)		(0.120)		(0.186)		(0.799)		(0.625)		(0.150)		(1.057)
$BackGVC_{jk,t-1}$		0.111		0.0426		0.0351		-0.726**		0.00695		0.0823		1.326***
		(0.176)		(0.0447)		(0.0631)		(0.326)		(0.112)		(0.0619)		(0.116)
Constant	10.54	11.00	18.37***	13.31***	16.79***	15.36***	35.81***	66.05***	20.15***	13.34	9.293**	13.30***	-47.41***	-31.57***
	(10.48)	(10.40)	(2.978)	(3.963)	(3.072)	(4.828)	(11.83)	(20.34)	(2.969)	(8.777)	(3.679)	(3.018)	(6.031)	(7.180)
Country-Pair FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Source country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,733	4,733	2,801	2,801	4,736	4,736	4,243	4,243	4,009	4,009	1,149	1,149	2,423	2,423
Pseudo R-squared	1.0000	1.000	1.0000	1.000	1.0000	1.000	1.0000	1.000	1.0000	1.000	1.0000	1.000	1.0000	1.000

*** p<0.01, ** p<0.05, * p<0.1

Regarding the effect of GVC backward and forward participation, the position of the host country in the later and early stages of production is significantly positive in attracting FDI. However, this effect is seen only in the "basic metals" industry, similar to the effect of GVC participation in general. The results for the "machinery and equipment" industry are significantly negative. The elasticity of the GVC backward variable is significantly positive for "rubber and plastic" and "other manufacturing" industries. Although "other transport equipment" shows does not significantly affect overall GVC trade, it shows a significant negative effect when it becomes more integrated into GVCs, as measured by forward linkage.

To explain the negative elasticity of the "machinery and equipment" and "other transport equipment" industries, we may consider the position of the host country in two cases, namely, upstream and downstream specialization. In the case of upstream specialization, the host country is an active participant in fragmented international production, providing the know-how to its foreign subsidiaries. It is also a likely competitor in the same industry in the source country. Therefore, the host country's government may limit the number of greenfield factories in the home country, to reduce foreign competition in the domestic market, and protect its proprietary technology. However, in the case of downstream specialization, the host country heavily relies on import inputs. Repeated imports (i.e., an input that has crossed a border more than once) may increase the price of the final product, which may be subject to import taxes. Hence, the investors' profits are likely to decrease, and the host country may not be considered an attractive destination for MNEs.

Fixed cost characteristics of a specific industry may also contribute to disinvestment. For example, the fixed cost to set up a factory in the host country could be higher than the cost in the source country, or the minimum wage level in the host country may not be relatively cheaper.

Therefore, the parent company may not invest despite the host country having a high level of participation in a GVC.

Table 19. PPML results by regions for the electrical equipment industry

	Whole Sample		**Three-Region Sub-sample** • Europe and Central Asia • East Asia and Pacific • North America		**Two-Region Sub-sample** • Europe and Central Asia • East Asia and Pacific	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
$PartGVC_{jk,t-1}$	0.0374		0.0376		0.0371	
	(0.0512)		(0.0570)		(0.0571)	
$ForGVC_{jk,t-1}$		0.175		0.151		0.150
		(0.186)		(0.171)		(0.171)
$BackGVC_{jk,t-1}$		0.0351		0.0318		0.0313
		(0.0631)		(0.0665)		(0.0664)
Constant	16.79***	15.36***	16.78***	15.79***	16.81***	15.82***
	(3.072)	(4.828)	(3.423)	(4.779)	(3.425)	(4.776)
Country-Pair FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Source country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,736	4,736	3,645	3,645	3,274	3,274

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 20. PPML results by regions for the computer, electronic, and optical industries

	Whole Sample		**Three-Region Sub-sample** • Europe and Central Asia • East Asia and Pacific • North America		**Two-Region Sub-sample** • Europe and Central Asia • East Asia and Pacific	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
$PartGVC_{jk,t-1}$	0.0149		0.00495		0.00480	
	(0.0470)		(0.0555)		(0.0559)	
$ForGVC_{jk,t-1}$		0.186		0.173		0.175
		(0.120)		(0.129)		(0.128)
$BackGVC_{jk,t-1}$		0.0426		0.0340		0.0337
		(0.0447)		(0.0542)		(0.0545)
Constant	18.37***	13.31***	19.00***	13.96***	19.01***	13.94***
	(2.978)	(3.963)	(3.519)	(4.520)	(3.541)	(4.513)
Country-Pair FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Source country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,801	2,801	2,121	2,121	1,872	1,872

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As shown in Tables 19 and 20, the results for the “electronics” and “electrical equipment“ industries are insignificantly positive, even though they are known to operate actively in global production chains. However, the increase in FDI for the electronics industry may depend on various factors other than the level of global production integration of that industry in the host

country. Alternatively, the sample period of 2005–2015, may not adequately capture the effect of this industry, which has been globally active for many decades.

3.4.3. Region-specific Results

In Table 21, we divide the sample by regions of the FDI recipient country. The five main regions include Europe and Central Asia, East Asia and the Pacific, North America, South Asia, and Sub-Saharan Africa. Further, we apply two PPML specifications for each region.

Due to the insufficient number of observations, we find no evidence of a relationship between FDI and GVC in South Asia and Sub-Saharan Africa. This is consistent with the findings of several studies, (Baldwin (2011) and OECD (2014)) suggesting that GVCs are not a global phenomenon but mainly occur in three regions. Specifically, GVC participation is positively associated with greenfield FDI flows in Europe and Central Asia, East Asia and the Pacific, and North America.

Moreover, we tried to combine a three-region sub-sample including the regions of Europe and Central Asia, East Asia, Pacific, and North America. We also considered other subsamples consisting of two among these three regions. Further, we examined each subsample by industry. The results are similar to those in the worldwide data sample, by industry.

Table 21. PPML Results by Regions

	Europe and Central Asia		East Asia and Pacific		North America		Latin America and Caribbean		Middle East and North Africa	
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$PartGVC_{jk,t-1}$	0.0153**		0.0309**		0.0979***		-0.00878		0.0510	
	(0.00718)		(0.0126)		(0.0214)		(0.0155)		(0.0344)	
$ForGVC_{jk,t-1}$		-0.00575		0.0460		0.0622***		0.0590**		0.260***
		(0.0177)		(0.0335)		(0.0232)		(0.0244)		(0.0283)
$BackGVC_{jk,t-1}$		0.0164**		0.0321**		0.160***		-0.0187		0.00807
		(0.00737)		(0.0152)		(0.0304)		(0.0154)		(0.0237)
Constant	-3.867***	-3.615***	16.58***	16.30***	-9.009***	-10.41***	-2.793***	-3.317***	-3.909**	-6.151***
	(0.382)	(0.449)	(0.775)	(1.158)	(0.968)	(1.130)	(0.632)	(0.651)	(1.580)	(0.986)
Source country-Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	22,591	22,591	9,755	9,755	1,214	1,214	3,520	3,520	505	505
	0.3331	0.3333	1.000	1.000	0.2530		0.2785	0.2807	0.3586	0.4121

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.4.4. Robustness Checks

Given that our left-hand side variable ($GrFDI_{ijkt}$) is more narrowly defined than the right-hand side variable ($PartGVC_{jkt-1}$), the reverse causality effect may not be critical. Therefore, the one-period lag of GVC participation variables is considered to satisfactorily address reverse causality. To further rule out strong reverse causality effects, we undertake a PPML estimation by regressing FDI inflows on GVC participation. The results are insignificantly positive.

However, to address other possible sources of endogeneity, such as omitted variables, we re-estimate Equation 1 using a system-GMM estimator. In this estimation, we exclude the zero-valued bilateral FDI observations from our sample. A system-GMM estimator allows us to use lagged levels of endogenous variables as instruments in the equation with first differences, and the lagged differences as instruments for the equation in levels. This estimator is conditional upon the fact that, even if the unobserved country-specific effect is correlated with the regressors' level, it is not correlated with their difference. We then instrument both FDI and GVC with GMM-style instruments. We follow Roodman (2006) to insert them into the instrument matrix in different forms. As the GVC variable is not strictly exogenous, standard treatment with one or more lags is

used. Additionally, the FDI variable is likely to be endogenous which is why standard treatment with two or more lags, is used. Despite this standard treatment being quite powerful, it automatically chooses the number of suitable lags.

Table 22. System-GMM Results for the Whole Sample

	GMM	
VARIABLES	(1)	(2)
$\boldsymbol{lnFDI_{ijk,t-1}}$	0.000414	-0.00322
	(0.0301)	(0.0291)
$\boldsymbol{lnPartGVC_{jk,t}}$	-0.258	
	(1.058)	
$\boldsymbol{lnPartGVC_{jk,t-1}}$	1.324*	
	(0.702)	
$\boldsymbol{lnForGVC_{jk,t}}$		0.0533
		(0.232)
$\boldsymbol{lnBackGVC_{jk,t}}$		0.430**
		(0.183)
$\boldsymbol{lnForGVC_{jk,t-1}}$		-0.182
		(0.236)
$\boldsymbol{lnBackGVC_{jk,t-1}}$		0.381***
		(0.145)
Constant	-2.299	-3.787***
	(2.168)	(1.064)
Observations	5,898	5,898
Host country FE	Yes	Yes
Source country FE	Yes	Yes
Industry FE	Yes	Yes
Year FE	Yes	Yes

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Overall, the GVC participation and GVC backward coefficients are significantly positive, but the results for the GVC forward participation variable are insignificant (Table 22). Furthermore, the AR (1) test rejects the null hypothesis stating that there is no first-order correlation, whereas the AR (2) test cannot reject the second-order correlation among residuals.

The Hansen test cannot reject the validity of the set of instruments. Therefore, all tests are valid for the GMM estimator.

3.5. Conclusion

We contribute to the existing literature by examining the relationship between greenfield FDI and trade, considering GVCs at the sectoral level. To our best knowledge, this correlation has not been previously established. We find that, the higher the level of engagement in a GVC, the higher the amount of greenfield investment toward the host country. Our findings, which rely on disaggregated data at the industry level, are consistent with the results of existing studies based on aggregate country-level data.

We find that backward and forward linkages of GVC participation, are positively associated with inward greenfield FDI. However, this effect is heterogeneous and varies according to the sector and region. Among all sectors, the "basic metals" industry has a strong positive impact in the case of forward and backward linkages. Surprisingly, the electronics industry, despite being one of the most active industries in the global production chain, shows insignificantly positive results.

If the host country is in later stages of production for "basic metals," and "rubber and plastic" industries, policymakers should increase, improve and upgrade related infrastructure and/or introduce newer (de-) regulations that encourage the GVC activity in these sectors. However, such effects may be more pertinent for countries located in Europe and Central Asia, East Asia and Pacific, and North America. These effects are weak for countries located in South Asia and Africa, in our data sample. Additionally, "machinery and equipment" does not seem to be a key sector in GVC-driven FDI policy.

A further investigation using different data sets and methods, such as firm-level data, would complement this study.

Appendix 3. Method of Gross Export Decomposition

$$
\begin{aligned}
E_{sr} = {} & V_s (\mathrm{I} - A_{ss})^{-1} Y_{sr} && \text{(T1)} \\
& + V_s (\mathrm{I} - A_{ss})^{-1} A_{sr} (\mathrm{I} - A_{rr})^{-1} Y_{rr} && \text{(T2)} \\
& + V_s (\mathrm{I} - A_{ss})^{-1} A_{sr} (\mathrm{I} - A_{rr})^{-1} \textstyle\sum_{j \neq r,s}^{G} Y_{rj} && \text{(T3)} \\
& + V_s (\mathrm{I} - A_{ss})^{-1} A_{sr} (\mathrm{I} - A_{rr})^{-1} \textstyle\sum_{j \neq r,s}^{G} A_{rj} \sum_{k}^{G} \sum_{l \neq s}^{G} B_{jk} Y_{kl} && \text{(T4)} \\
& + V_s (\mathrm{I} - A_{ss})^{-1} A_{sr} (\mathrm{I} - A_{rr})^{-1} Y_{rs} && \text{(T5)} \\
& + V_s (\mathrm{I} - A_{ss})^{-1} A_{sr} (\mathrm{I} - A_{rr})^{-1} \textstyle\sum_{j \neq r,s}^{G} A_{rj} \sum_{k}^{G} B_{jk} Y_{ks} && \text{(T6)} \\
& + V_s (\mathrm{I} - A_{ss})^{-1} \textstyle\sum_{j \neq s}^{G} A_{sj} B_{js} E_{sr} && \text{(T7)} \\
& + \textstyle\sum_{t \neq s}^{G} V_t B_{ts}^{g} Y_{sr} && \text{(T8)} \\
& + \textstyle\sum_{t \neq s}^{G} V_t B_{ts}^{g} A_{sr} (\mathrm{I} - A_{rr})^{-1} Y_{rr} && \text{(T9)} \\
& + \textstyle\sum_{t \neq s}^{G} V_t B_{ts}^{g} A_{sr} (\mathrm{I} - A_{rr})^{-1} \sum_{j \neq r,s}^{G} Y_{rj} && \text{(T10)} \\
& + \textstyle\sum_{t \neq s}^{G} V_t B_{ts}^{g} A_{sr} (\mathrm{I} - A_{rr})^{-1} \sum_{j \neq r}^{G} A_{rj} \sum_{k}^{G} \sum_{l}^{G} B_{jk} Y_{kl} && \text{(T11)} \\
& + \textstyle\sum_{t \neq s}^{G} V_t B_{ts}^{g} \sum_{j \neq s}^{G} A_{sj} B_{js} E_{sr} && \text{(T12)}
\end{aligned}
$$

$\mathrm{DAVAX_{sr}}$ = (T1) + (T2); Indirect absorbed VAX = (T3) + (T4); $\mathrm{VAX_{sr}}$ = $\mathrm{DAVAX_{sr}}$ + Indirect absorbed VAX; $\mathrm{REF_{sr}}$ = (T5) + (T6); $\mathrm{DDC_{sr}}$ = (T7); $\mathrm{FVA_{sr}}$ = (T8) + (T9) + (T10) + (T11); $\mathrm{FDC_{sr}}$ = (T12); $\mathrm{DVA_{sr}}$ = $\mathrm{VAX_{sr}}$ + $\mathrm{REF_{sr}}$ + $\mathrm{DDC_{sr}}$ + $\mathrm{FVA_{sr}}$ + $\mathrm{FDC_{sr}}$

Source: Authors' illustration, based on Borin et al. (2019)

$$
\begin{aligned}
E_{sr} = {} & V_s (\mathrm{I} - A_{ss})^{-1} Y_{sr} && \text{(T1)} \\
& + V_s (\mathrm{I} - A_{ss})^{-1} A_{sr} (\mathrm{I} - A_{rr})^{-1} Y_{rr} && \text{(T2)} \\
& + V_s (\mathrm{I} - A_{ss})^{-1} A_{sr} (\mathrm{I} - A_{rr})^{-1} \textstyle\sum_{j \neq r,s}^{G} Y_{rj} && \text{(T3)} \\
& + V_s (\mathrm{I} - A_{ss})^{-1} A_{sr} (\mathrm{I} - A_{rr})^{-1} \textstyle\sum_{j \neq r,s}^{G} A_{rj} \sum_{k}^{G} \sum_{l \neq s}^{G} B_{jk} Y_{kl} && \text{(T4)} \\
& + V_s (\mathrm{I} - A_{ss})^{-1} A_{sr} (\mathrm{I} - A_{rr})^{-1} Y_{rs} && \text{(T5)} \\
& + V_s (\mathrm{I} - A_{ss})^{-1} A_{sr} (\mathrm{I} - A_{rr})^{-1} \textstyle\sum_{j \neq r,s}^{G} A_{rj} \sum_{k}^{G} B_{jk} Y_{ks} && \text{(T6)} \\
& + V_s (\mathrm{I} - A_{ss})^{-1} \textstyle\sum_{j \neq s}^{G} A_{sj} B_{js} E_{sr} && \text{(T7)} \\
& + \textstyle\sum_{t \neq s}^{G} V_t B_{ts}^{g} Y_{sr} && \text{(T8)} \\
& + \textstyle\sum_{t \neq s}^{G} V_t B_{ts}^{g} A_{sr} (\mathrm{I} - A_{rr})^{-1} Y_{rr} && \text{(T9)} \\
& + \textstyle\sum_{t \neq s}^{G} V_t B_{ts}^{g} A_{sr} (\mathrm{I} - A_{rr})^{-1} \sum_{j \neq r,s}^{G} Y_{rj} && \text{(T10)} \\
& + \textstyle\sum_{t \neq s}^{G} V_t B_{ts}^{g} A_{sr} (\mathrm{I} - A_{rr})^{-1} \sum_{j \neq r}^{G} A_{rj} \sum_{k}^{G} \sum_{l}^{G} B_{jk} Y_{kl} && \text{(T11)} \\
& + \textstyle\sum_{t \neq s}^{G} V_t B_{ts}^{g} \sum_{j \neq s}^{G} A_{sj} B_{js} E_{sr} && \text{(T12)}
\end{aligned}
$$

Traditional $\mathrm{trade_{sr}}$ = (T1) + (T2); GVC $\mathrm{forward}_{\mathrm{sr}}$ = (T3) + (T4) + (T5) + (T6); GVC $\mathrm{backward}_{\mathrm{sr}}$ = (T7) + (T8) + (T9) + (T10) + (T11) + (T12); GVC $\mathrm{trade_{sr}}$ = GVC $\mathrm{forward}_{\mathrm{sr}}$ + GVC $\mathrm{backward}_{\mathrm{sr}}$

Source: Authors' illustration, based on Borin et al. (2019)

Table 23: Definition of Decomposition Terms

T1	DVA in final exports directly absorbed by direct importer
T2	DVA in intermediate exports directly absorbed by direct importer
T3	DVA in intermediate exports used by the direct importer to produce final exports for third countries
T4	DVA in intermediate exports used by the direct importer to produce intermediate export for final completion and final absorption of third countries
T5	DVA in intermediate exports used by the direct importer to produce final exports returned home country
T6	DVA in intermediate exports returned home country via intermediate from the direct importer and intermediate and final good from third countries
T7	Double counting in source-based framework as intermediate shipped abroad that re-enter in exports from s to r
T8	FVA in final exports directly absorbed by direct importer
T9	FVA in intermediate exports directly absorbed by direct importer
T10	FVA in intermediate exports used by the direct importer to produce final exports for third countries and home country
T11	FVA in intermediate exports used by the direct importer to infinite produce further for final exports absorbed by home, the importer and third countries
T12	Double counting in source-based framework as intermediate shipped abroad that re-enter in exports from s to r

Source: Authors' illustration, based on Borin, *et al*. (2019)

Appendix 4

Table 24. List of Source Countries

Angola	Egypt	Lithuania	Serbia
Argentina	Estonia	Luxembourg	Singapore
Armenia	Finland	Macedonia FYR	Slovakia
Australia	France	Malaysia	Slovenia
Austria	Germany	Malta	South Africa
Azerbaijan	Greece	Mauritius	South Korea
Bahrain	Guatemala	Mexico	Spain
Barbados	Hong Kong	Monaco	Sri Lanka
Belarus	Hungary	Morocco	Sweden
Belgium	Iceland	Myanmar	Switzerland
Bermuda	India	Netherlands	Syria
Bosnia & Herzegovina	Indonesia	New Zealand	Taiwan
Brazil	Iran	Nigeria	Thailand
Bulgaria	Ireland	Norway	Trinidad & Tobago
Canada	Israel	Oman	Tunisia
Cayman Islands	Italy	Pakistan	Turkey
Chile	Japan	Peru	UAE
China	Jordan	Philippines	Uganda
Colombia	Kazakhstan	Poland	Ukraine
Congo (DRC)	Kenya	Portugal	United Kingdom
Costa Rica	Kuwait	Qatar	United States
Croatia	Kyrgyzstan	Romania	Uruguay
Cyprus	Latvia	Russia	Venezuela
Czech Republic	Lebanon	Samoa	Vietnam
Denmark	Liechtenstein	Saudi Arabia	Zimbabwe
Dominican Republic			
Ecuador			

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