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INTEGRACIÓN EN CADENAS GLOBALES DE VALOR:
EVIDENCIA DEL CASO LATINOAMERICANO Y BRASILEÑO

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Tese apresentada como requisito parcial para a obtenção do grau de Doutor em Economia, pelo Programa de Pós-Graduação em Economia da Escola de Negócios da Pontifícia Universidade Católica do Rio Grande do Sul em regime de cotutela

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UNIVERSIDAD CATÓLICA DEL NORTE

FACULTAD DE ECONOMÍA Y ADMINISTRACIÓN

Departamento de Economía

INTEGRACIÓN EM CADENAS GLOBALES DE VALOR: EVIDENCIA DEL CASO LATINOAMERICANO Y BRASILEÑO

Memoria para optar al grado de Doctor en Economía Aplicada con Mención en Estudios Regionales y al grado de Doutor em Economia do Desenvolvimento.

EDUARDO RODRIGUES SANGUINET

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Antofagasta, Chile

2021

Do “filhote” que dedica este trabalho e o que ele significa ao Senhor Luiz Farias Sanguinet (*in memorian*) e à Dona Maria do Carmo Rodrigues Sanguinet.

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Fim de 2016. Decidi trocar o curso de doutorado – em Desenvolvimento Rural na UFRGS – para voltar à Economia. A PUCRS me aceitou. Passado o primeiro semestre, leio uma nota do jornal da PUCRS sobre uma pesquisa relacionada à integração regional, com a participação do Professor Augusto. Penso que um caminho interessante para este “retorno à economia” é também voltar à pesquisa sobre comércio internacional – tema do meu TCC. Augusto aceita me orientar – sem ter a mínima ideia de quem eu era. Passa mais um semestre, e recebo a notícia de duas aprovações em doutorados no Chile. Crise existencial com doutorados? Talvez. Não posso trocar a PUCRS pelo Chile, concluo. Mas leio que é possível “unir”, e de quebra ainda ter dois títulos de doutorado. Organizo toda a documentação necessária. É janeiro, e as aulas no Chile iniciariam em março de 2018. Era uma quarta-feira à tarde, tenho reunião agendada com o Professor Augusto na PUCRS. “*Professor, aprovei em um curso de doutorado no Chile, gostaria de ir sem deixar a PUCRS. Eles aceitaram fazer um convênio de cotutela*”. Nervoso sem saber a reação, ouço “*Claro, Eduardo! Vai que eu cuido das coisas aqui*”. Obrigado, professor Augusto! Por confiar em mim, por sempre estar disposto a ajudar, por ter investido tempo e atenção durante toda minha formação doutoral.

Primeiro mês de estudos no Chile e preciso de um orientador – que aceite trabalhar em cotutela com um convênio ainda inexistente e outro orientador também desconhecido. Leio os CV, converso com pessoas e encontro um nome ideal – Miguel Atienza. Era uma confraternização de boas-vindas aos novos alunos. Começo a conversar com professora Gianni – que fez seu doutorado na USP. Falamos sobre a experiência dela no Brasil. Aproveito que estou conversando em português e pergunto – “*Como é o Professor Miguel Atienza? Gostaria de pedir a ele que fosse meu orientador. “Muito acessível, vá conversar com ele*”. Conversei, e sem me conhecer aceitou prontamente ser meu orientador. Passou uma semana, descobri que ele e Gianni eram casados. Até hoje não sei se minha pergunta “discreta” a ela teve relação com o aceite dele. De toda forma, obrigado por ter me “aceito” sem nem me conhecer. E obrigado pelo suporte e puxões de orelhas de sempre.

Segundo semestre de 2018, estou no congresso da Sociedad Chilena de Estudios Regionales – SOCHER, em uma sala de apresentações. Uma pessoa pergunta. Ouço um sotaque brasileiro. Vou conversar para ver quem é, penso. Professor Carlos Azzoni. “*Vá passar um período conosco, na USP*”. E passou-me seu cartão. Passou mais um semestre, se aproxima a defesa do projeto de tese. Penso em convidar o professor Azzoni. Talvez nem se lembre de mim. Prontamente aceitou, fez novamente o convite e fui para o NEREUS passar um semestre. Três professores que me deram oportunidades ótimas. Meu sincero muito obrigado!

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RESUMO

Surgiu nas últimas décadas uma nova divisão na organização industrial mundial: as empresas se integram com parceiros comerciais estratégicos e geograficamente dispersos, em estruturas fragmentadas baseadas em cadeias globais de valor (CGV). A análise da CGV tem geralmente focado na organização dos fluxos de intermediários entre países, com pouca atenção aos níveis desiguais de integração entre e dentro dos países. Esta tese analisa a geografia da integração nas CGV e as oportunidades de desenvolvimento na América Latina em três artigos. O primeiro considera a geografia internacional, e avalia econometricamente o papel da política comercial na integração latino-americana nas CGV. Os resultados evidenciam que os acordos bilaterais de comércio incrementam a geografia desigual da integração e reforçam a posição exportadora líquida nas indústrias primárias latino-americanas. O segundo artigo inclui o componente espacial na contabilidade socioambiental e avalia os encadeamentos interregionais das emissões regionais e industriais de CO2 e as compensações da integração em cadeias de valor e do nível de intensidade poluidora das redes de produção desde uma perspectiva multiescalar. Avaliou-se a interação entre as cadeias domésticas e as globais de valor no Brasil a partir da técnica de extração hipotética bilateral. Para cada fluxo de comércio origem-destino, os resultados destacam a concentração de redes poluentes impulsionadas por desigualdades espaciais. A relativa heterogeneidade mostra que os estados brasileiros periféricos são menos poluentes em termos absolutos, em resposta à especialização em atividades de baixo valor agregado. No entanto, as regiões centrais são relativamente menos poluentes em termos de integração nas cadeias de valor subnacionais e internacionais. O terceiro e último artigo discute a exposição regional às cadeias de valor como resultado de choques exógenos. Simularam-se restrições parciais no consumo intermediário e na demanda final inter-regional associadas às políticas de mitigação da disseminação da COVID-19 no Brasil. Os resultados indicam que as áreas periféricas são duplamente afetadas, pois dependem da demanda das áreas centrais da rede de produção doméstica, e da demanda externa de base exportadora. Por fim, torna-se relevante para a política regional considerar o papel das cadeias de valor a diferentes escalas espaciais para minimizar os efeitos negativos e promover a convergência. Conclui-se que as interdependências espaciais são relevantes para impulsionar estratégias focalizadas de desenvolvimento regional baseadas nas vocações territoriais.

Palavras-chave: Integração Regional. Cadeias Globais de Valor. América Latina. Geografía Desigual.

RESUMEN

En las últimas décadas, ha surgido una nueva división en la organización industrial global: las empresas se integran con socios comerciales estratégicos y geográficamente dispersos, basados en estructuras fragmentadas en cadenas de valor globales (CGV). El análisis de CGV se ha centrado en general en organizar los flujos de intermediarios entre países, prestando poca atención a los niveles desiguales de integración entre países y dentro de ellos. Esta tesis analiza la geografía de la integración en las CGV y las oportunidades de desarrollo en América Latina en tres artículos. El primero considera la geografía internacional y evalúa econométricamente el papel de la política comercial en la integración latinoamericana en CGV. Los resultados muestran que los acuerdos comerciales bilaterales aumentan la geografía desigual de la integración y refuerzan la posición exportadora neta de las industrias primarias en los países latinoamericanos. El segundo artículo incluye el componente espacial en la contabilidad socioambiental y evalúa las cadenas interregionales de emisiones de CO2 a nivel de región e industrias y las compensaciones de la integración en las cadenas productivas y la intensidad de contaminación de las redes de producción desde una perspectiva multiescalar. La interacción entre las cadenas de valor domésticas y globales en Brasil se evaluó utilizando la técnica de extracción hipotética bilateral. Para cada flujo de comercio origen-destino, los resultados resaltan la concentración de redes contaminantes impulsadas por desigualdades espaciales. La relativa heterogeneidad muestra que los estados brasileños periféricos son menos contaminantes en términos absolutos, en respuesta a la especialización en actividades de bajo valor agregado. Sin embargo, las regiones centrales son relativamente menos contaminantes en términos de integración en cadenas de valor subnacionales e internacionales. El tercero y último artículo analiza la exposición regional a cadenas de valor como resultado de shocks exógenos. Se simularon restricciones parciales al consumo intermedio y la demanda final interregional, asociadas a las políticas de mitigación para la propagación de COVID-19 en Brasil. Los resultados indican que las áreas periféricas se ven doblemente afectadas, ya que dependen de la demanda de las áreas centrales de la red productiva nacional y de la demanda externa de una base exportadora. Finalmente, es relevante para la política regional considerar el papel de las cadenas de valor en diferentes escalas espaciales para minimizar los efectos negativos y promover la convergencia. Concluimos que las interdependencias espaciales son relevantes para promover estrategias de desarrollo regional focalizadas basadas en vocaciones territoriales.

Palabras-clave: Integración Regional. Cadenas Globales de Valor. América Latina. Geografia Desigual.

ABSTRACT

In the last few decades, a new global division of industrial organization has emerged: companies are integrated with strategic and geographically dispersed business partners, based on fragmented structures in global value chains (GVC). GVC's analysis has generally focused on intermediates flows between countries, with little attention to uneven levels of integration between and within countries. This thesis analyzes the geography of integration in GVC and the development opportunities in Latin America in three articles. The first considers the international geography, and econometrically assesses the role of trade policy in Latin American on the GVC participation. The results show that bilateral trade agreements increase the uneven geography of integration and reinforce the net export position of primary industries in Latin American countries. The second article includes the spatial component in socio-environmental accounting and assesses the interregional chaining of CO2 emissions at regional and industrial level, as well as the trade-offs of integration in value chains and the intensity of pollution networks from a multiscalar perspective. The interaction between domestic (DVC) and global value chains (GVC) in Brazil was evaluated using the hypothetical extraction method at bilateral level. For each flow of origin-destination trade, the results highlight the concentration of polluting networks driven by spatial inequalities. The relative heterogeneity shows that the peripheral Brazilian states are less polluting in absolute terms, in response to specialization in activities with low added value. However, central regions are relatively less polluting in terms of integration into subnational and international value chains. The third and last article discusses regional exposure to value chains as a result of exogenous shocks. Partial restrictions on intermediate consumption and interregional final demand were simulated, associated with the mitigation policies for the spread of COVID-19 in Brazil. The results indicate that the peripheral areas are doubly affected, as they depend on the demand of the core areas of the domestic production network, and on the foreign demand of an export base. Finally, it is relevant for regional policy to consider the role of value chains at different spatial scales to minimize negative effects and promote convergence. We conclude that spatial interdependencies are relevant to promote focused regional development strategies based on territorial vocations.

Keywords: Regional integration. Global Value Chains. Latin America. Uneven Geography.

LISTA DE FIGURAS

LISTA DE QUADROS

LISTA DE ABREVIATURAS E SIGLAS

CGV	Cadenas Globales de Valor
CU	Custom Union
DVA	Domestic Value-Added
DVC	Domestic Value Chains
DVX	Indirect Value-Added
EIA	Economic Integration Agreement
EMN	Empresas multinacionales
FTA	Free Trade Agreement
FVA	Foreign Value-Added
GLM	Generalized Linear Models
GPN	Global Production Networks
GVC	Global Value Chain
HEM	Hypothetical Extraction Method
I+D	Investigación y Desarrollo
LA	Latin America
LEF	Linear Exponential Family
LVA	Locked Value-Added
OLS	Ordinary Least Squares
PPML	Pseudo Poisson Maximum Likelihood
PS	Partial Scope
R&D	Research & Development
RTA	Regional Trade Agreements
TIVA	Trade in value-added
VA	Valor Agregado

SUMÁRIO

1 INTRODUCCIÓN[1]

La liberalización comercial ha cambiado fundamentalmente la distribución espacial de la producción. Una cadena de valor involucra a la geografía de las empresas y agentes económicos en la producción de un bien o servicio, desde su concepción hasta el consumo final. La discusión sobre las cadenas globales de valor (CGV) fue iniciada por Gereffi (1994)[2] y aborda la desigualdad de la dispersión espacial de la fragmentación productiva. El debate de las CGV se presenta como una herramienta analítica: el enfoque GVC (*Global Value Chain – GVC approach*). En general, este enfoque evalúa la participación de industrias y productos a lo largo de la cadena de valor en base a cuatro dimensiones analíticas: (1) una estructura de insumo-producto, que describe el proceso de transformación de la materia prima en productos finales; (2) la consideración geográfica; (3) la estructura de gobernanza, que explica el control de la cadena de valor; y (4) un contexto institucional en el que se inserta la cadena de valor de la industria (GEREFFI; FERNANDEZ-STARK, 2011, p. 4).

La división espacial de la producción supone la existencia de grados de interdependencia entre la economía subnacional y la conectividad a los mercados externos. Una de las consecuencias de ese proceso, es la geografía desigual de la organización industrial, que ha implicado en la ubicación de determinadas etapas de la producción en países con niveles de desarrollo distintos – por lo general, determinados por diferenciales de costos que conectan compradores y vendedores en todo el mundo (COE; YEUNG, 2015; DICKEN, 2015; GEREFFI, 2018). Este documento cuestiona el potencial de desarrollo apuntado por la literatura de CGV, apuntándose la necesidad de tenerse una mirada espacial más clara. Si argumenta que la distribución espacial de los activos territoriales (estructura industrial, infraestructura, habilidades en el mercado laboral, disponibilidad de recursos naturales, economías de aglomeración, centros de investigación, etc. (Atienza et al., 2020)) es un elemento relevante para comprender el rol

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[1] El Convenio de Co-tutela doctoral indica que el idioma de esta tesis es el castellano. Por ende, la introducción y las conclusiones están en este idioma, siguiendo las normas de la Associação Brasileira de Normas Técnicas (ABNT). Los artículos enviados a revistas científicas están en inglés.

2 El estudio original explica el proceso de industrialización en regiones en desarrollo – América Latina y Asia, con el modelamiento de los tipos de vínculos que conectan las unidades económicas (empresas) a los mercados mundiales. Los productores de los países en desarrollo acceden mayoritariamente a esos mercados indirectamente, al convertirse en proveedores de empresas más grandes, a menudo extranjeras.

de la integración en CGV en el desarrollo regional en distintas dimensiones, sean ellas económicas, sociales o ambientales.

Un punto clave de cuestionamiento es la relación entre desarrollo regional e integración sostenible en las CGV. El debate sobre CGV ha ganado espacio en muchas organizaciones internacionales y en la literatura económica, siendo apuntado como un patrón estructural de largo plazo de la economía global (ELMS; LOW, 2013; ANTRÀS, 2020). Además, la idea de integración en diferentes etapas de la producción fragmentada es apuntada como una estrategia para lograr oportunidades de impulso al desarrollo económico (KUMMRITZ et al., 2016; LEE; SZAPIRO; MAO, 2018; TAGLIONI; WINKLER, 2016). El concepto de *upgrading*[3], entendido como el potencial de transición de los patrones de especialización incluyendo el conjunto de estrategias para calificar los vínculos y la posición de las empresas o países en la economía global, es apuntado como el camino hacia el desarrollo (GEREFFI, 2019; GEREFFI; FERNANDEZ-STARK, 2011).

Esta tesis busca comprender las dimensiones de la geografía subnacional del enfoque CGV, evidenciando la heterogeneidad espacial de las oportunidades de desarrollo. La fragmentación de la producción opera a nivel regional, con implicaciones que difieren de las evidencias puramente nacionales (nivel país). La discusión de la geografía subnacional de los flujos de valor agregado (VA) incluye el conjunto de preferencias de ubicación para la producción (HADDAD; ARAÚJO, 2020), que depende de la distribución espacial de los activos regionales, las capacidades territoriales, la disponibilidad de recursos naturales, etc. – lo que implica en roles diferenciados a nivel de escala geográfica y en la naturaleza de la integración. Como consecuencia, es necesario avanzar en la comprensión de los patrones espaciales de conectividad, de la intensidad y calidad del contenido local creado y transferido a las cadenas de valor, al grado de responsabilidad ambiental y de exposición regional frente a las CGV. En esa línea de investigación, es posible construir un marco analítico más claro cuanto al potencial de desarrollo sostenible de la conectividad espacial hacia las redes de producción.

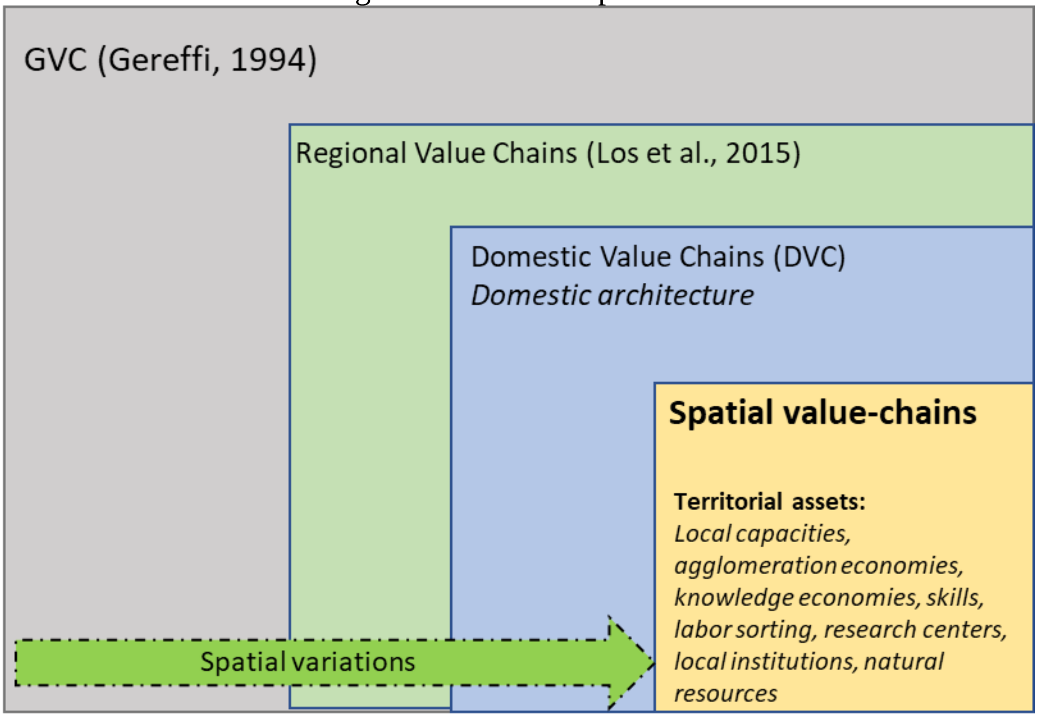
1.1 PROBLEMA DE INVESTIGACIÓN

[3] La noción, aunque amplia, está orientada a construir competencias (capacidades) que puedan “mejorar” productos y procesos productivos, con el fin de permitir que empresas y países aumenten el valor y contribuyan a etapas más avanzadas en la cadena de producción fragmentada (GERREFI, 2019).

Las variaciones en las escalas espaciales de integración en CGV dependen de las capacidades territoriales instaladas, que implican en oportunidades de desarrollo heterogéneas en el espacio. La Figura 1 plantea tres diferentes escalas espaciales genéricas que apuntan a diferentes enfoques analíticos para evaluar el potencial de impulso hacia al desarrollo y el *Upgrading* en las CGV. Globalmente, la evidencia sugiere una desigualdad en el proceso de participación en las CGV (CADESTIN; GOURDON; KOWALSKI, 2016a; DE BACKER; DE LOMBAERDE; IAPADRE, 2018; LOS; TIMMER; DE VRIES, 2015): (1) en países especializados en etapas de bajo VA, con énfasis en el "sur global" que cumple por lo general las funciones de abastecimiento de materias primas (recursos naturales); (2) en los bloques regionales que se especializan en funciones de alto valor (servicios empresariales, diseño de productos, industrias de I+D, etc.) – donde están, por ejemplo, los centros económicos europeos, asiáticos y norteamericanos (LOS; TIMMER; DE VRIES, 2015).

La división espacial de la organización industrial genera transacciones jerárquicas de empresas líderes y multinacionales (EMN) en los diferentes mercados proveedores y consumidores alrededor del mundo. Más allá del hecho estilizado de la fragmentación geográfica global, donde están nodos centrales de las CGV (como, por ejemplo, América del Norte y Europa), o los centros de montaje en Asia, y los proveedores de materias primas en América Latina (COE; YEUNG, 2015; GEREFFI, 2018), es importante comprender la multidimensionalidad del *Upgrading* y de las diferencias existentes en las diferentes escalas geográficas de integración. La desigualdad de las cadenas de valor opera en nivel subnacional, siendo particularmente relevante explorar el grado de exposición de las regiones, y el potencial para generar desarrollo – economico, social y/o ambiental. La desigualdad global de la integración también opera a nivel subnacional, en que las áreas centrales y responsables por la mayor parte del VA creado y transferido a las redes globales en un país tienen dos roles principales: (1) coordinación de la participación nacional en las CGV – conectividad del país a los mercados globales –, y (2) gestión de las cadenas de valor domésticas (dentro de un país) – conectividad de los centros a las periferias.

Figura 1 – Escalas espaciales.



Fuente: Elaboración propia, 2020.

La evidencia empírica indica que la participación latinoamericana en las CGV está por debajo de su potencial en comparación a otras regiones en desarrollo, con vínculos intrarregionales son más débiles (BLYDE, 2014; CADESTIN; GOURDON; KOWALSKI, 2016a; CECCHINI; FILGUEIRA; ROBLES, 2014; OCDE, 2013; RODRÍGUEZ; RODRIK; RODRIGUEZ, 2000). La contribución latinoamericana a las CGV se da en las etapas iniciales, con pocas excepciones en términos del contenido de intensidad tecnológica en el comercio (TSEKERIS, 2017; YAMANO; GUILHOTO, 2018). México y Costa Rica, por ejemplo, se especializan en el procesamiento y exportación de insumos y están bien integrados con las cadenas de suministro de América del Norte, mientras que Chile y Perú están especializados en insumos agrícolas y mineros cada vez más orientados hacia los mercados asiáticos. Brasil tiene un alto nivel de contenido domestico incorporado a las exportaciones, impulsado por la demanda china y europea (PEROBELLI et al., 2019). La importación para procesamiento y reexportación es menos frecuente en Chile, Argentina, Brasil y Colombia. Estos países se especializan en el suministro de insumos globales basados en *commodities*, que posteriormente son procesados o consumidos en el exterior, principalmente en Europa y Asia. En LA, los principales vínculos con GVC se encuentran en México y Chile (con América del Norte) y Brasil (Asia y Europa). México y Brasil tienen una estructura manufacturera importante, pero la escala de diversificación en las CGV es menor.

En base a esas características estructurales, la participación de América Latina y de Brasil en las CGV abre espacio interesante para la inclusión del componente espacial en el análisis del potencial hacia el desarrollo a diferentes escalas geográficas y dimensiones analíticas. Un aspecto crítico de la literatura sobre CGV también es anclado en la geografía económica y está relacionado con las redes de producción global (RPG), discutiendo el desarrollo regional desigual (BAIR et al., 2005). Las RPG dan atención a los actores económicos y no-económicos en el análisis de la integración de los territorios hacia las redes globales (COE et al., 2010), con interesantes evidencias cualitativas.

Esta tesis parte de la crítica a la mirada nacional de las estructuras de las CGV, y a las limitaciones de generalización analítica de los aportes de las RPG[4], para avanzar en la incorporación de la geografía de la integración y la interacción entre escalas geográficas y dimensiones en el marco conceptual y analítico de las CGV. Se propone contribuir teórica y empíricamente a medida que se evidencia el rol del espacio en el análisis de la descomposición del valor agregado (VA) – principal indicador de integración productiva en las CGV – brindando elementos medibles para el campo de la ciencia regional y de las CGV. En particular, se analiza la geografía de la integración y el potencial de desarrollo basado en la integración en CGV, analizando tres aspectos: (1) la relación entre la política comercial y la participación de los países latinoamericanos en CGV; (2) patrones de conectividad multiescalar, analizando el potencial contaminante de las cadenas de valor domésticas y su interacción con las cadenas de valor globales; y (3) el grado de exposición y dependencia multiescalar de las regiones integradas en cadenas de valor, considerando la presencia de choques exógenos de oferta y demanda.

Un punto clave de la argumentación es que las vocaciones territoriales son diferenciadas, y la geografía de los recursos naturales juega un rol importante, principalmente en grandes economías – que tienen capacidad de crear redes domésticas (subnacionales) de producción con grados de responsabilidad ambiental y tecnológica variados. Los activos regionales – densidad de mercados laborales, complejidad industrial, conocimiento e investigación, habilidades, recursos naturales, etc. – están distribuidos espacialmente y los sistemas de producción e innovación regionalmente

[4] Interesantes contribuciones son hechas en estudios de caso, con carácter puramente local y ni siempre generalizable en un marco analítico más amplio, como es el caso de las CGV (FOLD, 2014).

desiguales (DIETZENBACHER; GUILHOTO; IMORI, 2015; VISENTIN; GUILHOTO, 2019). Esa heterogeneidad hace con la calidad del VA creado y transferido a las CGV sea también desigual – por ejemplo, es posible que un país se integre en cadenas intensas en tecnología y conocimiento, o en cadenas intensas en contaminación. En ambos los casos, la literatura teórica carece de mecanismos explicativos concretos sobre la incorporación de los recursos territoriales incorporados a las diferentes redes de producción (DEDRICK, KRAEMER; LINDEN, 2010; STURGEON, VAN BIESEBROECK; GEREFFI, 2008; BALDWIN; VENABLES, 2013b; LOS; TIMMER; DE VRIES, 2015). La identificación de esos patrones es relevante para el debate de desarrollo e integración productiva.

Desde el punto de vista teórico, se asume que la ubicación de proveedores, de las empresas líderes y de los consumidores depende de la especialización industrial y tecnológica en un contexto de fragmentación productiva (KANO; TSANG; YEUNG, 2020). Esas preferencias de localización dependen de las vocaciones territoriales (ATIENZA et al., 2020), siendo aún más evidente en economías de grandes áreas y especializadas en las exportaciones de materias-primas – que generan encadenamientos productivos y grados de conectividad productiva doméstica y externa espacialmente diversas. De hecho, diferentes territorios pueden desarrollar diferentes funciones (etapas) en las cadenas de valor, ya sean nacionales (subnacionales) o internacionales (globales), con implicaciones relevantes para la sostenibilidad económica y ambiental del perfil de integración productiva regional.

En base a esas variaciones, esta tesis cuestiona la relación entre la geografía de la integración en las CGV y el potencial para generar desarrollo regional sostenible. Para eso, se toman como dos líneas de investigación asumiendo diferentes escalas geográficas: (1) los países de la América Latina y (2) las regiones subnacionales de Brasil.

1. La primera línea cuestiona el rol de la política comercial en generar oportunidades de desarrollo y *Upgrading* en la región latinoamericana. Las evidencias del campo de la economía internacional indican una relación positiva entre la política comercial y las ganancias de las CGV (ANTRÀS et al., 2013; BICKWIT; ORNELAS; TURNER, 2018). Si bien en bloques regionales como Asia, Unión Europea y América del Norte esta relación es más clara, en América Latina (AL) este patrón es más difuso. Aparentemente, la estrategia de política comercial asociada con socios extrarregionales no se ha traducido en avances en *Upgrading*

en AL (BOFFA; JANSEN; SOLLEDER, 2019; CADESTIN; GOURDON; KOWALSKI, 2016a; SUDER et al., 2015). Desde la década de 1960, los esfuerzos de integración regional de AL han consolidado una compleja red de acuerdos comerciales, tanto bilaterales como multilaterales (CHOI, 2019). Sin embargo, el continente está atascado con industrias de baja tecnología, poca diversificación y como proveedor global de materias primas. En este sentido, es relevante comprender la geografía desigual de las ganancias de las CGV asociadas a las políticas comerciales en AL.

2. La segunda línea de investigación analiza los roles heterogéneos en la organización espacial de la producción. Estos roles son aún más evidentes en países con grandes áreas y con históricas desiguales regionales – sean en términos estructurales, en los sistemas regionales de innovación o mismo en la disponibilidad de recursos naturales – como es el caso de Brasil (AZZONI; HADDAD, 2018). Aspectos como el tamaño del país (población, superficie, PIB), la diversidad de recursos naturales puede convertirse en un instrumento de desarrollo e integración nacional y regional hacia capacidades locales de integración en redes más complejas (SILVEIRA-NETO; AZZONI, 2011). La forma en que se integran las economías regionales con una calidad heterogénea de cadenas. Esta desigualdad es analizada en dos dimensiones – económica y ambiental – que interactúan a nivel nacional e internacional de maneras distintas. Con esto, se apunta a la necesidad de una mirada multiescalar y multidimensional para construir estrategias de integración productiva asociadas a la responsabilidad económica, social y ambiental (GUILHOTO; SIROËN; YÜCER, 2015; IMORI, 2015; LEE; SZAPIRO; MAO, 2018; STURGEON, 2016).

En definitiva, la inclusión del espacio abre posibilidades para un abordaje teórico multiescalar de las CGV, a través del mapeo de las interacciones entre las cadenas domésticas (interregionales) con las globales (a través del VA incorporado en las exportaciones). Estas interacciones generan calidades en la integración variadas, siendo relevante comprender cómo las regiones generan encadenamientos y cómo eso puede convertirse en desarrollo. Se discuten: (a) la relación teórica entre la economía regional y los mercados globales, en la que se asume que la fragmentación de la producción conduce a efectos de política comercial a nivel regional diferentes a los del nivel nacional (BEUGELSDIJK; MCCANN; MUDAMBI, 2010; LOS; TIMMER; DE VRIES, 2015; MCCANN; MUDAMBI, 2005); (b) la intensidad de la contaminación de la interacción entre cadenas subnacionales y globales, a través del rastreo de los flujos de VA – los efectos sobre la demanda de recursos naturales imponen grados de responsabilidad ambiental y contaminante heterogéneas (BEUGELSDIJK; MCCANN; MUDAMBI, 2010; IMORI, 2015; LOS; TIMMER; DE VRIES, 2015; MCCANN; MUDAMBI, 2005; MUDAMBI; PUCK, 2016); y, (c) análisis del grado de exposición regional en la integración a diferentes escalas geográficas en la presencia de shocks exógenos de oferta y demanda.

En estas líneas de investigación se espera aportar al campo teórico y empírico, en base a la descomposición del VA de las regiones y en el análisis de sus implicaciones para el campo de las políticas de desarrollo regional sostenible (LOS; TIMMER; DE VRIES, 2015; MUDAMBI; PUCK, 2016). El enfoque de las CGV se incluye a menudo en un marco de interpretación estrecho con respecto a la inclusión de variables subnacionales para determinar la posición de los países en la gobernanza de los flujos de VA.

1.2 LAS ESCALAS GEOGRÁFICAS DE INTEGRACIÓN

El debate original sobre las CGV se centró en explicar el proceso de desarrollo desigual basado en la especialización de los países en funciones o etapas de la producción global (GEREFFI, 1994). Una estrategia de desarrollo implica la creación de ventajas comparativas para incorporar más valor agregado al comercio (BALDWIN, 2011). Este enfoque ignora las características subnacionales como explicación de la posición de los países en los flujos de valor agregado (FOLD, 2014). Hay poca evidencia en la literatura de las CGV a diferentes escalas (STURGEON, 2016; IMORI, 2015; BALDWIN; VENABLES, 2013; LOS, TIMMER; DE VRIES, 2015). Las estrategias de las empresas multinacionales incluyeron la decisión de ubicar, los flujos intraindustriales y el comercio de productos intermedios (MARKUSEN, 1989). La ventaja de ubicación de las empresas multinacionales también puede aparecer a escala subnacional (MUDAMBI; PICK, 2016). Así, para discutir aspectos de las disparidades regionales dentro de un país e integrarlos con el comercio entre países, es necesario incorporar los determinantes de la heterogeneidad espacial de las EMN: costos espaciales y diferenciales de capacidad local (BEUGELSDIJK, MCCANN; MUDAMBI, 2010; IAMMARINO; MCCANN, 2013; MCCANN, 2008).

La estrategia de las empresas líderes para convertirse en redes de innovación transnacionales aumenta la necesidad de incorporar la interdependencia de múltiples escalas en el análisis de las CGV (ATIENZA; LUFIN; SOTO, 2018). Como resultado, existen bases desiguales de conocimiento, tecnología, innovación y recursos naturales en el espacio. La coordinación subnacional de las cadenas de valor se basa en activos espacialmente especializados (SCHOTTER et al., 2017). Las ventajas de la innovación local dependen de los recursos locales y de sus conexiones globales, de modo que la dispersión espacial de los encadenamientos productivos depende de la complejidad de las cadenas nacionales y globales. Las preferencias y decisiones de ubicación estratégica en términos de acceso al conocimiento, mercados, mano de obra y recursos naturales, tienen implicaciones para la organización espacial de la producción, sobre el desarrollo y al grado de responsabilidad ambiental de las regiones.

De hecho, la distribución geográfica de los activos territoriales es un elemento analítico relevante, pues genera funciones y roles distintos de las regiones en las cadenas de valor, así como en la calidad de la conectividad a las redes de producción. La interdependencia de la integración en las CGV y la economía regional hace con las relaciones de oferta y demanda de VA tengan contenidos locales implícitamente transferidos en el espacio, así como la forma como los territoriales presentan ganancias hacia el desarrollo a partir de los encadenamientos. A nivel subnacional, una respuesta al aumento de los costos de transacción espacial para actividades de bienes y servicios de alto valor (MCCANN, 2008; MUDAMBI & PUCK, 2016) y las capacidades de innovación y bases de conocimiento son localmente arraigadas (MARKUSEN, 1996).

1.3 MEDICIÓN DE LA INTEGRACIÓN

En el enfoque CGV, la integración se mide mediante tablas de insumo-producto nacionales (recursos y usos) y en matrices globales. Los modelos empíricos de comercio miden la inserción de un país en los movimientos de fragmentación, a través de su contribución a redes de producción específicas y su posición dentro de la CGV. Esta medida considera el valor agregado (VA) que una industria (o producto) de un país (región) incorpora a la cadena productiva. La definición de medida de VA es "*valor que agrega un país en la producción de un producto o servicio, que se incorpora a productos intermedios y/o finales y, posteriormente, se exporta*" (MONTALBANO; NENCI, 2014). La idea principal es que la suma de los VA por todas las industrias, directa o indirectamente, sea lo necesario para producir. Koopman et al. (2014) lo caracteriza como *un sistema de fuentes y destinos de valor agregado dentro de una red de producción globalmente integrada* (KOOPMAN; WANG; SHANG-JIN, 2014; KOOPMAN; WANG; WEI, 2011).

El análisis de CGV considera la generación y transferencia de valor dentro del sistema económico como consecuencia de los esfuerzos para optimizar las redes de producción y, a la inversa, el mecanismo de cómo la estructura de distribución del valor afecta la elección de la forma de organización de la empresa como una red global. Algunos conceptos son esenciales para la adecuada discusión teórica, como de desagregación tecnológica (movilidad y reubicación de actividades), integración vertical[5] y gobernanza. Este último determina la forma en que se realizan las transacciones, refleja la estructura de las relaciones de poder entre las partes, que incluyen las empresas líderes y sus proveedores, lo que finalmente determina el alcance y la magnitud de las distribuciones de valores en las transacciones entre empresas clientes y proveedoras (GEREFFI; HUMPHREY; STURGEON, 2005a).

La lógica del VA mide los ingresos generados (valor agregado) por cada país (región) en un paso de producción, con base en el análisis del valor de las exportaciones (ventas) de productos intermedios (insumos, partes, componentes) o por el valor de los factores producción (capital y trabajo) agregada a lo largo del proceso de producción. Esta medida se puede extender midiendo el comercio de valor agregado (*trade in value-added – TiVA*) de las unidades espaciales subnacionales consumidas dentro del país o en todo el mundo. Los estudios desarrollados en esta tesis operan el concepto de TiVA como una extensión de la tercera generación de estadísticas comerciales desde la dimensión subnacional (HADDAD; MENGOUB; VALE, 2020; TIMMER; MIROUDOT; DE VRIES, 2019). Los procesos de fragmentación están fundamentalmente interconectados, y las tendencias en la renta regional se han vuelto más dependientes en la medida en que las regiones subnacionales pueden contribuir a las cadenas productivas, sean domésticas

[5] La literatura en CGV enfatiza este tipo de integración a menudo de la división de la producción entre países. Sin embargo, hay otros tipos de integración productiva, como presenta Parr (2002).

o globales (BEUGELSDIJK; MCCANN; MUDAMBI, 2010; LOS; TIMMER; DE VRIES, 2015; MUDAMBI; PUCK, 2016).

La extensión de la medición del VA a diferentes escalas geográficas se estima por la relación entre origen y destino del TiVA (BALDWIN; TAGLIONI, 2011a). Montalbano, Nenci & Pietrobelli (2016) mencionan algunos conceptos fundamentales[6]: (1) *Valor agregado nacional (DVA):* Medida del valor agregado de la región a sus exportaciones de bienes y servicios. No indica vínculos o comercio de VA con otras regiones; (2) *Valor agregado extranjero (FVA):* Medida del valor agregado extranjero (originado en una otra región) incorporado a las exportaciones brutas. Es el valor agregado de otras regiones e incorporadas en productos finales o intermediarios a las exportaciones brutas. Es un indicador de integración hacia atrás en una cadena de valor, y (3) *Valor agregado indirecto (DVX):* Medida de participación de las exportaciones de valor agregado originario de una región e incorporadas como insumos intermediarios en otras. Es un indicador de integración hacia adelante en una cadena de valor.[7]

La aplicación de técnicas de insumo-producto para analizar el contenido regional transferido a largo de las redes de productivas es flexible, y permite incorporar elementos de variadas naturalezas[8]. De hecho, en el segundo artículo se avanza en la incorporación del grado de intensidad contaminante de las cadenas de valor en dos escalas espaciales – interregionales y globales. En ese sentido, el uso de modelos económicos ambientalmente integrados es ampliamente aceptado en la literatura, sin embargo, la evidencia encontrada es de carácter nacional, con poca evidencia de los efectos potenciales en territorios subnacionales (PETERS et al., 2011; IMORI, 2015). La economía regional apunta al comportamiento de la empresa como un elemento explicativo de la ubicación, sin embargo, la asociación teórica entre jerarquías espaciales y aspectos ambientales es aún incipiente. La unidad de análisis subnacional permite avanzar e incorporar interdependencias a lo largo de la cadena de valor, incluidos los aspectos territoriales y

[6] Otros estudios, como Meng et al. (2017) utilizan conceptos de: valor agregado interno indirecto incluido en las exportaciones intermedias (IVA), que refleja la contribución indirecta de las industrias proveedoras nacionales de bienes o servicios intermedios utilizados en las exportaciones de otros países (es decir, el valor agregado exportado en productos intermedios reexportados a terceros países) y de valor agregado nacional reimportado incorporado en las exportaciones brutas, que refleja él VA nacional que se exportó en bienes y servicios utilizados para producir las importaciones intermedias de bienes y servicios utilizados por la industria (es decir, productos intermedios exportados que regresan al lugar de origen).

[7] El grado de integración en una cadena de valor puede ser medido sumando el FVA y el DVX de una sola región.

[8] En el marco de esta tesis, se ha avanzado en la inclusión del grado de conectividad industrial, habilidades del mercado de trabajo y funciones laborales. Al final del Capítulo 5 (Conclusiones) se presenta brevemente dichos avances que aún no fueron sometidos a publicación y revisión por pares.

socioambientales (BEUGELSDIJK; PEDERSEN; PETERSEN, 2009; HERNÁNDEZ; PEDERSEN, 2017a; SCHMEISSER, 2013).

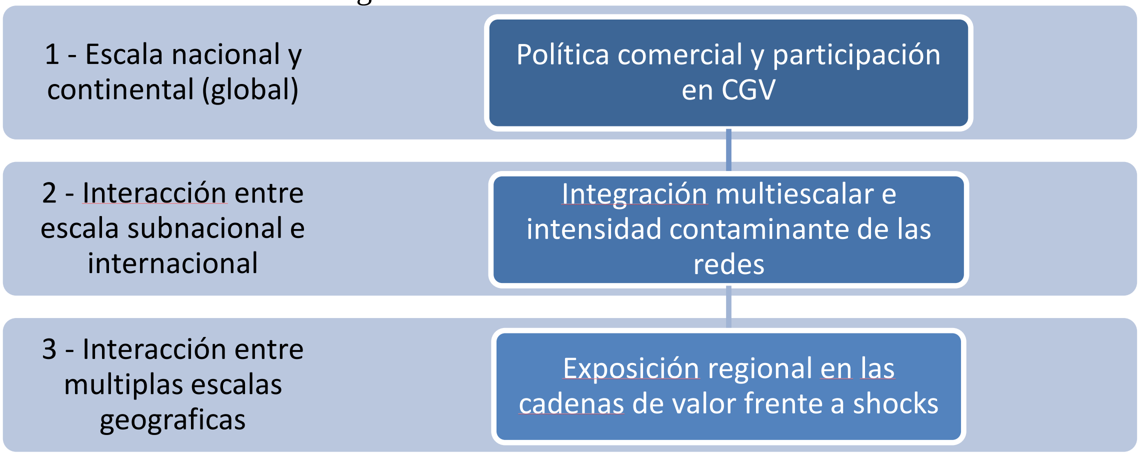
Al asociar la interacción entre las cadenas de valor domésticas (DVC) con cadenas globales (CGV), se avanza en la identificación del grado de intensidad contaminante en términos de huello de dióxido de carbono (CO2) y al grado de responsabilidad ambiental por el lado del VA (CAO et al., 2019). La estructura económica desigual a nivel subnacional implica diferentes grados de dependencia de los recursos naturales. La literatura tiende a desconocer el rol del VA como componente central del debate sobre justicia ambiental y acciones de mitigación en el contexto del cambio climático, eximiendo a los territorios que reciben los beneficios de la remuneración de factores productivos (HADDAD; MENGOUB; VALE, 2020). En este sentido, se propone no solamente el lado del consumo o de la producción, sino que se amplía hacia la evaluación del grado de responsabilidad ambiental por el uso de los recursos, generando diagnósticos sistemáticos sobre el uso de factores y el grado de responsabilidad ambiental.

Por fin, se explora el grado de exposición de las regiones en las cadenas de valor, sean ellas subnacionales (interregionales) o globales (internacionales), permitiendo evaluar las fuentes regionales de especialización en términos de activos territoriales incorporados en el comercio. Al comprender los activos nacionales y territoriales se revela la sofisticación de las actividades comerciables en el espacio como motor de crecimiento regional. Todos los estudios derivados se basan en los flujos bilaterales de TiVA (LOS; TIMMER; DE VRIES, 2016; TIMMER et al., 2016; TIMMER; MIROUDOT; DE VRIES, 2019).

1.4 OBJETIVO Y ESTRUCTURA DE LA TESIS

El objetivo general de esta tesis es analizar la geografía de la integración en las CGV y las implicaciones para el desarrollo regional. La dimensión espacial es multiescalar, lo que permite estudiar la estructura económica, productiva y comercial de los países (regiones) y el desarrollo. La Figura 2 detalla las escalas espaciales consideradas en los tres artículos que componen la tesis.

Figura 2 – Estructura de los artículos.



Fuente: Elaboración propia, 2020.

La aplicación del enfoque CGV analiza cómo las empresas locales y/o los clústeres participan en los mercados globales. Los capítulos siguientes presentan los tres estudios que buscan atender a este objetivo, como se detalla en el Cuadro 1.

Cuadro 1 – Descripción de la estructura de la tesis

Cap.	**Título**	**Resumen**
1	Introducción	Describe el problema, el enfoque y los objetivos.
2	Trade agreements and participation in global value chains: empirical evidence from Latin America	Se asume una escala nacional, con enfoque en bloques regionales. El objetivo es analizar la relación entre los acuerdos regionales de comercio y la participación de América Latina en las CGV. Esta línea de investigación enfatiza el rol de la política comercial y las relaciones heterogéneas entre compradores y proveedores, que incrementan la geografía desigual en potencializar el *Upgrading* en las CGV. Los resultados muestran que los acuerdos regionales de comercio (*regional trade agreements, RTA*) más profundos refuerzan la posición de los proveedores de la industria de tecnología inferior en AL, impulsados por una estrategia extrarregional de política comercial latinoamericana.
3	Regional inequality and CO2 emissions-based trade across value chains: multiscalar assessment from Brazilian' states	Se incluye el componente espacial en la contabilidad socioambiental de los gases de efecto invernadero en el análisis de cadenas de valor a múltiples escalas geográficas. El estudio evalúa los encadenamientos de las emisiones de CO2 regionales e industriales y la distribución espacial de las cadenas de valor

Cap.	Título	Resumen
		contaminantes con base en un método de extracción hipotético a nivel interregional e internacional. Para cada flujo comercial origen-destino, los resultados destacan la concentración de redes contaminantes, impulsada por desigualdades espaciales. La relativa heterogeneidad muestra que los estados brasileños periféricos son menos contaminantes en términos absolutos, como respuesta a la especialización en actividades de bajo valor agregado. Sin embargo, las regiones centrales son relativamente menos contaminantes en términos de integración en cadenas de valor tanto subnacionales como internacionales.
4	The subnational supply chain and the COVID-19 pandemic: assessment of short-term impacts on the Brazilian regional economy	El tercero estudio analiza los posibles efectos regionales de las medidas de mitigación de COVID-19 sobre la integración en DVC y GVC en Brasil. Los resultados de las simulaciones de medidas de distancia social y restricción de actividades económicas muestran efectos espaciales heterogéneos. Las áreas núcleo, principalmente São Paulo y Río de Janeiro, están más expuestas a los choques comerciales del COVID-19. Sin embargo, las periferias están doblemente expuestas, ya sea por el choque externo – que afecta su modelo de crecimiento agroexportador - o por la retracción de la demanda interregional de los estados centrales.
5	Consideraciones finales	Presenta las principales contribuciones y conclusiones. Se sintetiza los avances paralelos relacionados a la línea de investigación desarrollada en esta tesis.

Fuente: Elaboración propria, 2021.

2 TRADE AGREEMENTS AND PARTICIPATION IN GLOBAL VALUE CHAINS: EMPIRICAL EVIDENCE FROM LATIN AMERICA[9]

Abstract

The rise of global sourcing implies a heterogeneous relationship between buyers and suppliers regarding the liberalization scenarios in emerging countries. This paper analyzes the effect of Regional Trade Agreements (RTA) on participation in the Global Value Chains of Latin American countries between 1995 and 2015. We combine the theoretical framework of gravity equations with the trade in intermediates, applying a Pseudo Poisson Maximum Likelihood (PPML) estimator with panel data and fixed effects to deal with endogeneity and heteroscedasticity. Heterogeneous estimations show that the deepest RTAs reinforce the position of lower technology-industry suppliers, driven by an extra-regional strategy of Latin American trade policy. The geography of value chains has little effect on industrial upgrading in the region, reducing the development potential. The study concludes that the region's trade policy could reduce the dependent relationship between distant partners and pay more attention to the creation of shorter value chains as a strategy to generate local capacities to gain competitiveness in value chains.

Keywords: Trade Agreements. Global Value Chains. Latin America. Geography of Trade. PPML.

JEL Classification: O24. R15.

2.1 INTRODUCTION

Regional Trade Agreements (RTAs) can promote technological transfers between developing countries and large nodes of global value chains (GVC), increasing the industrial upgrading potential (Gereffi, 2009; Baldwin, 2011; Miroudot, Rouzet, & Spinelli, 2013). Evidence on the positive relationship between trade policy and GVC gains is consolidated in international economy studies (Antràs & Staiger, 2012; Bickwit et al., 2018). Although in regional blocks such as Asia, the European Union, and North America, this relationship is clearer, in Latin America (LA) this pattern is fuzzier.

[9] Articulo envíado al *The World Economic* Journal.

Apparently, the trade policy strategy associated with extra regional partners has not resulted in gains in upgrading in LA (BOFFA; JANSEN; SOLLEDER, 2019; CADESTIN; GOURDON; KOWALSKI, 2016a; SUDER et al., 2015). The unequal geography of GVC-gains generates controversies regarding the benefits of GVCs (WERNER; BAIR; FERNÁNDEZ, 2014). Since the 1960s, LA regional integration efforts have consolidated a complex network of RTAs, both bilateral and multilateral (CHOI, 2019). Nevertheless, the continent is stuck with low technological industries, little diversification, and as being a supplier of raw materials on GVCs.

This article analyzes the role of RTAs on LA integration in GVCs from 1995 to 2015. To better understand the gains and losses related to upgrading, we consider three analytical dimensions of trade policy effects. The first relates to the depth of RTAs, providing evidence on the relationship between provisions and the effects on value-added flows. The second addresses the effect of the geography of the GVCs, allowing the evaluation of trade gains according to location patterns. We study GVC trade based on the countries' position in the network, distinguishing between integrating as a "buyer" (backward linkages) or as a value-added "seller" (referred to as a forward linkage) (Johnson & Noguera, 2012; Koopman, Wang, & Wei, 2014). The last dimension details the role of trade policy on the industrial position in GVCs, assessing the technological-intensity embedded across networks. Empirically, we apply the nonlinear estimator Pseudo Poisson Maximum Likelihood (PPML) with fixed effects to deal with the endogeneity between RTAs and cross-border flows (Egger & Staub, 2016; Santos Silva & Tenreyro, 2011). The GVC trade data is from the Multiregional EORA input-output tables, in a panel with 180 countries, 20 of which are from LA. Value-added flows are based on the concept of import to export proposed by Baldwin and Venables (2015) and accounts for the foreign content in exports from each pair of countries. The trade agreements database is from the World Bank (Hofmann et al., 2017), and gravitational data was obtained from CEPR (2015).

Empirical evidence suggests that RTAs increase the predictability of the trade and political-institutional environment by reducing costs and trade barriers (Miroudot, Rouzet, & Spinelli, 2013). Models by Antràs and Staiger (2012) and Ornelas, Turner, and Bickwit (2018) show that in the presence of offshoring's intermediate inputs, deep agreements can mitigate the global sourcing decisions under incomplete contracts and endogenous correspondence. An endogenous buyer–supplier match is created

(BICKWIT; ORNELAS; TURNER, 2018), where the role played by each country in GVCs is driven by geographical patterns (Baldwin & Lopez-Gonzalez, 2015; Johnson & Noguera, 2012). In this context, GVC-trade in nearby countries with a high level of technological and innovative development is strongly induced, contributing to the creation of global high-tech hubs. At the other extreme are resource-rich countries, held hostage by price competition that keeps wages low and keeps them dependent on the vagaries of commodity prices (resource curse), as a dependent trade policy result (Gereffi, 2019).

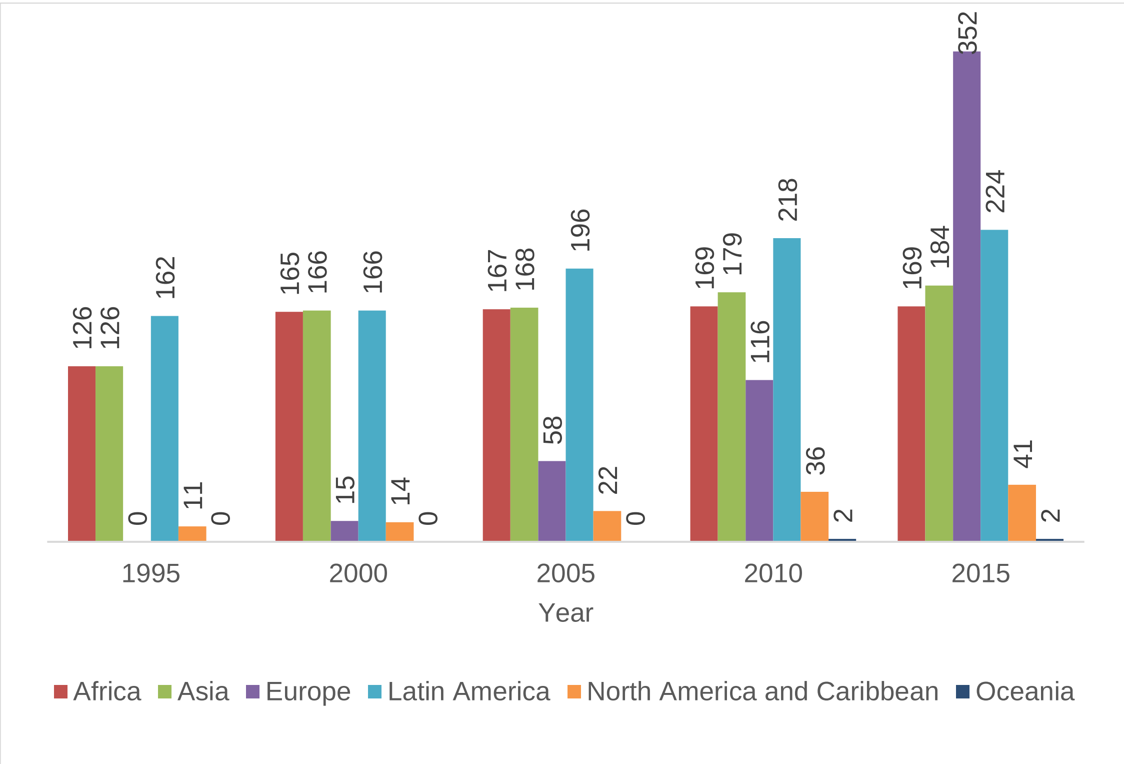
Our theoretical and policy contributions are based on the analysis of a controversial approach to the relation of RTAs and potential gains on trade in LA countries. In non-LA countries, there is evidence that value chains are regional, and RTAs bring national clusters together in a fragmentation context (Miroudot, Rouzet, & Spinelli, 2013). Unlike other regions, intra-regional integration as well as trade policy is adding to foreign dependence as a development barrier (Blyde, 2014; UNECLAC, 2014; OECD, 2015). In part, this may reflect weak barriers that increase trade costs at the continent level, especially across non-literal borders, as well as a “spaghetti bowl” of RTAs. Despite the representative case of LA, our empirical application advances on considering the gross output as a mass variable in the gravity model (Jang & Song, 2018). In situations where trade in intermediate goods is relevant, GDP is not the mass indicator affecting RTA estimations (Baldwin & Taglioni, 2011). Heterogeneous analysis allows us to verify the patterns of geographic shifts based on the position of LA on value chains, be it exporter or importer of value added according to technological bases on trade. This could be a representative case of some emerging economies.

The article is structured as follows: The next section presents a brief background on LA trade agreements and its position in GVCs. Next, we describe the main aspects of the theoretical model that is the basis for estimation. The third section describes the data and our empirical strategy. Later, we present the results considering the influence of RTAs on LA participation in GVCs. We conclude with a discussion on the role of trade policy in the upgrading process of Latin America in GVC.

2.2 RTA AND GVC PATHS IN LATIN AMERICA

Since the 1960s, the geographical composition of RTAs has expanded in LA. As a result of these prolific integrations, predominantly through bilateral agreements, the RTA's *spaghetti bowl* is now more complex. Figure 1 represents the total bilateral trade agreements between one LA country and countries on other continents. The increase in the participation in the number of agreements is accompanied by greater provisions, with the potential to form a complex network of deep agreements. Free Trade Agreements (FTAs) and Economic Integration (EIA)[10] have increased since the 2000s, mainly in European and Asian countries. It is to be expected that this type of agreement will generate greater security for transactions in the context of global sourcing and encourage an increase in value-added flows. As shown by Bickwit et al. (2018) and Jinji, Zhang, and Haruna (2019), deeper agreements include aspects that go beyond tariff changes, and serve as a lever for broader structural and regulatory changes for signatories.

Figure 1. Bilateral Trade Agreements in force by LA countries (1995 – 2015)[1]

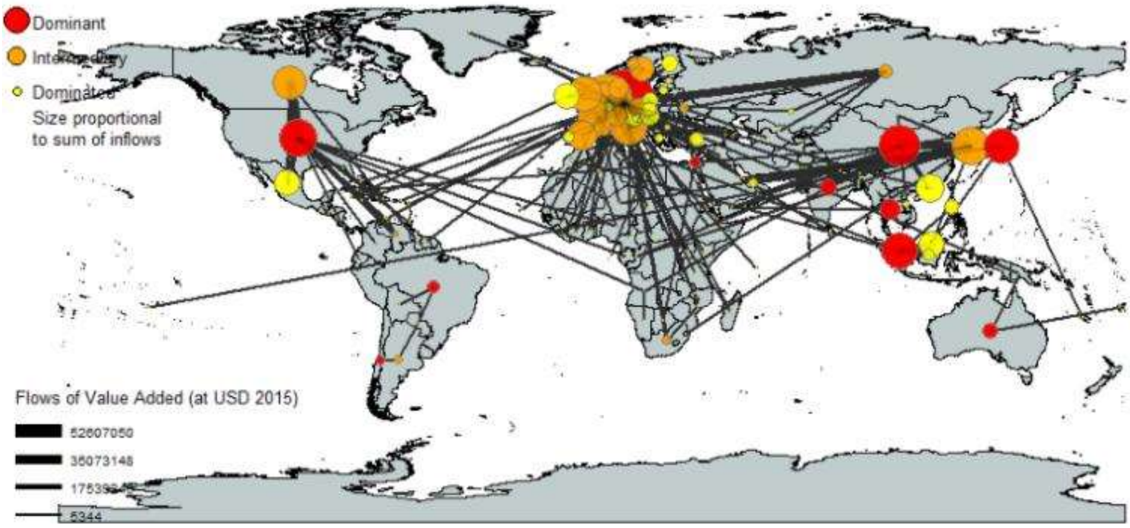


Source: Mario Larch Database (Hoffman et al., 2017).
Note: [1.] At least one country is from Latin America. We considered the sum of all bilateral agreements in each year.

[10] A Free Trade Agreement (FTA) as defined in Paragraph 8(b) of GATT (1994) Article XXIV, whereas an Economic Integration Agreement (EIA) as defined in Article V of General Agreement on Tariffs and Trade (GATT, 1994).

Figure 2 portrays the composition of global networks in 2015, based on the "import to export" concept proposed by Baldwin and Lopez-Gonzales (2013). Foreign Value Added (FVA) is the foreign value-added sourcing in one country and reexported by another (ASLAM; NOVTA; RODRIGUES-BASTOS, 2017). An uneven profile of the international division of production highlights asymmetries in the institutional and technological environment between different countries (Blyde, 2014; Cadestin, Gourdon, & Kowalski, 2016)[11]. Despite the deepening of RTAs, over the past decades, participation in global and regional chains has been weaker (Blyde, 2014; UNECLAC, 2014; OECD, 2015). LA countries are relatively disconnected by global drivers on GVCs. Intraregional value chains present low connectivity, except Venezuela and Mexico, which are oriented to provide North American value chains. At the global level, developed countries have stronger advanced linkages, while emerging economies have weaker connectivity (BOFFA; JANSEN; SOLLEDER, 2019).

Figure 2 – Global flows of foreign value-added in 2015.



Note: This map shows the flows of value added between countries. Three hierarchical relations are considered based on the concept of nodal regions by Dacey (1960): dominant, dominated, and intermediate. We define that a region r is dominated by s if the most important flow of r originates in s; (2) the sum of the flows received per s is at least 15% of the total trade in value-added (TiVA) from r.
Source: Authors based on EORA-UNCTAD-GVC (2019).

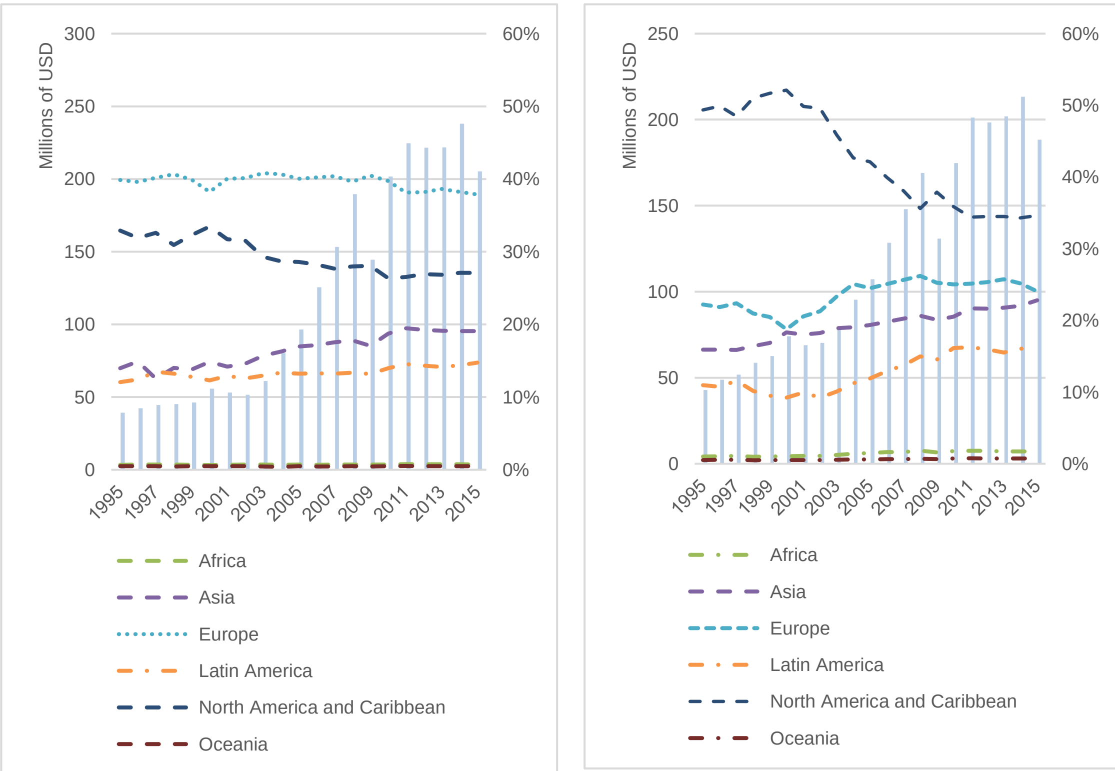
Figure 3 describes the participation of LA in GVCs between 1995 and 2015. **Part (a)** represents the value added sourced by LA countries, with details of reexported amount

[11] These results are consistent with Taglioni and Winkler (2016) who worked with TiVA OECD and Aslam (2017) who used data from EORA.

by each continental aggregate (share in lines). **Part (b)** shows the participation of foreign content in LA re-exportation. There is a clear increase in value-added flows originating in different regions of the world in recent years. Between 1995 and 2015, Mexico, Brazil, and Venezuela consolidated themselves as the main sources of value added exported by LA, representing, on average, about 60% of total trade. Despite this increase, the geography of integration had little change. European and North American countries were still the main destinations for value-added sourcing from LA and, subsequently, re-exportation. LA's position as an importer for reexport has changed markedly since 2004. There is an increase in European and Asian content reexported by the LA region. This increase is accompanied by lower North American participation, indicating a reorientation of the downstream position of LA. Evidence from LA suggests that the region's participation is lower compared to other developing regions and that intra-regional ties are weaker, representing about 14% in 2015 (Blyde, 2014; Cadestin, Gourdon, & Kowalski, 2016; Cecchini, Filgueira, & Robles, 2014; OECD, 2015; Rosales, Herreros, Frohmann and García-Millán, 2013; Rodrik, 2016).

Figure 3. Geography-based of GVC's integration in LA (1995 – 2015)

(a) Supplier position (value-added exporter) *(b) Buyer position (value-added reexporter)*



Source: Authors based on EORA-UNCTAD-GVC (2019).

GVC integration based on industries of low technological level, knowledge, and innovation embedded in trade, delegates LA countries to have a uniform and little diversified role in global sourcing (CADESTIN; GOURDON; KOWALSKI, 2016b; GÓMEZ-MERA, 2015). The contribution to GVCs occur in the initial stages, with few exceptions in terms of the technological-intensity content in trade (OCDE, 2015). Mexico and Costa Rica, for example, specialize in processing and exporting inputs and are well integrated with the North American supply chains, while Chile and Peru are specialized in agricultural and mining inputs increasingly oriented towards Asian markets. Brazil has a high level of domestic content incorporated into exports, encouraged by Chinese and European demand (PEROBELLI et al., 2019). Import for processing and reexport is less prevalent in Chile, Argentina, Brazil, and Colombia. These countries specialize in the supply of global inputs based on commodities, which are subsequently processed or consumed abroad, mainly in Europe and Asia. In LA, the main links with GVC are found in Mexico and Chile (with North America) and Brazil (Asia and Europe). Mexico and Brazil have a major manufacturing structure, but the scale of diversification in GVCs is lower.

2.3 THEORETICAL MODEL

This section describes the main foundations of the theoretical model associated with the trade of intermediates[12], which is representative of the GVC context. The model is based on monopoly trade, as in Krugman (1979) and Anderson and Van Wincoop (2003). The structural gravity equation is a modified version of Krugman and Venables (1996) and Eaton and Kortum (2002) in which gross output is the mass variable instead of GDP. Based on Aichele and Heiland (2018), Baldwin and Taglioni (2011), Caliendo and Parro (2015), and Jang and Song (2018), the model allows the consideration of composite inputs and multilateral resistance terms in the gravity equation (Anderson & Van Wincoop, 2003).

The model assumes that firms produce one representative good and are in a seller or buyer country along the value chains, with free entry and zero profit. As in Caliendo and Parro (2015), each industry produces a variety of intermediate goods using labor and

[12] The complete derivation of the model is in Appendix I.

composite intermediate goods as inputs. Composite intermediate goods producers demand subinputs from the lowest cost supplier, implying that the source of the purchase is determined endogenously and may change as a result of tariff reductions or the removal of trade barriers. Perfect competition and constant returns to scale assumptions imply that firms charge prices equal to unit costs. As a result, an important condition of the model is that these costs directly determine the share of inputs, in terms of value added and produced in each country along the value chain[13].

In this multi-sectorial gravity model, a change in trade policy can affect the price in any single sector and will indirectly influence the use of sub-input along the GVC. Furthermore, it changes the local content embodied in each country's trade, according to firm behavior[14]. The profit maximization assumption and its prices are set as a markup over the marginal cost, based on price elasticity of its demand. Price levels depend on the iceberg-type bilateral trade cost factor, which includes RTAs and gravity variables. Bilateral trade costs fall within the gravity structure, which can vary across regions and industries. The implications of RTAs directly affect the value-added share as they depend on the cost unit as acting to reduce trade barriers. The role of the depth of RTAs remains the models of Lawrence (1996) and Baldwin (2011), formalized by Antràs and Staiger (2012) and Ornelas et al. (2018). Global sourcing decisions associated with incomplete contracts and buyer–supplier matching tend to be mitigated by deeper agreements, as the institutional environment for transactions in GVCs improves. In addition, the type of intermediate input globally sourced by emerging countries has a competitive price level paid by demanding producers.

As with standard gravity models, we consider that the profit margin is identical for all destinations if perfect competition or monopolistic Dixit-Stiglitz competition is assumed. In these cases, the price variation is characterized by the transfer of trade costs to consumers in the destination market j (Baldwin and Taglioni, 2011). The structure of the model is closed considering trade imbalances. Input-output data assumes that the total value of goods supplied to the country is equal to its domestic production, plus imports

[13] The characteristics of the type of integration of each country in the global chains are essential for the international heterogeneity of this share. As the importance of intermediary trade increases, gravitational estimates using GDP is lower. The influence of trade costs affects the demand and supply of intermediaries across global production networks.

[14] There is a discussion in the theoretical literature about the effects of relocation on the use of domestic and foreign labor (see Grossman & Rossi-Hansberg, 2012). An important point in this discussion is the substitution between local or foreign production in some sectors, in which the different price of labor induces the dispersion of production at an international level.

minus exports (AICHELE; HEILAND, 2018). The gravity equation for a world with intermediate trade is given by-

$$T_{ij}^{m} = \left(\frac{\tau_{ij}^{m}}{\Pi_i^m P_j^m}\right)^{1-\sigma^m} \frac{Y_i^m Y_j^m (1+\phi_j^m)}{Y_w^m} \qquad (1)$$

where T_{ij} is the participation in GVCs indicator, as representing the value-added flow sourced by i and reexported by j along the value chains of an industry m (EORA-UNCTAD-GVC, 2019); τ_{ij} is a bilateral iceberg-cost parameter and includes RTAs and gravity variables; Π_i and P_j are the multilateral resistance terms (Anderson & Wincoop, 2003);, Y_i, Y_j and Y_m are the gross output of i and j and the rest of the world, w, respectively (Jang & Song, 2018); ϕ_j^m and are the net imports of j and σ^m is the elasticity of substitution between the sub-inputs of the compound intermediate goods (Caliend & Parro, 2015).

As in Baldin and Taglioni (2011), Equation 1 is the modified gravity equation that allows trade intermediates, with gross output as a mass variable, since purchases are now driven by both consumer demand (whose income is the demand shifter) and intermediate demand (for which total production costs demand shifts). In a world with intermediates, it is expected that RTAs can reinforce the relationship between buyer and supplier in GVCs. The reduction of trade barriers decreases trade costs and expands bilateral flows (JINJI; ZHANG; HARUNA, 2019). It is important to emphasize that there is a direct relationship between country pairs along the value chain, with specific functions geographically governed. Cross-border policies influence trade when production is internationally fragmented (ANTRÀS et al., 2013). The governance and coordination structure implies that value-added trade does not depend only on bilateral costs, but also on costs with third countries. Deeper RTAs explicitly include provisions that encourage technological dissemination (Amendolagine et al., 2019; Laget et al., 2018), resulting in an increase in technological potential spread throughout GVCs.

2.4 DATA AND ESTIMATION

We built a panel with data from a multiregional input-output model EORA (Lenzen, 2013), which incorporates bilateral flows of value added from 1995 to 2015.

The panel includes 180 countries, of which 20 are from LA (the country list is available in Appendix 2). Gravity variables were obtained from CEPR (2015). Bilateral trade agreement data is provided by Hoffman et al. (2017). Table 1 shows the description of the variables used in our estimation.

Table 1 – Variables details

Variable		***Description***	***Source***
fva	Foreign Value Added (i to j)	Bilateral flow of added value, by country of origin (i) and re-export (j). Indicates chaining in value chains.	EORA-UNCTAD-GVC Database
lndist	Log of distance	Distance between the centroids of each country i and j. (log of values in kilometers)	CEPR Gravity Database
contig	Contiguity	It assumes the value of 1 if i and j are contiguous, and 0 if the opposite.	CEPR Gravity Database
comlang_off	Common official of primary language	It assumes a value of 1 if i and j have the same official language, and 0 if the opposite.	CEPR Gravity Database
colony	Historical colonial relationship	Assumes the value of 1 if i and j already had a colonization relationship, and 0 if the opposite.	CEPR Gravity Database
lngross	Log of gross output	Difference from the natural logarithm of the gross output of i multiplied by the gross output of j.	EORA-UNCTAD-GVC Database
netimports_j	Log of Net Imports	Difference from natural logarithm of net imports from country j (re-exporter)	EORA-UNCTAD-GVC Database
rta	Any regional trade agreement	It assumes the value of 1 if i and j have at least one trade agreement in year t in effect, and 0 if the opposite.	Mario Larch Database (Hoffman et al., 2017).
cu	Custom Union	It assumes the value of 1 if i and j have at least one custom union trade agreement in year t in effect, and 0 if the opposite.	Mario Larch Database (Hoffman et al., 2017).
fta	Free Trade Agreement	It assumes the value of 1 if i and j have at least one free trade agreement in year t in effect, and 0 if the opposite.	Mario Larch Database (Hoffman et al., 2017).
eia	Economic Integration Agreement	It assumes the value of 1 if i and j have at least one economic integration agreement in year t in effect, and 0 if the opposite.	Mario Larch Database (Hoffman et al., 2017).
ps	Partial Scope Agreement	It assumes the value of 1 if i and j have at least one partial scope agreement in year t in effect, and 0 if the opposite.	Mario Larch Database (Hoffman et al., 2017).
cuandeia	Customs Union and Economic Integration Agreement	It assumes the value of 1 if i and j simultaneously have at least one Custom Union and an Economic Integration Agreement, and 0 if the opposite.	Mario Larch Database (Hoffman et al., 2017).
ftaandeia	Free Trade Agreement and Economic Integration Agreement	It assumes the value of 1 if i and j simultaneously have at least one Free Trade Agreement and an Economic Integration Agreement, and 0 if the opposite.	Mario Larch Database (Hoffman et al., 2017).

Note: The dependent variable was re-scaled to 10^6 to reduce convergence issues (ZYLKIN, 2014).
Source: Own ellaboration, 2020.

Our goal is to identify the effect of RTAs on foreign value-added from a country i and embedded in exports by j, we call this measure T_{ij}. Following Mulabdic, Osnago, and Ruta (2017) and Jang et al. (2018), our benchmark is given by the logarithmic version of Equation (1):

$$lnT_{ij}^{m} = lnY_{i}^{m}Y_{j}^{m} + \ln\left(1+\varphi_{j}^{m}\right) - (\sigma^{m}-1)ln\tau_{ij}^{m} + (\sigma^{m}-1)ln\Pi_{i}^{k} + (\sigma^{m}-1)lnP_{j}^{m} - lnY_{W}^{m} + \varepsilon_{ij} \quad (2)$$

This model shows that sales from country i to country j can be proportional to the product of the masses of the two countries (measured in gross output), reducing the bilateral costs of trade between them. As proposed by Anderson and Van Wincoop (2003), the terms Π_{i}^{m} and P_{j}^{m} represent the terms of multilateral resistance and are trade costs between i and j as in Baldwin and Taglioni (2011). Both terms are captured by fixed effects of exporters and importers, respectively. As a standard in the literature, iceberg-type costs (τ_{ij}) include all natural and artificial barriers and can be estimated by including gravity dummies (contiguity (*contig*), common language (*common*), colony (*colony*), log of distance (*lndist*) and RTAs (and their depth levels)). The term Y_{W}^{m} is captured by year fixed effects.

In the linear form, model (2) has two potential misspecification issues: (*i*) the presence of zero flows[15] between i and j that can generate selection bias[16] (Anderson, Larch, & Yotov, 2018; Baier & Bergstrand, 2009), and (*ii*) the consistency of the linear estimator in the presence of heteroscedasticity[17] (like OLS, for example). This is because $E\ [ln\ \varepsilon_{ij}|X]$ depends on the average of superior orders, so that if the error's conditional variance is not constant, there is a correlation with regressors (SANTOS SILVA; TENREYRO, 2006). Following several studies in the literature, we adopted the exponential multiplicative form of the nonlinear PPML estimator (Egger & Staub, 2016;

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[15] Some studies adopt the negative binomial model in place of Poisson if the data presents greater dispersion in relation to the mean. However, such an approach presents theoretical problems: (i) PPML is a consistent probability estimator, regardless of distribution, (ii) the negative binomial estimator is not invariable in scale, so when applied to trade data it may be inconsistent and inefficient.

[16] According to Laget et al. (2018), omitted variables bias arises when the error term is correlated with some unobservable country-specific policy variables (like restrictive domestic policy regulation), which at the same time affects both GVC-related trade and the probability of forming a deep RTA. Reverse causality may arise from the fact that firms in country pairs involved in GVC may lobby for deeper trade agreements to secure the supply of intermediates in partner countries.

[17] The Ramsey test was performed, with $\chi^2 = 121.48$, in which the hypothesis of misspecification of the non-linear model is rejected.

Santos Silva & Tenreyro, 2011). Exponentiation of the terms of model (2), we have the following reduced equation:

$$T_{ij} = \exp\big(\boldsymbol{x}_{ij}\boldsymbol{\beta} + \boldsymbol{\tau_{ij}} + \boldsymbol{\mu_{it}} + \boldsymbol{\delta_{jt}}\big)\, \varepsilon_{ij,t} \tag{3}$$

where $\boldsymbol{\tau}_{ij}$ is our trade-cost, and the parameters μ_{it} and δ_{jt} are the exports and re-exporter (importers) fixed effects (multilateral resistance terms), and ε_{ij} is the disturbance (*stochastic*) error term[18]. The first-order condition is $\sum_{i=1}[T_{ij} - \exp\big(x_{ij}\hat{\beta}\big)\,|x_{ij} = 0$. The consistency of the estimator is required $E\big[T_{ij}\big|x\big] = \exp\big(x_{ij}\beta\big)$. The data did not have a Poisson distribution. PPML gives equal weight to observations and is more efficient than linear estimators. Thus, T_{ij} changes when trade costs are affected. With elasticity of substitution between labor and composite intermediate goods, the value-added content traded, changes when there are changes in the price level of inputs, changes in trade barriers, or number of intermediate goods (JANG; SONG, 2018a).

2.5 EMPIRICAL RESULTS

As shown in the first section, we consider three dimensions to analyze the relationship between RTAs and GVC integration in LA: (1) the depth of the agreements, (2) LA position (as an exporter or re-exporter of value-added), and (3) the technological content in value added.

2.5.1 Depth of trade agreements

Table 2 shows the estimated coefficients considering the phase-in strategy with five-year intervals to allow us to the capture of the effects related to new agreements over time (Baier & Bergstrand, 2009; Baier et al., 2008; Kohl, Brakman, & Garretsen, 2016). Column 1 includes all countries and considers the existence of at least some type of RTA, whereas Columns (2–8) consider intra-regional trade in LA.

[18] To solve the collinearity problem between the paired dummies contained in τ_{ij} invariant over time with the product at gross output and with the terms of multilateral resistance, we adopted the solution of Zylkin (2019) and only allowed fixed effects of invariant exporter and importer.

Table 2. Effects of RTA on value-added flows

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All countries	*Intraregional trade (between Latin America countries)*						
		rta	cu	fta	eia	ps	cuaneia	ftaandeia
Rta	0.38***	0.86***						
	(0.03)	(0.08)						
Cu			0.40***					
			(0.11)					
Fta				0.46***				
				(0.11)				
Eia					0.28***			
					(0.07)			
Ps						1.52***		
						(0.15)		
cuandeia							0.50***	
							(0.15)	
ftaandeia								0.41***
								(0.11)
Lndist	-0.48***	-0.97***	-0.94***	-1.04***	-1.01***	-0.98***	-0.97***	-1.04***
	(0.01)	(0.06)	(0.07)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Contig	0.29***	0.65***	0.68***	0.65***	0.65***	0.68***	0.68***	0.65***
	(0.04)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
comlang_off	0.16***	0.69***	0.68***	0.69***	0.75***	0.70***	0.82***	0.68***
	(0.04)	(0.13)	(0.12)	(0.14)	(0.13)	(0.12)	(0.12)	(0.14)
Colony	0.27***	-3.98***	-3.07***	-3.07***	-3.16***	-3.72***	-3.18***	-3.05***
	(0.03)	(0.20)	(0.14)	(0.16)	(0.15)	(0.16)	(0.16)	(0.16)
lngross3	0.23	0.51	0.54	0.62	0.59	0.46	0.56	0.62
	(1.49)	(44.81)	(45.08)	(47.06)	(47.13)	(47.90)	(45.91)	(47.32)
netimports_j	0.13***	-0.76***	-0.78***	-0.92***	-0.89***	-0.56***	-0.82***	-0.89***
	(0.03)	(0.09)	(0.09)	(0.09)	(0.10)	(0.10)	(0.09)	(0.09)
Observations	161,100	1,900	1,900	1,900	1,900	1,900	1,900	1,900

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

Source: Own elaboration, 2020.

RTAs are positively related to participation in value-added trade flows. It is interesting to note the differences in the magnitude of elasticities. Gravity variables (*lndist*, *contig*, *comlang_off*, and *colony*) are significant at the 1% level, showing that geographical proximity influences the formation of regional value chains, as shown by Los, Timmer, and de Vries (2015)[19]. With all the countries in the sample, the existence of bilateral RTA predicts a 40%[20] increase in value-added flows, compared to non-RTA relationships. However, the prediction is an increase of approximately 145% in the value-added flows within the LA[21]. As much as in relative terms, trade within the region is

[19] The authors discuss the existence of global or regional value chains. Their study extends the Feenstra and Hanson's (1999) fragmentation measure to a multi-country scenario and concludes that the trend of "global inputs" was halted after the 2008 financial crisis and that countries with similar levels of development tend to share regionally delimited production networks.

[20] It computes the effect as $(e^{\beta} - 1) * 100\%$, where β is the estimated coefficient

[21] When the sample includes only Latin American countries, the common language coefficient is excluded by collinearity, because all countries use Spanish but Brazil.

lower and the model shows that trade could be considerably increased if trade policy were adjusted regionally. These results are based on empirical evidence applied to final goods (GUILHOTO; SIROËN; YÜCER, 2015; RUBÍNOVÁ, 2017; YOTOV et al., 2016) as well as intermediate goods (Egger et al., 2017; Laget et al., 2018).

Columns 2–8 show estimates according to the depth of trade agreements. The empirical literature considers that customs unions (*cu*) and partial agreements (*ps*) are less deep, with fewer provisions and obligations, indicating different levels of countries' commitment to trade policy. Bickwit et al. (2018) and Jinji, Zhang, and Haruna (2019) show that deeper agreements are generally signed developed regions, like North American and European countries. In our application, the parameter of RTA predicts 46.23% greater trade when LA shares a free trade agreement (*fta*) compared to none. Free Trade Agreement (*fta*) and Economic Integration Agreement (*eia*) are deep agreements as they cover areas that go beyond tariff reduction. The partial scope (*ps*) coefficient is 1.52, while *that of the Custom Union (cu*) is 0.40. Despite these differences, the models show that trade policy within the region can encourage intraregional trade in value added to a considerable extent, regardless of the role played in GVCs, whether buying or selling intermediate inputs. The elasticities of gravity variables suggest that distance and contiguity are important when bilateral trade flows are dominated by intermediaries. This emphasizes the potential for fragmentation at the regional level in LA in response to trade policy. The gross output coefficient (*lngross*) is not significant in all models and has a high standard error. Zylkin (2019) and Jang (2018) explain this fact due to the potential collinearity between the effects for symmetrically paired countries.

2.5.2 GVC's position and geography-based integration

In Table 3, Models 1 - 7 show the estimates for different degrees of depth of agreements on the value-added trade from the seller's (exporter) perspective of intermediate inputs, while regressions 8–14 estimate the effect on the re-exporter's position.

Table 3. Effects of RTAs according to GVC's position

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	LA as a VA exporter (i)						
	RTA	CU	FTA	EIA	PS	CU-EIA	FTA-EIA
rta	0.14						

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	LA as a VA exporter (i)						
	RTA	CU	FTA	EIA	PS	CU-EIA	FTA-EIA
	(0.09)						
cu		0.57***					
		(0.15)					
fta			0.21**				
			(0.09)				
eia				0.24***			
				(0.07)			
ps					0.41***		
					(0.11)		
cuandeia						0.72***	
						(0.19)	
ftaandeia							0.21**
							(0.09)
lndist	-1.50***	-1.43***	-1.50***	-1.49***	-1.49***	-1.45***	-1.50***
	(0.11)	(0.12)	(0.11)	(0.11)	(0.11)	(0.12)	(0.11)
contig	0.01	-0.00	-0.01	-0.03	0.05	-0.01	-0.01
	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)
comlang_off	-1.03***	-1.00***	-1.03***	-0.99***	-1.05***	-0.98***	-1.03***
	(0.20)	(0.19)	(0.20)	(0.20)	(0.20)	(0.19)	(0.20)
comlang_ethno	1.02***	1.08***	1.02***	1.03***	1.03***	1.08***	1.02***
	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)
netimports_j	-0.40***	-0.39***	-0.41***	-0.42***	-0.41***	-0.42***	-0.40***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Observations	17,900	17,900	17,900	17,900	17,900	17,900	17,900
Variable	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	LA as a value added re-exporter (j)						
	RTA	CU	FTA	EIA	PS	CU-EIA	FTA-EIA
rta	-0.03						
	(0.03)						
cu		0.24***					
		(0.09)					
fta			-0.11***				
			(0.03)				
eia				-0.06*			
				(0.03)			
ps					0.46***		
					(0.05)		
cuandeia						0.16*	
						(0.10)	
ftaandeia							-0.10***
							(0.03)
lndist	-1.15***	-1.11***	-1.14***	-1.15***	-1.14***	-1.13***	-1.14***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
contig	0.38***	0.35***	0.41***	0.40***	0.36***	0.36***	0.41***
	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.05)
comlang_off	-0.06	-0.03	-0.08	-0.07	-0.09	-0.04	-0.08
	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)	(0.09)
comlang_ethno	0.08*	0.12**	0.10**	0.08*	0.10**	0.10**	0.10**
	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)
netimports_j	-0.28***	-0.30***	-0.28***	-0.28***	-0.35***	-0.30***	-0.29***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Observations	17,900	17,900	17,900	17,900	17,900	17,900	17,900

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

Source: Own elaboration, 2020.

The elasticities are higher and more significant when LA countries are input suppliers. This result highlights the role of LA as a global supplier of raw materials. The deeper trade agreements (*fta* and *eia*) have lower coefficients when considering the role of the buyer of inputs for export. Shallow agreements become efficient mechanisms to increase the role of Latin American primary exporters. The results reveal the sensitivity of LA integration in more complex value chains, besides showing that trade policy alone cannot promote upgrades in the region. From the FTA and EIA coefficients, the deep agreements favor the increase of LA participation as a supplier of inputs, while the less deep agreements contribute to the strengthening of the purchase process for export (with greater processing level). Factors such as internal costs resulting from participation in more complex trade agreements help to explain this phenomenon (Cadestin, 2016). These internal costs are obstacles to increasing participation in chains, since the way in which trade agreements can reduce trade costs is less compensated when compared to other regions of the world. Bickwit et al. (2018) show that the level of development and trade openness in countries are relevant to consolidating more efficient value chains. In this sense, Table 4 includes dummy variables for the direction of value-added flows (Africa, Asia, Europe, North America, Oceania, and Latin America), which allows us to analyze the heterogeneous response of T_{ij} flows to trade policy.

Table 4. Effects of RTAs according to geography-based trading partners

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Latin America as a value added exporter (i)					
	Africa	Asia	Europe	North America	Oceania	Latin America
rta	0.40***	0.23*	0.30**	-0.21	0.38***	0.86***
	(0.08)	(0.12)	(0.13)	(0.20)	(0.03)	(0.08)
lndist	-1.54***	0.85**	0.44	-0.95***	-0.48***	-0.97***
	(0.15)	(0.36)	(0.84)	(0.25)	(0.01)	(0.06)
contig	0.84***			-0.71***	0.29***	0.65***
	(0.18)			(0.21)	(0.04)	(0.09)
comlang_off	1.70***	0.16	0.21*	-0.44*	0.16***	0.69***
	(0.08)	(0.15)	(0.12)	(0.27)	(0.04)	(0.13)
lngross3	1.12***	-0.56	-0.28	0.50	0.23	0.51
	(0.21)	(20.54)	(1.42)	(33.27)	(1.49)	(44.81)
netimports_j	-0.91***	-0.10	-0.40***	-0.33	0.13***	-0.76***
	(0.04)	(0.16)	(0.07)	(0.28)	(0.03)	(0.09)
colony			0.37***		0.27***	-3.98***
			(0.12)		(0.03)	(0.20)
Observations	5,100	5,100	4,000	1,300	161,100	1,900
Variables	(7)	(8)	(9)	(10)	(11)	(12)
	Latin America as a value added re-exporter (j)					
	Africa	Asia	Europe	North America	Oceania	Latin America
rta	0.45***	0.10***	-0.10	0.27**	0.52***	0.86***
	(0.12)	(0.03)	(0.06)	(0.12)	(0.12)	(0.08)

lndist	0.55*	-0.54***	-0.25	-1.16***	-1.62***	-0.97***
	(0.32)	(0.14)	(0.20)	(0.17)	(0.51)	(0.06)
contig	-1.60***			0.50***		0.65***
	(0.28)			(0.05)		(0.09)
comlang_off	-1.40***	-1.12***	1.10***	-0.19	-0.75***	0.69***
	(0.27)	(0.10)	(0.10)	(0.32)	(0.22)	(0.13)
lngross3	-0.39	0.34	0.17	0.52	1.10	0.51
	(2.52)	(12.36)	(6.89)	(23.45)	(3.19)	(44.81)
netimports_j	-1.48***	-0.10**	-0.17***	0.10	-1.00***	-0.76***
	(0.15)	(0.04)	(0.02)	(0.08)	(0.05)	(0.09)
colony			-0.68***			-3.98***
			(0.11)			(0.20)
Observations	5,100	5,100	4,000	1,300	500	1,900

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

Source: Own elaboration, 2020.

The results indicate that RTAs facilitate the creation and expansion of the consumer market for intermediate inputs produced in LA. However, the intensity of this relationship is different when considering the GVC's geography. From the buyer's perspective, RTAs show higher gains within LA (coefficient 0.86), followed by sales to Africa, Oceania, and Europe, respectively. The network of trade agreements in the South-South scope, including Southern Asia and Oceania, is relevant to integrating South America into GVC. On the other hand, the supply of intermediate inputs to North America has negative elasticities. These results are corroborated by the empirical evidence applied to African, Asian, and global Southern countries (DEL PRETE; GIOVANNETTI; MARVASI, 2018; KOWALSKI et al., 2015; LUND-THOMSEN; WAD, 2014; TINTA, 2017).

The role of re-exporters in LA is less favored if the products originate in Europe, with an estimated reduction of 10.42% in the presence of at least one RTA. This result highlights the external dependency in the trade relationship between Latin America and Europe. Here, the diverse effects of geographical features are noteworthy. The distance coefficients are positive for sales to Europe and Asia, showing a compensation effect between the trade cost altered by trade agreements and the cost linked to geographical distance. The estimates reveal a character of complementarity for transactions with Africa, Oceania, and the South American region itself.

2.5.3 Technology-intensity embedded in GVCs

Many RTAs seek deeper integration, including provisions that encourage technological spread. As a result, the technological potential of each country can spread throughout the GVC. Table 5 shows the estimates for the positions (buyer and supplier) across Latin American countries according to five levels of R&D intensity.

Table 5. Effects of RTAs according to the intensity of R&D and GVC' position

	(1)	(2)	(3)	(4)	(5)	(6)
	LA as a value added exporter (i)					
Regressors	Low R&D intensity	Medium-low R&D intensity	Medium R&D intensity	Medium-high R&D intensity	High R&D intensity	Re-export and Re-import
rta	0.14*	0.22**	0.15**	0.14*	0.10	-0.03
	(0.07)	(0.11)	(0.08)	(0.08)	(0.07)	(0.11)
lndist	-1.31***	-1.82***	-1.51***	-1.70***	-1.64***	-0.90***
	(0.13)	(0.15)	(0.12)	(0.15)	(0.14)	(0.18)
contig	0.61***	-0.34**	0.14	0.26	0.24	0.33**
	(0.15)	(0.15)	(0.17)	(0.17)	(0.16)	(0.16)
comlang_off	-0.35**	-0.38**	-0.34**	-0.48***	-0.32**	-0.65***
	(0.14)	(0.19)	(0.14)	(0.16)	(0.15)	(0.21)
colony	0.78***	0.78***	0.87***	1.05***	0.86***	0.92***
	(0.14)	(0.21)	(0.15)	(0.17)	(0.16)	(0.21)
lngross3	0.79	1.07	0.87*	1.00	0.96	0.64
	(0.51)	(0.86)	(0.49)	(0.85)	(0.75)	(0.40)
netimports_j	-0.45***	-0.20*	-0.55***	-0.32***	-0.29***	-1.34***
	(0.06)	(0.12)	(0.06)	(0.08)	(0.07)	(0.10)
	(7)	(8)	(9)	(10)	(11)	(12)
	LA as a value added re-exporter (j)					
Regressors	Low R&D intensity	Medium-low R&D intensity	Medium R&D intensity	Medium-high R&D intensity	High R&D intensity	Re-export and Re-import
rta	-0.05	0.02	-0.04	-0.06*	-0.06**	0.10**
	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.05)
lndist	-1.19***	-1.08***	-1.18***	-1.17***	-1.22***	-0.64***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)
contig	0.37***	0.48***	0.41***	0.35***	0.35***	0.21*
	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.11)
comlang_off	-0.03	-0.10	0.06	-0.10	0.02	-0.06
	(0.10)	(0.09)	(0.08)	(0.09)	(0.08)	(0.08)
colony	0.33***	0.43***	0.21*	0.35***	0.30***	-0.04
	(0.12)	(0.12)	(0.11)	(0.11)	(0.11)	(0.06)
lngross3	0.68	0.64	0.68	0.67	0.68	0.43
	(3.52)	(9.33)	(4.01)	(15.00)	(9.88)	(2.03)
netimports_j	-0.30***	-0.26***	-0.29***	-0.33***	-0.27***	-0.49***
	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)

Robust standard errors in parentheses.

Source: Own elaboration, 2020.

In the exporter's position, the elasticities of RTAs are more significant for less intense R&D trade. The opposite occurs for the buyer's role, in which RTA's coefficient related to exports of higher intensity R&D is statistically significant but negative. This pattern shows the potential of trade policy to encourage the export of inputs with less technological content and with a lower level of value added. Low-complexity industries incorporate little knowledge and technology to GVC, and the estimated elasticities indicate that RTAs can reduce up to 5.82% in value-added trade when LA countries are re-exporters. The position of re-exporters is important in GVC (Baldwin & Gonzales, 2015). Taglioni and Winkler (2016) argue that a country cannot become a major exporter in GVC without first becoming a successful importer of intermediate imports because imported intermediate inputs contain foreign technology. Several studies have identified that technological transmission is enhanced by trade (Acharya & Keller, 2009; Coe & Helpman, 1995). Imports of foreign intermediate goods that incorporate foreign advanced technology allow the implicit use of this technology in the production of final goods in each country (Keller, 2004). Although EORA' s routine-export and re-import industry represents outsourcing, it does not represent the incorporation of value by each country region, which is significant and positive. On average, the model predicts that the presence of bilateral RTAs increases (up to 10.52%) the foreign content that is incorporated by Latin American exports without representing a virtuous process of incorporation and local value to trade.

There is an industrial and technological pattern for hub-and-spoke networks, based on developed regions governing the functions performed by Latin America. This productive dynamic of the global supply of inputs with little processing by the Latin region is reinforced by RTAs. In this context, the evidence found in the literature applied to developed regions (such as the US and EU) reveals results opposite to ours. In these cases, activities with a higher level of knowledge and technology are more sensitive to trade agreements. This is because there is a productive and regional structure that is often already established between countries, besides lower internal costs for adapting to rules established by RTAs. This increases the effect of trade policy on reducing trade barriers.

The most direct relationship between RTAs and the flows of intermediaries in Latin America largely depends on the past and the role performed by the countries of the region in the process of international fragmentation of production. As many RTAs seek deeper integration, there is evidence that these results of positive effects for upgrading are seen in regions that are already in advanced positions in the value chain and are located, in most cases, in developed regions of the global north. In LA, policy actions are still required to reduce internal costs and international competitiveness, to increase the development potential around GVC in the region.

The results presented in this section indicate that RTAs can enhance intraregional value-added flows associated with the effects of distance and institutional similarity, which act as cost reducers. However, the market-size effect associated with less integration in regional value chains is driven for estimations, revealing lower potential to improve upgrades across close-geography value chains. When we incorporate the deep agreements in the analysis, the results show less effect on the formation of LA value chains. The profile of extra regional integration becomes a determinant of this pattern. The deepest RTAs influence the exports of basic inputs on GVCs. The coefficients are higher when considering the exporter side of value-added and is lower as to the effect of increasing the “import to export” position, which is associated with the indirect gains of the upgrading strategy (Baldwin, 2011).

The geography of GVCs implies that RTAs contribute to LA countries’ dominance over international demand, coordinated by global hubs. The supply of global inputs is reinforced by the distance, showing that large distances do not reduce the potential to provide lower technology industries across value chains. Exports of higher value-added industries are weakly enhanced by RTAs, while positive coefficients increase as we move to low-technology industries. This pattern of results is maintained with our robustness exercises, applying other standardized estimators on international trade literature (Annex 2).

2.6 CONCLUSIONS

LA countries have consolidated a dense network of RTAs, as suggested by GVC’s studies and international institutions. At the same time, in the last two decades, the region does not show a consistent structural change in favor of upgrading, development, and convergence to higher income levels. The paradigm of global fragmented production across borders aimed to exploit the lower costs associated with the intensification of knowledge and technology flows does not prove to be entirely true in LA. As global buyers, some countries may exercise power over subcontractors, reducing the spread of gains from globalization. Based on a heterogeneous estimation strategy, our results revealed the RTA’s role of reinforcing the region’s position as a global raw material supplier. Latin countries have chosen a trade policy strategy based on increasing trade relations with global drivers in GVCs, despite the promotion of an approximation with intraregional partners.

Our estimations support the argument in favor of intraregional articulation; however, other complementary actions are needed to bring countries closer together in more complete ways. Without this policy mix, the historically consolidated export-based profile tends to persist or even grow because of trade cost reductions by RTAs. It is also important to rescue the idea of intraregional integration. Regional value chains tend to generate greater competitiveness than isolated countries do. In the face of exogenous shocks, the strengthening of nearby production networks increases the stability of structural production systems. It is necessary that industrial and trade policies promote integration at the regional level, so that with this, the benefits of productive fragmentation allow the Latin American region to gain competitiveness in a diversified way.

Evidence on GVC shows that integration internalizes bilateral externalities and affects the size-effect of RTAs on reducing barriers such as trade costs and facilities (BICKWIT; ORNELAS; TURNER, 2018; CADESTIN; GOURDON; KOWALSKI, 2016a). Indeed, our strategy does not explicitly explain the role of third countries along the chains or how this linkage affects LA. We have adopted a bilateral approach assuming that it represents the entire shock on trade flows, including the dependence on demand from high-income countries. The concern about the size-effect of deeper RTAs on internal costs and the ability to upgrade or diversify is an open question for future studies. The productive potential of each country underlines the capacity for stronger integration, which is noted by the greater participation of the region in more complex trade agreements in recent years and presence in global foreign trade. The increase in the domestic value added embedded by Latin American countries in response to the RTA policies is evident, while it is accompanied by the process of export prioritization.

Our study sheds light on questions regarding regional and subnational assets incorporated in GVCs. Likewise, the potential of joint intranational or multilateral policies to favor productive diversification requires specific analyses and mailing in terms of subnational effects. It is to be expected that external demand from large global drivers will induce local adaptations, be it in the production structure, in the qualification of the labor market, or in the productive chains. For emerging regions, these channels of effects are little explored in the economic literature, and future evidence is needed. Another important aspect of our discussion is related to the dependence on international prices of commodities and natural resources. Economies become fragile to externalities. As a result, global connectivity was impacted by the 2008 financial crisis and by the COVID-19 outbreak, where regional value chains began to dominate and became necessary.

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2.7 ANNEX

2.7.1 Robustness check

To verify the consistency of the results, we add in this analysis a small sample of other data generation process estimators that is consistent with the economic models of international trade equilibrium. The first two columns of Table 6 present the OLS estimation in two stages, which partially solves the problem of standard error of the existence of a correlation between the volume traded and the unobservable variables. In the two-stage approach (2SLS), the bidirectional fixed effect version is estimated first, and in the second stage, gravitational variables are used (Head & Ries, 2008). Columns (3) - (6) show the results of two GLM estimators, based on the probability estimate of potentially poorly specified densities of the linear exponential family (LEF) of distributions. Here, we present the binomial negative and gamma families (LARCH et al., 2019).

Table A1 – Robustness estimations

Regressors	(1)	(2)	(3)	(4)	(5)	(6)
	2SLS	2SLS - LA	Gamma	Gamma - LA	Negative Binomial	Negative Binomial - LA
Rta	3.26***	6.46***	0.07***	0.24***	0.16***	0.33***
	(0.03)	(0.29)	(0.01)	(0.04)	(0.02)	(0.07)
lngross3	0.23***		-0.30***	0.19***	-1.15***	0.22***
	(0.03)		(0.02)	(0.04)	(0.18)	(0.06)
netimports_j	-0.68***	-0.03	-0.41***	-0.55***	-0.80***	-0.70***
	(0.01)	(0.13)	(0.00)	(0.06)	(0.01)	(0.12)
lngross		-1.52***				
		(0.54)				
lndist			-0.19***	-0.50***	-0.54***	-0.61***
			(0.00)	(0.05)	(0.01)	(0.07)
contig			0.46***	0.23***	0.35***	0.19**
			(0.03)	(0.08)	(0.04)	(0.09)
comlang_off			0.07***	-0.01	0.16***	0.12
			(0.01)	(0.10)	(0.03)	(0.13)
colony			0.46***	-1.56***	0.42***	-1.57***
			(0.04)	(0.09)	(0.04)	(0.15)
Constant	3.14***	64.01***				
	(0.14)	(21.37)				
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	161,100	1,900	161,100	1,900	161,100	1,900

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

Source: Own elaboration, 2020.

The specific effects remain, both for the estimators applied to all countries in the sample, and for trade within LA. The GLM structure is a probability-based approach that remains consistent for the parameters of interest, as long as the conditional expectation function is specified correctly, as are the gravitational models (LARCH et al., 2019; SANTOS SILVA; TENREYRO, 2006). Thus, when comparing the coefficients, the pattern of results remains the same as that presented in the previous sections: RTAs have positive effects on value added flows between countries in LA and globally. The effect is positive and greater for intra-regional trade. Elements such as distance or colonial and linguistic relations have been interpreted to include all the observable characteristics that can create resistance.

2.8 SUPPLEMENTARY MATERIAL

DATABASE ORGANIZATION

We adopted three main data sources:

- GVC-UNCTAD-EORA
- Mario Regional Trade Agreements
- CEPII gravity data

Steps and estimation procedure:

1. Data on bilateral value-added flows is from multiregional EORA input-output tables. Available at https://worldmrio.com/unctadgvc/ ("*2. Country by country breakdown, 1990 - 2015"*).
2. Stata Do-file "**0_Organization_EORA.do**" was used to create the main data file.
3. Industry-flows calculations are based on share of interindustries trade according to EORA data. The Matlab code ("**code_eora_c_final.m**") was used by Aslam, Novta, and Rodrigues-Bastos (2017) to supporting the creation of matrix value-added trade flows. Then, Stata Do-file was used to compile specific-pair flows.
4. The data on the "Mario Larch's Regional Trade Agreements Database" of trade agreements was cleaned up, available at https://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html, with the Stata do-file **(.do file)**

code “**2_Database.do**”. In this step, the codes and names of the countries were standardized according to Table 1.

5. The gravitational data had the source and destination codes according to the United Nations Standard Countries/ Area codes. https://unstats.un.org/unsd/methodology/m49/overview/). The data were obtained by CEPII (http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8).
6. The **EORA_c_c.dta** database was consolidated. Both bases were joined in these single file.
7. Descriptive graphs are available in the Excel file (“**Results.xlsx**”).
8. The estimation results were obtained from the Stata Code “**5_Estimation_May02l.do**”.

2.9 DATA STATEMENT

The data that support the findings of this study are openly available in Mendeley Data repository at http://doi.org/10.17632/pvb847766y.1. The full information about the management of public data sources as well as the estimation procedures is available in the same repository.

2.10 APPENDIX

2.10.1 Theoretical foundations of structural gravity equation with intermediates

In this Appendix, we present a theoretical model based on monopolistic trade (Krugman, 1979; Anderson & van Wincoop, 2003) between competitive countries capable to including trade in intermediates. The structural gravity model is a modified version of Krugman & Venables (1996) and Eaton & Kortum (2002) in which gross output is the mass variable instead GDP. This model description is based on study of Aichele & Heiland (2018), Baldwin & Taglioni (2011), Caliendo & Parro (2015) and Jang & Song (2018), and allows us to consider the composite inputs and the multilateral resistance terms in the gravity equation, as emphasized by Anderson and van Wincoop (2003).

Firms produce only one representative good (m, s). These goods produced in the K industries of the world are differentiated. Firms are located in seller or buyer's countries (i, j) along the value chain, and free entry and zero profits are assumed. Each industry produces a variety of intermediate goods (G_i) using labor (L_i) and composite intermediate goods $(Z_i^{k_m})$[22] (composite good m $(m = 1, \dots, M)$ of industry k) as inputs. The production technology is a CES function given by:

$$G_i^k = \left[(\alpha^{kL})^{\frac{1}{\lambda^k}}(L_i^k)^{\frac{\lambda^k - 1}{\lambda^k}} + \sum_{m=1}^{M} (\alpha^{km})^{\frac{1}{\lambda^k}}(Z_i^{km})^{\frac{\lambda^k - 1}{\lambda^k}}\right]^{\frac{\lambda^k}{\lambda^k - 1}}, \tag{1}$$

where $\lambda^k > 1$ is the elasticity of substitution among L_i and Z. Producers of composite intermediate goods demands subinputs (z) from the lowest cost supplier. This implies that the source of the purchase is determined endogenously and may change as a result of tariff reductions or the removal of trade barriers. Thus, it is assumed that the production function is a Dixit-Stiliglitz type (1977) according to:

$$Z_i^{km} = \left[\iint_{s \in N^m} z_i^k(s)^{\sigma^{km-1}/\sigma^{mk}}\, ds\right]^{\frac{\sigma^m}{\sigma^m - 1}} \tag{2}$$

where σ^m is the elasticity of substitution between sub-inputs z_i^m's. For adequacy of input-output (IO) tables structure, we consider two additional assumptions: (1) that no direct labor L is used to produce household's utility (u_i), and (2) σ^m do not depend on industry k (that also uses intermediate inputs). The model assume perfect competition and constant returns to scale and imply that firms charge prices equal to unit costs. Therefore, the unit cost of G_i^k is given by the price index V_i^k:

$$V_i^k = \left[(\alpha^{k_L})(W_i)^{1-\lambda^k} + \sum_{m=1}^{M} \alpha^{km}(P_i^m)^{1-\lambda^k}\right]^{\frac{1}{1-\lambda^k}} \tag{3}$$

---

[22] Caliendo & Parro (2015) refers that as "materials". As each firm produces a single good, we use the notation m and s to represent both firms and goods.

where W_i is the wage rate[23], and P_i^m is the unit price of the composite intermediate good[24] Z. Each seller and buyer's country (i, j) have a representative household (h_i) that maximizes utility according to:

$$u_i = \left[\sum_{m=1}^{M} (\alpha^{hm})^{1/\lambda^h} (Z_i^{hm})^{\lambda^h - 1/\lambda^h}\right]^{\lambda^h/\lambda^h - 1}, \tag{4}$$

where Z_i^{hm} is one composite intermediate good m consumed as a final good by households in country i. This implication follow Caliendo & Parro (2015), which Z produced in industry k are used as materials for the production of intermediate good G in all k industries, and as final goods in the household's consumption.

In country i, the total cost of firm producing n units of an industry k can be represented by $C_i^k = (f_i^k + a_i^k n)V_i^k$, with marginal cost $a_i^k V_i^k$. This cost is equal to total expenditure, due every final good m is produce in the same way that the industry uses the intermediate good (JANG; SONG, 2018a). Thus, the CES demand function of a composite intermediate good is

$$p_i(s) z_i^k(s) = \left[\frac{p_i(s)}{P_i^m}\right]^{1-\sigma^m} \gamma_i^{km} E_i^k \text{ for } s \in N^m \tag{5}$$

where N is a subset of produced goods. Applying Shepard's lemma, we can recuperate the shares of labor and composite intermediate goods in the final expenditure of i:

$$\gamma_i^{kL} = \frac{w_i L_i^k}{E_i} = \alpha^{kL} \left(\frac{W_i}{V_i^k}\right)^{1-\lambda^k} \text{ and } \gamma_i^{km} = \frac{P_i Z_i^{km}}{E_i} = \alpha^{km} \left(\frac{P_i^m}{V_i^k}\right)^{1-\lambda^k} \tag{6}$$

where E_i is a total expenditure of a country i (equal to GDP plus net imports). The strength of the correlation is governed by the cross-sectoral intermediate cost shares. As a result, an important condition of the model is that these costs directly determine the proportion

[23] Caliendo & Parro (2015) considers that income is derived from two sources: households supply labor at a wage rate and transfers on a lump-sum basis (tariff revenues and transfers from the rest of the world).

[24] The price index is equal to $P_i^m = \left[\int_{s \in N^m} p_i(s)^{1-\sigma^m} ds\right]^{\frac{1}{1-\sigma^m}}$, where $p_i(s)$ is the price of good s in a country i.

of value-added in terms of inputs produced in each country along the value chain[25]. Both equations are analogous to the share of value added in each country, since the profit of each firm is zero and all firms are symmetrical.

As in Caliendo & Parro (2015), bilateral trade shares γ_i can take the form of a multisectoral version in gravity equation. The cost of the sub-input of Z^{km} depends on the wages rate and the price of all intermediate goods in the economy. A change in trade policy can affect the price in any single sector and will indirectly influence the use of sub-input along the GVC, and, furthermore, changing the local content (L_i) embodied into each country's trade, according to firm behavior[26]. The firms maximize profit and set its prices as a *markup over the marginal cost*, based on elasticity' price of its demand given by σ^m. Thus, the price of good m exported by i to j is[27]:

$$p_{ij}^m = \tau_{ij}^m \left(\frac{\sigma^m}{\sigma^m - 1}\right) c_i^m \quad (7)$$

where τ_{ij}^m is the iceberg-type bilateral trade cost factor and includes RTAs. Bilateral trade costs fall within the gravity structure that can vary across regions and industries. Implications of RTAs (related to depth and provisions, for example) affect directly the value added share as they depend on the cost unit through c_j^m as acting to reducing trade barriers. As with standard gravity models, we consider that the profit margin is identical for all destinations if we assume perfect competition or monopolistic Dixit-Stiglitz competition; in these cases, the price variation is characterized by transfering of trade costs to consumers in the destination market j (Baldwin & Taglioni, 2011).

The composite intermediate goods used by industries are same production technology as the composite final good. Thus, based on demand function in Equation (5)[28], the total value traded from i to j is given by:

[25] The characteristics of the type of integration of each country in the global chains are essential for the international heterogeneity of this ratio. As the importance of intermediary trade increases, gravitational estimates using GDP is lower. The influence of trade costs affects the demand and supply of intermediaries across global production networks.

[26] There is a discussion in the theoretical literature about the effects of relocation on the use of domestic and foreign labor (see Grossman & Rossi-Hansberg (2012)). An important point in this discussion is the substitution between local or foreign production in some sectors, in which the different price of labor induces the dispersion of production at an international level.

[27] Here, $p_j(s) = p_{ij}^m$ if $s \in N^m$ and s is produced in a country i.

[28] The value of good s produced in country i and sold in country j, both as an intermediate good as a final good, is identical for all n_i^m firms' production in country i.

$$T_{ij}^{m} = n_i^m \left(\frac{p_{ij}^m}{p_j^m}\right)^{1-\sigma^m} \left(\sum_{k=1}^{M} \gamma_j^{km} n_j^k C_j^k + \gamma_j^{hm} E_j\right) \quad (8)$$

where $n_j^k C_j^k$ is the total cost of industry k in country j that equals to their gross output (Y_j^m). The structure of the model is closed considering trade imbalances. IO data assume that the total value of goods supplied to the country is equal to its domestic production, plus imports minus exports (AICHELE; HEILAND, 2018). From (8), we can write this as $\sum_{k=1}^{M} \gamma_j^{km} n_j^k C_j^k + \gamma_j^{hm} E_j = Y_j^m + \left(IM_j^m - EX_j^m\right)$. The share of domestically produced goods and imported goods can be obtained dividing γ_j^{km} in two parts, as $\gamma_j^{km_d} = \gamma_j^{km_d} + \gamma_j^{km_f}$ and imported goods, $\gamma_j^{km_f} = \gamma_j^{hm_d} + \gamma_j^{hm_f}$, respectivally. Using (7), the value traded between i and j can be write as:

$$T_{ij}^{m} = n_i^m \left(\frac{\sigma^m}{1-\sigma^m} C_i^m\right)^{1-\sigma^m} \left(\frac{\tau_{ij}^{m}}{p_j^m}\right) Y_j^m (1+\phi^m) \quad (9)$$

where net imports are $\phi^m = \left(\frac{IM_j^m - EX_j^m}{Y_j^m}\right)$. Following Jang & Sang (2018), the sum of T_{ij}^m over all $j's$, including domestic sales X_{ii}^k must be equal to Y_i:

$$Y_i^m = n_i^m \left(\frac{\sigma^m}{1-\sigma^m} C_i^m\right)^{1-\sigma^m} \left[\sum_j \left(\left(\frac{\tau_{ij}^m}{P_j^m}\right)^{1-\sigma^m} \frac{Y_j^m (1+\phi_j^m)}{Y_W^m}\right)\right] Y_W^m \quad (10)$$

where $Y_W^m = \sum_j Z_j^m$. Let's the expression inside of brackets equal to Π_i^m. Solving $n_i^m \left(\frac{\sigma^m}{1-\sigma^m} C_i^m\right)^{1-\sigma^m}$ in (9) and plugging in Equation (10) with Π_i^m yields the gravity equation for a world with intermediate's trade as:

$$T_{ij}^{m} = \left(\frac{\tau_{ij}^m}{\Pi_i^m P_j^m}\right)^{1-\sigma^m} \frac{Y_i^m Y_j^m (1+\phi_j^m)}{Y_W^m} \quad (11)$$

As in Baldin & Taglioni (2011), expression (11) is the modified gravity equation to allow trade intermediates, with gross output as a mass variable, since purchases are now driven by both consumer demand (whose income is the demand shifter) and intermediate demand (for which total production costs demand shifts). In a world where intermediates are relevant, RTAs can reinforce the relationship between seller and buyer in GVC. The reduction of trade barriers reduces trade costs and expands bilateral flows (JINJI; ZHANG; HARUNA, 2019). It is important to emphasize that there is a direct relationship between country-pairs along the value chain, with specific functions governed by specific regions. Cross-border policies influence trade when production is internationally fragmented (ANTRÀS et al., 2013). The governance and coordination structure implies that value added traded does not depend only on bilateral costs, but also on costs with third countries. In this way, we use data from a global IO structure, which incorporates bilateral flows over time. Deeper RTAs explicitly include provisions that encourage technological dissemination (Amendolagine et al, 2019; Laget et al., 2018). As a result, the technological potential of each country can spread throughout the global production networks.

3 REGIONAL INEQUALITY AND CO2 EMISSIONS-BASED TRADE ACROSS VALUE CHAINS: A MULTISCALAR ASSESSMENT FROM BRAZILIAN' STATES[29]

Abstract

This article analyses the interregional linkages and the relative intensity of CO2 emissions embedded across Domestic Value Chains (DVC) and Global Value Chains (GVC) from Brazilian states. An extended environmentally interregional input-output (EEIO) is applied to measure the bilateral trade in value-added (TiVA) and the total implicit emissions trade (TTE). The results reveal unbalanced pollution patterns in space. Few industrialized hubs in Southeastern core states (mainly São Paulo and Rio de Janeiro) are responsible for most interregional consumption of resources industries from peripheries, implying environmental responsibility on the regional pool in value chains. By recognizing the role that interregional trade plays in greenhouse gas emissions (GHG) within the country, opportunities are opened to develop local strategies to reduce spatial gaps in industrial sustainability.

Keywords: Greenhouse gas emissions (GHG). Implicit emissions. Trade in value-added (TiVA). Value chain integration. Regional sustainable. Brazil

JEL Classification: R12. R15. Q52.

3.1 INTRODUCTION

There is a gap in recognizing the spatial variability of carbon footprints at different spatial scales (Batabyal & Folmer, 2020). Therefore, this paper analyzes the interregional linkages and the relative GHG emissions intensity embedded in Domestic Value Chains (DVC) and Global Value Chains (GVC). For that, an interregional input-output (IRIO) strategy is applied to Brazilian regions. GHG linkages consider carbon dioxide (CO2) coefficients at the industry-level. We measure the bilateral trade in value-added (TiVA) (Chen et al., 2017; Liu et al., 2019) from a multiscalar perspective, being more relevant

[29] This is a short second-round review manuscript for the Early Career section of the journal *Regional Studies, Regional Science*.

in large countries like Brazil that can architect spatially domestic networks and global ones.

This study's novelty identifies carbon footprints across subnational areas. This link is made by accounting for the GHG embedded in each pair of origin-destination, including DVC (interregional) and GVC (exports) (Owen et al., 2018). We measure the backward (BL) and forward (FL) linkages, as well as the relative intensities of domestic value-added (DVA) in trade and GHG flows, based on hypothetical extraction method (HEM) techniques (Zheng et al., 2020). Therefore, this paper advances as explicitly assessed the pollution in space, considering production networks' as a GHG transfer mechanism.

The results reveal that Brazilian inequalities deal with unbalanced industrial structures, implying uneven environmental responsibilities across DVC and territorial content supplied to GVC. By including a spatial dimension in environmental accounting, we provide a useful assessment regarding the need to consider uneven integration patterns to design place-based sustainable policies.

3.2 LITERATURE REVIEW

Despite the growing concern about climate change, little attention is given to the subnational geography of GHG in trade (Wang et al., 2019). Spatial articulation within networks is relevant to understanding the uneven integration opportunities (Atienza et al., 2018). The resources peripheries are often unable to capture the value created in their territories, implying an unsustainable linkage (Atienza et al., 2020). The combination of interaction DVC and GVC can provide useful insights to discuss trade-offs between subnational integration and pollution embedded in trade.

As sustainable development is not spatially neutral, regional inequalities matter to promote structural changes for sustainable quality linkages (Zheng et al., 2020). Given the economic effort involved in mitigating GHG, it is essential to assess the link between regional performance and CO2 emissions to understand carbon footprint geography (Sajid et al., 2019; Zhang et al., 2020; Yamano, N., & Guilhoto, 2018). Besides, the degree of regional exposure to production networks depends on spatial variations, being relevant analyses the articulation for both BL and FL GHG linkages for building sustainable value chains (Atienza et al., 2020; Martinus, 2018).

Empirically, the environmentally extended input-output (EEIO) models have received considerable attention in assessing GHG in trade (Ali et al., 2018; Meng et al., 2018; Zheng et al., 2020). There is an analytical potential for integrating the economic, social, and environmental interactions as a pillar of sustainability (Su et al., 2017). Nonetheless, there is a need for theoretical inclusion of spatial dimension. Recent efforts are attempting to include intra-country measures in developed countries (Ali et al., 2018; Chen et al., 2017); however, not seen the role of TiVA. Therefore, it is useful to assess the territorial endowments embodied in TiVA (Haddad et al., 2020). It can be more relevant in large developing countries like Brazil, with high resource-based BL towards GVC and persistent inequalities (Cruz et al., 2019).

3.3 DATA AND METHODOLOGY

This study relies on the 2011 IRIO calculated by the University of Sao Paulo Regional and Urban Economics Lab (NEREUS) (Haddad et al., 2017). An EEIO matrix was used, having 27 regions and 68 industries. The industry-level emissions database is given by EDGAR and EORA-Multiregional tables (Lenzen et al., 2013).

Initially, we assess the degree of spatial interdependency of total GHG generated inside the country, measuring the structural BL and FL total CO2 linkages applying the hypothetical extraction method (Dietzenbachen, 1993; Ali, 2015). The CO2 coefficient[30] is given by:

$$\boldsymbol{\varphi}_{\mathbf{s}} = \frac{\mathrm{P_s}}{\mathrm{x_s}} \qquad (1)$$

where $\mathrm{P_s}$ is the total emissions and $\mathrm{x_s}$ the total output of an industry s. Therefore, $\boldsymbol{\varphi}$ is the vector representing the direct emissions of each industry in the IRIO model. The total direct and indirect CO2 emissions are measured by multiplying $\boldsymbol{\varphi}$ by the Leontief and Ghosh inverses matrix. The demand-side is given by $\mathbf{C^d} = \hat{\boldsymbol{\varphi}}(\mathbf{I} - \mathbf{A})^{-\mathbf{1}}\mathbf{f}$ and the supply-side by $\mathbf{C^s} = \mathbf{v}'(\mathbf{I} - \mathbf{B})^{-\mathbf{1}}\hat{\boldsymbol{\varphi}}$; where $\mathbf{A}$ is a technical coefficients matrix that is equal to $\mathbf{A} = \mathbf{Zx^{-1}}$, $\mathbf{B} = \hat{\mathbf{x}}^{-\mathbf{1}}\mathbf{Z}$ represents the output coefficients, being $\mathbf{Z}$ the input requirements needed to produce \$1 output; $\mathbf{v'}$ is the row vector of value-added (VA) for each region

[30] Industrial compatibility and emission intensity coefficients are in Annex I.

and industry, and $\mathbf{f}$ represents the final demand.

The effect of extracting the interregional relations in region 1 is backward in essence, being represented by $\mathbf{BL}_{s} = \left[\mathbf{C}^{\mathrm{d}} - \mathbf{C}^{\mathrm{d}^*}\right]$. The superscript $*$ represents the Cella HEM extraction from the IRIO (Cella, 1984; Dietzenbachen, 1993; Perobelli, 2008). The same logic is applied to the supply-side, $\mathbf{FL_s} = \mathbf{C}^{\mathrm{s}} - \mathbf{C}^{\mathrm{s}^*}$. For both BL and FL, the normalized indexes show the relative changes associated with the Cella HEM, given by:

$$\mathbf{BL_s^n} = \left[\frac{\mathbf{i'C^d} - \mathbf{i'C^{d^*}}}{\mathbf{i'C^d}}\right] \text{ and } \mathbf{FL_s^n} = \left[\frac{\mathbf{i'C^s} - \mathbf{i'C^{sy^*}}}{\mathbf{i'C^s}}\right] \quad (2)$$

where $\mathbf{i}$ is a summation vector of ones. $\mathbf{BL^n} > 1$ suggests that the increase of a \$1 of $\mathbf{f}$ will produce an increase in emissions above the average without an extraction, whereas $\mathbf{FL^n} > 1$shows that the increase of \$1 of VA will generate emissions in the same way. Both BL and FL above to unity can be defined as a key region in generating emissions (Chang & Lahr, 2016).

Afterward, we account for the intensity of GHG in production networks from a multiscalar perspective. Initially, we estimated the bilateral TiVA for each origin-destination pair across DVC and GVC (exports). The DVC assessment consists of how much of VA region 1 send to region n. In specific, is the difference of the $\mathbf{DVA}$ of 1, $\mathbf{DVA_{1,n}} = \mathbf{v_1}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{fi}$, where $\mathbf{v_1}$ a row matrix of VA coefficients of region 1 and zeros elsewhere like $\mathbf{v_1} = [\widetilde{v_1} \quad 0 \cdots \quad 0]$. The counterfactual of DVA is based on the hypothetical extraction of the intermediate and final demand relations between 1 and n. Indeed, it equals to $\mathbf{DVA^*_{1,n}} = \mathbf{v_1}\left(\mathbf{I} - \mathbf{A^*_{1,n}}\right)^{-1}\mathbf{f^*_{1,n}i}$. Therefore, $\mathbf{TiVA_{1,n}} = \mathbf{DVA_{1,n}} - \mathbf{DVA^*_{1,n}}$. Assuming that exports are exogenously defined, the account of TiVA to foreign markets $\{\mathrm{m} = \mathrm{RoW}\}$ represents how much VA each state supply to GVC.

Then, we measured the bilateral trade in implicit emissions (TTE), following the same TiVA logic but replacing $\mathbf{v}$ by $\boldsymbol{\varphi}$. Therefore, from region 1 to region n, the TTE is given by $\mathbf{TTE_{1,n}} = \mathbf{TTE_1} - \mathbf{TTE^*_{1,n}}$. By combining TiVA measurements with GHG content in production networks from a multiscalar perspective, we provide useful measures to understand GHG regional inequalities. The polluting intensity of production networks was measured by a trade-based index (TBI) of CO2 emissions, as suggested by Haddad et al. (2020). TBI is the ratio of each TiVA flow and the total TiVA by the ratio of each TTE flow and the total TTE. The TBI from region 1 to region j (for DVC or GVC) is given by:

$$\mathbf{TBI_{1,j}} = \frac{\mathbf{TTE_{1,j}}}{\sum_i \mathbf{TTE}} \Bigg/ \frac{\mathbf{TIVA_{1,j}}}{\sum_\mathbf{i} \mathbf{TiVA}} \quad \forall\ \mathrm{i}, \mathrm{j} = 1, \ldots \mathrm{n}, \mathrm{m} \qquad \textbf{(3)}$$

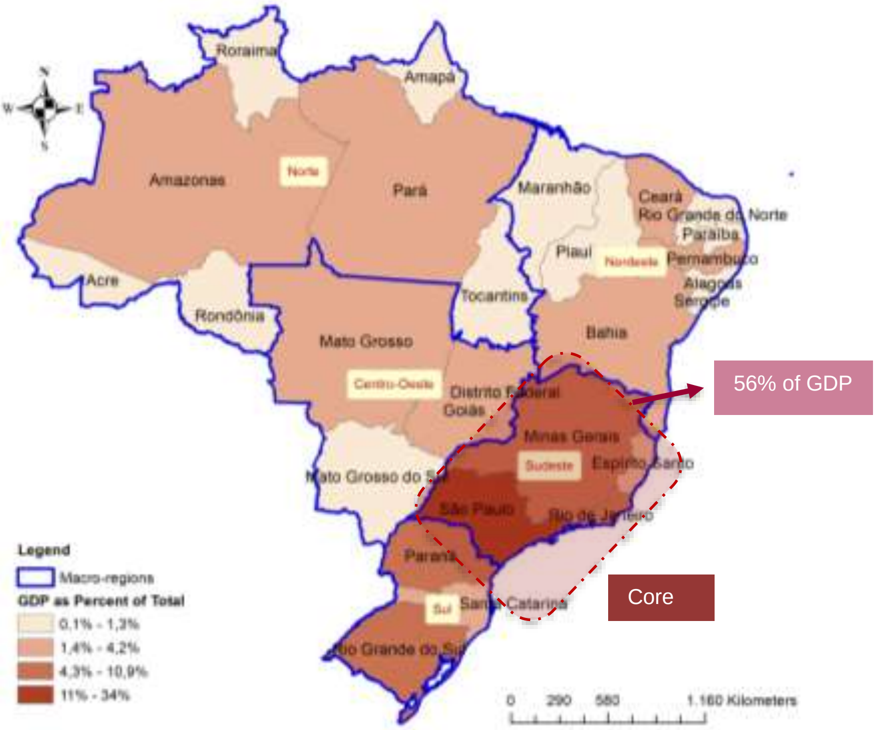
Values greater than 1 indicate that the value chain is potentially polluting compared to the DVA traded for each origin-destination pair. Values less than 1 show the opposite.

3.3.1 Case study overview

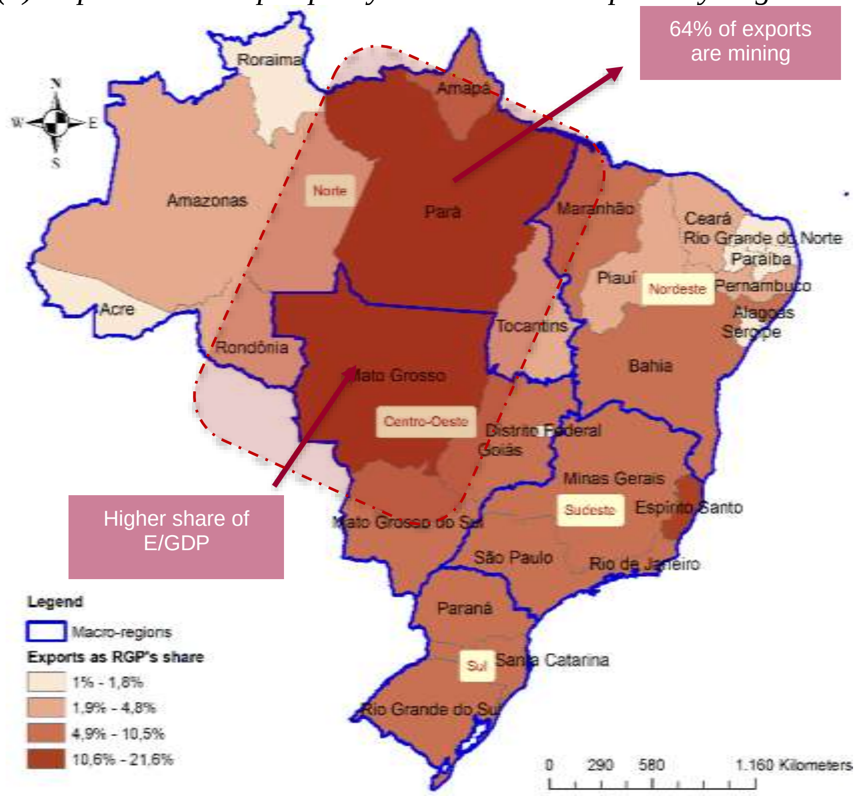
Figure 1 shows the core-periphery economy geography pattern in Brazil (1a) and the uneven spatial export orientation (1b). Economic concentration occurs in the poles of Southeastern states - São Paulo (SP), Rio de Janeiro (RJ), Minas Gerais (MG), and Espírito Santo (ES). This core area has an area representing just 11% of the territory but 53% of the national GDP and 42% of the population in 2017 (IBGE, 2020). These states also concentrate on the leading educational and R&D hubs, the financial market, the manufacturing industry, and close to 60% of FDI (Banco do Nordeste, 2016). The peripheries (mainly Midwest and North) follow an export-based growth model. There is a specialization in resource industries (mostly grains and cattle and mining).

Figure 1. Brazilian regional inequalities

(a) Core-periphery pattern – Regional GDP



(b) Export-based in periphery – Ratio Gross Exports by Regional GDP



Source: Authors based on 2011 Brazilian IRIO (Haddad et al., 2017).

Table 1. Brazilian states

Macrozone	Acronyms	State' name
North	RO	Rondônia
	AC	Acre
	AM	Amazonas
	RR	Roraima
	PA	Pará
	AP	Amapá
	TO	Tocantins
Northeast	MA	Maranhão
	PI	Piauí
	CE	Ceará
	RN	Rio Grande do Norte
	PB	Paraíba
	PE	Pernambuco
	AL	Alagoas
	SE	Sergipe
	BA	Bahia
Southeast	MG	Minas Gerais
	ES	Espírito Santo
	RJ	Rio de Janeiro
	SP	São Paulo
South	PR	Paraná
	SC	Santa Catarina
	RS	Rio Grande do Sul
Midwest	MS	Mato Grosso do Sul
	MT	Mato Grosso
	GO	Goiás
	DF	Federal District

3.4 EMPIRICS

We have extended the Cella HEM to assess the linkages of CO2 emissions, as shown in Table 2. It is noteworthy that Brazil is formed by several small economies with lower $\mathbf{BL^n}$ and $\mathbf{FL^n}$. The differences between total CO2 on the supply and demand side grow according to the hierarchical position of Brazilian states in the DVC. The peripheral economies of the North, Northeast, and Midwest have similarities in the size of linkages. An exception is in AM – which has the Manaus Free Zone, an important industrial complex in Northern Brazil. Indeed, AM is a key region, being a potential governance driver of transferring CO_2 across networks. The spatial pattern changes when we observe the differences between BL and FL for Southeastern and Southern states, revealing the network complexity on organizing DVC.

Table 2. BL and FL Cella HEM at regional level

Macrozone	State	Demand-side		Supply-side		Role in interregional system
		Total CO2	Normalized	Total CO2	Normalized	
North	RO	595.64	0.32	835.82	0.29	Self-Dependent
	AC	108.63	0.07	146.91	0.07	Self-Dependent
	AM	4,568.54	1.38	3,380.19	1.19	Key
	RR	82.93	0.05	92.21	0.04	Self-Dependent
	PA	2,404.92	0.96	2,033.41	0.94	Self-Dependent
	AP	129.98	0.07	139.81	0.05	Self-Dependent
	TO	486.84	0.21	412.36	0.20	Self-Dependent
Northeast	MA	1,175.44	0.54	966.05	0.49	Self-Dependent
	PI	585.62	0.25	533.02	0.23	Self-Dependent
	CE	1,972.13	0.78	1,678.78	0.67	Self-Dependent
	RN	862.80	0.37	777.78	0.38	Self-Dependent
	PB	1,091.43	0.40	928.00	0.35	Self-Dependent
	PE	3,461.09	1.16	3,013.43	1.07	Key
	AL	1,261.33	0.41	1,141.42	0.46	Self-Dependent
	SE	963.27	0.33	536.72	0.34	Self-Dependent
	BA	6,119.14	2.52	4,484.87	2.14	Key
Southeast	MG	14,252.84	5.30	10,936.96	4.63	Key
	ES	2,391.86	1.12	1,714.16	1.20	Key
	RJ	17,683.78	5.33	7,566.93	5.36	Key
	SP	53,106.29	16.02	37,496.64	14.36	Key
South	PR	10,402.84	4.39	8,828.23	3.96	Key
	SC	5,921.89	2.39	5,084.56	2.13	Key
	RS	8,424.95	3.54	8,103.31	3.10	Key
MidWest	MS	2,111.99	0.86	2,018.86	0.91	Self-Dependent
	MT	2,404.82	1.14	2,669.94	1.12	Key
	GO	4,509.56	1.87	4,737.63	1.78	Key
	DF	1,761.12	1.27	1,939.82	0.80	Base

Source: Authors, 2020.

The industry[31] role of total CO_2 is implicitly embedded in a multiscalar perspective is shown in Table 3, whereas the results at the regional level are in Table 4. TTE results reveal that Agricultural and Forestry industries, together with Energy, represent about 15% of the total CO_2 implicit in trade for DVC and GVC. Manufacturing

[31] Annex II details the industrial linkages on the demand and supply side.

industries stand out, responsible for more than 50% of TTE, while the tertiary sectors appear next, representing around 18%. An important role for GHG transfers is played by Wholesale and Retail industries, which have the highest $\mathbf{BL^n}$ in the meantime, in the fourth rank in the total CO2 emissions, revealing the potential of interregional flows induces emissions. Notwithstanding, trade relations at the subnational level differ from those foreign export orientations. The formation of DVC indicates that, except for SP, all other states have a heterogeneous profile being net importers or exporters of GHG in trade. SP (core Southeast), AM (north), and, with less extended PE (Northeast) and RJ (Southeast), are net interregional redistribution of CO2. However, when analyzing GVC-related flows, other states stand out as net exporters, apart from AM and RJ, which reveal themselves to be net importers to GVC partners. States that have a more diversified production structure – such as those in the South (RS, SC, and PR), the Southeast (MG and ES), and the Northeast (BA) – are net GHG importers across DVC.

Table 3. Industry-level (ISIC-Group) composition of implicit GHG to final demand (Gg CO2 per BRL Million)

Industry	Domestic		Foreign		Composition	
	Implicit emissions	(%)	Implicit emissions	(%)	Domestic	Foreign
Accommodation and food	3,588.74	1%	1,676.09	3%	68%	32%
Administrative activities and complementary services	15,646.95	5%	3,393.80	5%	82%	18%
Agriculture, livestock, forest production, fisheries and aquaculture	13,881.96	5%	2,989.43	5%	82%	18%
Arts, culture, sport and recreation	2,602.20	1%	521.65	1%	83%	17%
Construction	6,579.46	2%	432.35	1%	94%	6%
Domestic services	1,446.63	0%	0.00	0%	100%	0%
Education	1,492.53	1%	43.42	0%	97%	3%
Electricity and gas	15,815.05	5%	2,253.80	4%	88%	12%
Extractive industries	3,919.59	1%	2,775.07	4%	59%	41%
Financial, insurance and related services	8,308.26	3%	807.18	1%	91%	9%
Human health and social services	1,718.61	1%	4.00	0%	100%	0%
Information and communication	19,811.14	7%	1,410.36	2%	93%	7%
Manufacturing industries	152,482.32	52%	35,104.52	57%	81%	19%
Other service activities	1,382.64	0%	100.05	0%	93%	7%
Professional, scientific and technical activities	16,886.27	6%	5,139.94	8%	77%	23%
Public administration, defense and social security	3,594.37	1%	130.69	0%	96%	4%
Real estate activities	2,996.34	1%	346.97	1%	90%	10%
Trade; repair of motor vehicles and motorcycles	8,799.91	3%	2,996.39	5%	75%	25%
Transport, storage and mail	-	-	-	-	-	-
Water, sewage, waste management and decontamination activities	13,846.06	5%	1,685.68	3%	89%	11%
All industries (Brazil level)	294,799.06	100%	61,811.40	100%	83%	17%

Source: Authors, 2020.

Table 4. Emissions on multiscalar trade (outflows and inflows by origin, Gg CO2)

Macrozone	State	Subnational				Foreign			
		Outflows	**(%)**	**Inflows**	**(%)**	**Exports**	**(%)**	**Imports**	**(%)**
North	**RO**	1,674.4	0.6%	2,336.8	0.8%	195.2	0.3%	171.7	0.3%
	AC	282.1	0.1%	606.8	0.2%	27.4	0.0%	34.2	0.1%
	AM	10,602.0	3.6%	6,460.8	2.2%	1,107.1	1.8%	2,015.7	3.7%
	RR	184.5	0.1%	395.5	0.1%	11.0	0.0%	28.0	0.1%
	PA	4,340.4	1.5%	5,802.8	2.0%	2,011.6	3.3%	786.4	1.5%
	AP	253.7	0.1%	574.9	0.2%	69.3	0.1%	43.5	0.1%
	TO	1,087.1	0.4%	1,515.4	0.5%	109.5	0.2%	103.0	0.2%
Northeast	**MA**	2,251.4	0.8%	3,628.9	1.2%	563.5	0.9%	338.9	0.6%
	PI	1,228.3	0.4%	1,806.3	0.6%	106.1	0.2%	151.7	0.3%
	CE	4,509.0	1.5%	5,356.9	1.8%	407.1	0.7%	648.0	1.2%
	RN	1,786.9	0.6%	2,559.4	0.9%	151.3	0.2%	309.0	0.6%
	PB	2,219.7	0.8%	2,688.9	0.9%	140.3	0.2%	268.6	0.5%
	PE	7,179.9	2.4%	6,613.9	2.2%	1,145.5	1.9%	1,054.2	2.0%
	AL	2,367.9	0.8%	2,120.7	0.7%	1,372.0	2.2%	324.2	0.6%
	SE	1,664.2	0.6%	1,838.5	0.6%	101.3	0.2%	268.7	0.5%
	BA	10,425.5	3.5%	14,964.4	5.1%	2,193.2	3.5%	2,490.7	4.6%
Southeast	**MG**	26,034.6	8.8%	28,807.8	9.8%	6,385.4	10.3%	4,863.8	9.0%
	ES	3,905.3	1.3%	6,675.1	2.3%	1,635.8	2.6%	828.1	1.5%
	RJ	29,411.2	10.0%	28,361.5	9.6%	4,771.9	7.7%	5,676.5	10.5%
	SP	105,374.6	35.7%	79,889.5	27.1%	23,848.5	38.6%	21,710.1	40.2%
South	**PR**	21,106.3	7.2%	25,834.1	8.8%	4,074.2	6.6%	3,358.6	6.2%
	SC	12,199.9	4.1%	14,298.4	4.9%	2,350.1	3.8%	1,937.1	3.6%
	RS	18,620.0	6.3%	20,456.9	6.9%	3,939.8	6.4%	3,578.6	6.6%
MidWest	**MS**	4,625.2	1.6%	4,775.3	1.6%	976.0	1.6%	518.9	1.0%
	MT	5,657.9	1.9%	6,075.8	2.1%	2,189.7	3.5%	665.7	1.2%
	GO	10,586.4	3.6%	10,420.3	3.5%	1,689.9	2.7%	1,183.5	2.2%
	DF	5,220.8	1.8%	9,933.5	3.4%	238.9	0.4%	623.7	1.2%
Brazil		294,799.1	100.0%	294,799.1	100.0%	61,811.4	100.0%	53,980.9	100.0%

Source: Authors, 2020.

It is relevant to analyze the relative intensity of emissions in bilateral TiVA for both DVC and GVC. Based on Equation (3), Figure 2a shows the average TBI for each state in Brazil[32]. The results reveal different regional patterns. On the sales side (vertical axis), the AM state shows potential for transferring VA to the rest of the country. Meanwhile, the VA is also intense in GHG, increasing the TBI values. The other states of the Northern macrozone follow a spatial pattern like that of AM, with emission transfer rates higher than one for most of their interstate partners.

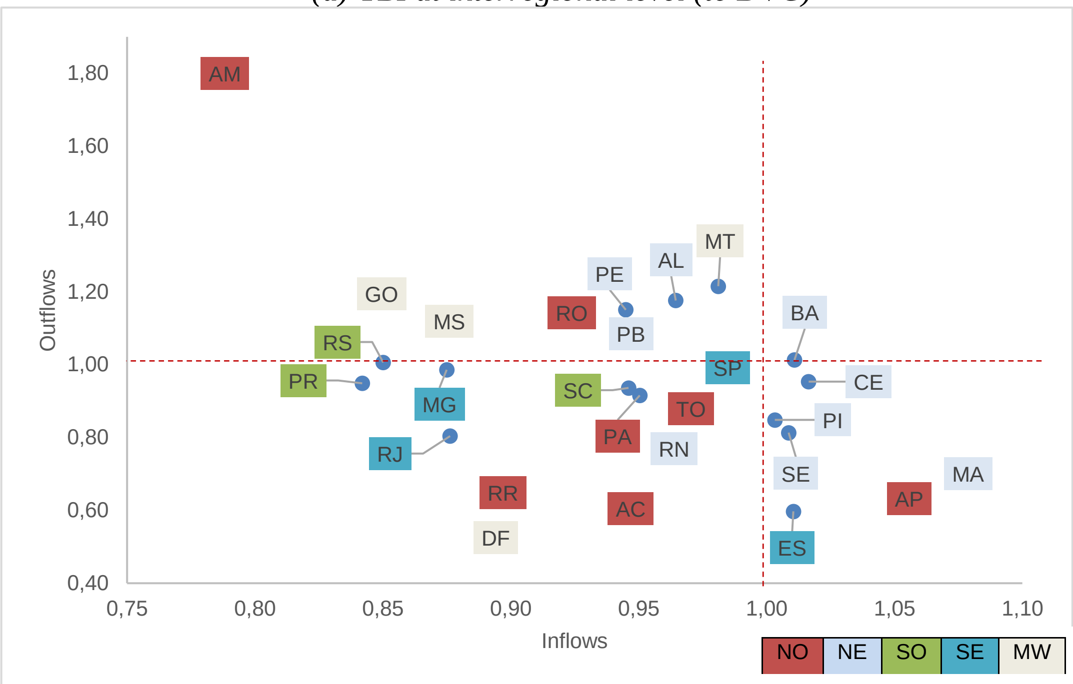
Regarding inflows, the Northern states receive intense polluting TiVA transfers from Northeastern and Midwestern states, driven by geographical proximity. Finally, Figure 2b shows the TBI's average considering TiVA from and towards GVC. Comparing the DVC with GVC, it is noteworthy that the regions specialized in resource

[32] Annex III shows the complete table with the 27 subnational origins and the RoW pairs of origin-destination of TiVA, TTE and TBI indexes.

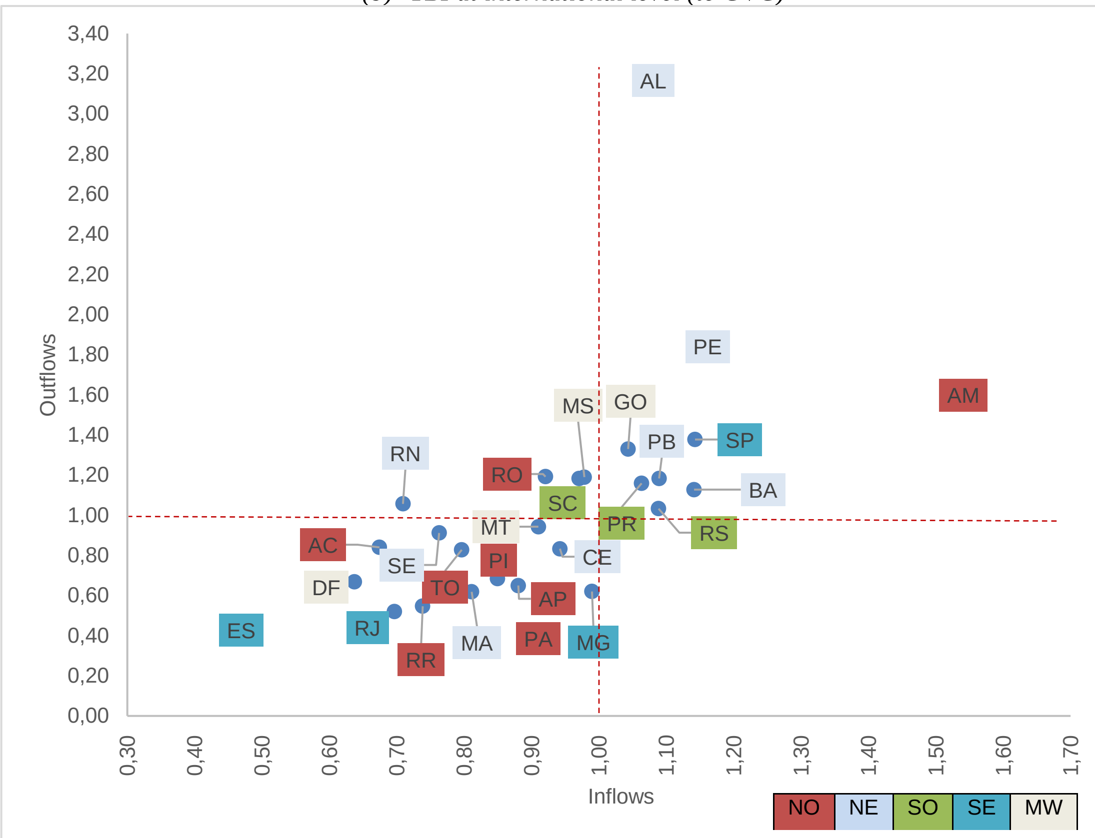
industries – mainly in the Northeast – are highly intense in CO2 emissions in exports. AL stands out (it is the most Sugar manufacture and refining exporter in Brazil), and PE has the highest TBI, indicating that foreign demand induces the incorporation of pollutants in both states. The AM' state is also higher exporter pollution towards GVC, together with SP, BA, and RS.

Figure 2. Multiscale TBI index (average)

(a) TBI at interregional level (to DVC)



(b) TBI at international level (to GVC)



Source: Authors, 2020.

3.5 DISCUSSION

About 30% of global emissions originating from international trade (Yamano & Guilhoto, 2018). Our results show that interregional TiVA is more relevant to GHG generation in Brazil. Approximately 83% of emissions embedded in trade are absorbed within the country, revealing the need to analyze the geography of emissions. Our assessment identified the main patterns of GHG interdependencies across different spatial scales (Chang & Lahr, 2016). Furthermore, the variety of industrial vocations in the territories imply a prominent heterogeneity in space, building a more complex network of GHG generation and transferring (Imori et al., 2018; Atienza et al., 2018). As much as the industries have heterogeneous CO2 intensity coefficients, the spatial location of production points out the polluting role across networks (Zheng et al., 2020). Interestingly, peripheries have relatively lower total TTE originated in their territories, while core areas are all key (**BL**$^{\mathbf{n}}$ and **FL**$^{\mathbf{n}}$ above than a unity). There is polluting governance dependent on the Brazilian DVC architecture, as **FL** surpasses **BL**, indicating that core states potentially orchestrate polluting exchanges within DVC.

Our results show that manufacturing can provide higher VA for both DVC and GVC, being the most intense GHG in the industrial pool[33]. It is relevant for tracing GHG along value chains. Besides, more complex linkages are in diversified core areas, implying the double role of demanding polluting inputs from the hinterland (induced effect) and transferring across networks. Therefore, the Southeastern hierarchical buyer-supplier relations become a relevant component for identifying spatial environmental responsibility. TBI results reveal that inequalities' strength becomes a critical analytical tool to guide policymakers to mitigate the pollution intensity in networks. It can impose enclaves for local capacities to environmentally sustainable integration in value chains, being the core states the main entrance and exit door for implicit GHG in Brazil. Remote regions (border peripheries) have diffused positions, depending on how they are linked to DVC and GVC. The local capacity to build consistent DVC is most evident in large countries, as the hinterlands connectivity to main hubs or gateways poles can be addressed (Chen et al., 2017). When this picture is analyzed under the lens of environmental accounting, the strength of inequalities becomes a critical analytical tool to guide policymakers to mitigate the pollution intensity in networks.

3.6 CONCLUSIONS

Spatial interdependencies matter to drive regional sustainability strategies. A relevant point demonstrated is that networks can transfer GHG across both DVC and GVC. Subnational networks can incorporate emissions by connecting directly to GVCs, or through production made within the country (along the DVCs), then exported to GVCs. The paper's novelty identifies unbalanced spatial patterns, where few industrialized hubs are responsible for most of the interregional consumption of resources industries from Brazilian's peripheries. By recognizing the role that interregional trade plays in GHG emissions within the country, opportunities are opened to develop local strategies to reduce spatial gaps in industrial environmentally sustainability.

Therefore, the construction of low-carbon gradual adaptation and mitigation strategies can be shaped by DVC's perspective and interaction with GVC ones. Low-

[33] The emission coefficients of primary activities (agriculture, forest, and mining) are high (see Annex I), but the DVA is relatively small, given the primary character of the industry.

GHG governance across different supply chains requires understanding connectivity patterns – that are not spatially neutral. Promoting local capacities to build territorial assets would create the basis for integration at higher steps of the value chain, contributing to reduce interregional gaps. Understanding the role of territorial vocations in defining the governance of production networks is necessary, being relevant to drive the direction of environmentally sustainable development policies within borders.

Despite advances in understanding intense subnational chains in GHG, our spatial view was restricted by an administrative setting. This view hides a set of relevant embeddedness territorial aspects. The EEIO strategy hidden the play role of some socioeconomic actors, allow us to create a partial picture of networks. However, extending the application to identify the final demand's environmental responsibility allows a broad understanding from an agent-based perspective.

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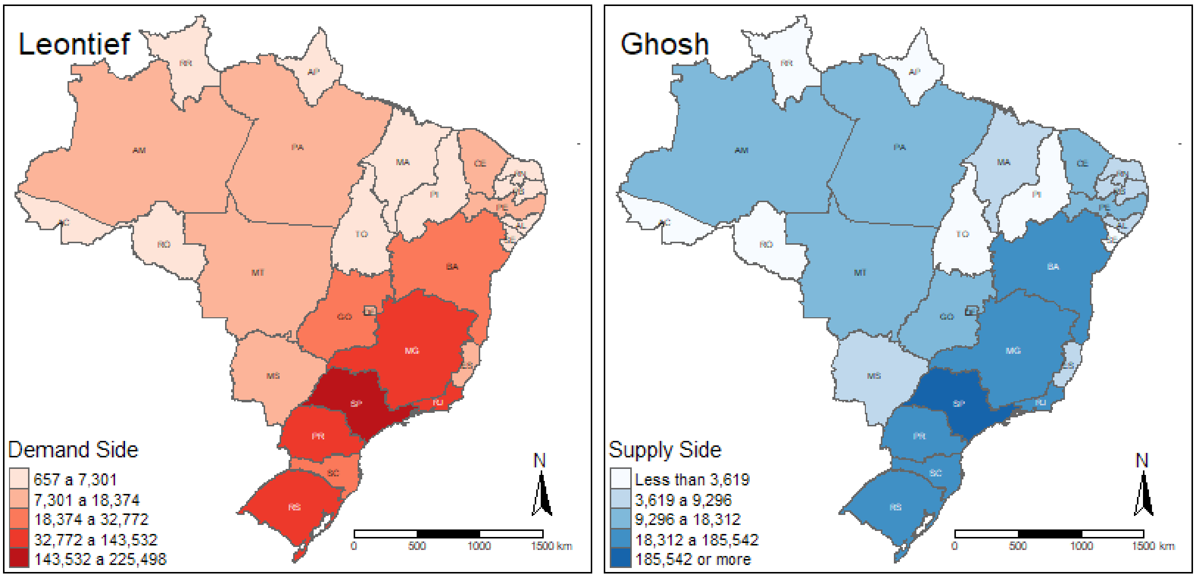
3.7 ANNEX

Figure I.1. Total of CO2 emissions in regional economics (demand and supply side)



Note: Figure I.1 shows the total emissions by Brazilian states on the supply and demand side. The spatial concentration of production in large economics centers of Southeastern is directly associated with the total emissions incorporated in the interregional productive systems. Within regional economic structure, urban and economic growth in peripheral areas is based of agriculture and mining export-oriented industries, implying less relative value-added from these areas. There is an uneven regional development formed by Southeastern states – mainly São Paulo and Rio de Janeiro.

Table I.1 CO2 coefficients – Industrial compatibilization of EDGAR-EORA and National Account System (SCN)**.**

	Industrial classification (System of National Accounts)	Gross Output (2011 BRL million)	EDGAR-EORA industries	Total CO2 emissions (Gg)	Share of CO2	Poluttin coefficient
S1	Agriculture, including support for agriculture and post-harvest	209,241	Agriculture and forestry	8,993.03	0.48%	0.04
S2	Livestock, including support for livestock	94,213	Grazing and fishing	5,482.92	0.65%	0.06
S3	Forest production; fisheries and aquaculture	23,693	Grazing and fishing	5,482.92	2.57%	0.23
S4	Extraction of mineral coal and non-metallic minerals	17,265	Iron ore	1,581.56	1.02%	0.09
S5	Oil and gas extraction, including support activities	158,885	Other minerals and ores	1,790.31	0.13%	0.01
S6	Iron ore extraction, including beneficiation and agglomeration	77,063	Other minerals and ores	1,790.31	0.26%	0.02
S7	Extraction of non-ferrous metallic minerals, including processing	10,533	Other minerals and ores	1,790.31	1.89%	0.17
S8	Slaughter and meat products, including dairy and fishery products	164,010	Food and beverages	30,139.13	2.04%	0.18
S9	Sugar manufacture and refining	55,818	Food and beverages	30,139.13	6.00%	0.54
S10	Other food products	171,317	Food and beverages	30,139.13	1.96%	0.18
S11	Beverage Manufacturing	56,908	Food and beverages	30,139.13	5.89%	0.53
S12	Manufacture of tobacco products	13,087	Tobacco products	793.18	0.67%	0.06
S13	Manufacture of textile products	43,173	Textiles	3,870.61	1.00%	0.09
S14	Manufacture of clothing artifacts and accessories	54,296	Clothing	3,689.27	0.76%	0.07
S15	Manufacture of footwear and leather goods	32,619	Leather and footwear	2,131.38	0.73%	0.07
S16	Manufacture of wood products	22,210	Wood products except furniture	1,594.03	0.80%	0.07
S17	Manufacture of cellulose, paper and paper products	58,510	Cellulose and paper products	3,334.91	0.63%	0.06
S18	Printing and playback of recordings	19,091	Newspapers, magazines and electronic publishing	3,594.87	2.09%	0.19
S19	Oil refining and coking plants	253,576	Petroleum refining and coke products	8,841.48	0.39%	0.03
S20	Manufacture of biofuels	23,588	Alcohol	1,339.75	0.63%	0.06
S21	Manufacture of organic and inorganic chemicals, resins and elastomers	105,437	Chemical products & Resins and elastomers	9,197.82	0.97%	0.09
S22	Manufacture of pesticides, disinfectants, paints and various chemicals	50,352	Pesticides & Other chemical products	3,453.05	0.76%	0.07
S23	Manufacture of cleaning products, cosmetics / perfumery and personal hygiene	27,643	Soaps and detergents	3,695.96	1.49%	0.13
S24	Manufacture of pharmaceutical chemicals and pharmaceutical products	42,790	Pharmaceutical products	5,406.03	1.40%	0.13

	Industrial classification (System of National Accounts)	Gross Output (2011 BRL million)	EDGAR-EORA industries	Total CO2 emissions (Gg)	Share of CO2	Poluttin coefficient
S25	Manufacture of rubber and plastic products	79,842	Rubber and plastic products & Inks, varnishes, enamels, lacquers	7,556.42	1.05%	0.09
S26	Manufacture of non-metallic mineral products	72,361	Other non-metallic mineral products & Cement	4,915.19	0.76%	0.07
S27	Production of pig iron / ferroalloys, steel and seamless steel tubes	96,034	Manufacturing of steel and steel alloys	5,472.78	0.63%	0.06
S28	Nonferrous metal metallurgy and metal casting	40,031	Non-ferrous metals	2,777.08	0.77%	0.07
S29	Manufacture of metal products, except machinery and equipment	80,782	Fabricated metal products except machines and equipment	5,195.43	0.71%	0.06
S30	Manufacture of computer equipment, electronic and optical products	68,505	Office equipment & Electronic and communication equipment & Medical and optical equipment	11,094.39	1.80%	0.16
S31	Manufacture of electrical machinery and equipment	62,609	Electric machines and materials & Household appliances	5,385.05	0.96%	0.09
S32	Manufacture of machinery and mechanical equipment	107,999	Machines and equipment, including maintenance	7,531.69	0.78%	0.07
S33	Manufacture of cars, trucks, and buses, except parts	164,711	Trucks and busses	1,603.98	0.11%	0.01
S34	Manufacture of parts and accessories for motor vehicles	88,005	Vehicle parts	4,528.81	0.57%	0.05
S35	Manufacture of other transport equipment, except motor vehicles	37,397	Other transport equipment	2,533.59	0.75%	0.07
S36	Manufacture of furniture and products from different industries	55,725	Furniture and other manufacturing	5,497.25	1.10%	0.10
S37	Maintenance, repair and installation of machinery and equipment	45,446	Maintenance and repair	2,918.64	0.71%	0.06
S38	Electric power, natural gas, and other utilities	164,366	Electricity, gas, water, sewerage and drainage services	36,630.00	2.48%	0.22
S39	Water, sewage, and waste management	46,839	Electricity, gas, water, sewerage and drainage services	36,630.00	8.69%	0.78
S40	Construction	507,895	Construction	37,770.00	0.83%	0.07
S41	Trade and repair of motor vehicles and motorcycles	122,008	Passenger and light utility vejicles	6,631.58	0.60%	0.05
S42	Wholesale and retail trade, except motor vehicles	622,833	Wholesale and retail trade	22,561.58	0.40%	0.04
S43	Ground transportation	236,960	Transport and postal services	-	-	-
S44	Water transportation	12,157	Transport and postal services	-	-	-
S45	Air Transport	29,117	Transport and postal services	-	-	-
S46	Storage, auxiliary transport and mail activities	81,006	Transport and postal services	-	-	-
S47	Accommodation	17,261	Hotels and restaurants	6,814.81	4.39%	0.39

	Industrial classification (System of National Accounts)	Gross Output (2011 BRL million)	EDGAR-EORA industries	Total CO2 emissions (Gg)	Share of CO2	Poluttin coefficient
S48	food	151,663	Hotels and restaurants	6,814.81	0.50%	0.04
S49	Editing and editing integrated with printing	22,566	Other services	9,718.40	4.79%	0.43
S50	Television, radio, cinema and sound / image recording / editing activities	31,112	Other services	9,718.40	3.47%	0.31
S51	Telecommunications	143,249	Information services	10,942.72	0.85%	0.08
S52	Development of systems and other information services	80,788	Information services	10,942.72	1.51%	0.14
S53	Financial intermediation, insurance and private pension	392,742	Finance and insurance	17,067.65	0.48%	0.04
S54	Real estate activities	343,197	Property services and hiring	18,095.12	0.59%	0.05
S55	Legal, accounting, consulting and corporate headquarters activities	124,627	Business services	12,283.36	1.10%	0.10
S56	Architectural, engineering, technical testing / analysis and R & D services	55,932	Information services	10,942.72	2.17%	0.20
S57	Other professional, scientific and technical activities	66,427	Other services	9,718.40	1.63%	0.15
S58	Non-real estate rentals and management of intellectual property assets	31,358	Business services	12,283.36	4.35%	0.39
S59	Other administrative activities and complementary services	143,082	Business services	12,283.36	0.95%	0.09
S60	Surveillance, security and investigation activities	24,822	Other services	9,718.40	4.35%	0.39
S61	Public administration, defense and social security	522,385	Public administration and social security	22,396.24	0.48%	0.04
S62	Public education	193,081	Public education	4,754.59	0.27%	0.02
S63	Private education	63,272	Private education	3,660.89	0.64%	0.06
S64	Public health	114,794	Public health services	3,073.43	0.30%	0.03
S65	Private health	125,360	Private health services	5,706.13	0.51%	0.05
S66	Artistic, creative and entertainment activities	24,702	Other services	9,718.40	4.37%	0.39
S67	Membership organizations and other personal services	110,483	Other services	9,718.40	0.98%	0.09
S68	Domestic services	44,434	Other services	9,718.40	2.43%	0.22

Source: Authors (2020) based on EORA-EDGAR National Input-Output Tables (2019).

Table I.2 Cella HEM CO_2 industry-level linkages (compatibilization ISIC-Group level and SCN industries include)

SCN	ISIC-Group Level	Demand side	BL	Demand side Normalized	Normalized BL rank	Supply side	Normalized FL rank	Supply side Normalized	FL rank
S1	Agriculture, livestock, forest production, fisheries and aquaculture	4,949.66	20	2.40	15	2,000.09	31	5.47	2
S2	Agriculture, livestock, forest production, fisheries and aquaculture	3,764.86	26	1.63	26	1,773.68	37	2.37	17
S3	Agriculture, livestock, forest production, fisheries and aquaculture	2,867.61	32	0.54	56	926.20	51	0.52	50
S4	Extractive industries	1,457.11	43	0.43	61	558.81	60	0.54	49
S5	Extractive industries	1,203.29	47	1.18	36	416.21	61	2.75	14
S6	Extractive industries	310.78	57	0.48	58	390.03	63	0.41	54
S7	Extractive industries	1,150.31	49	0.28	65	662.32	58	0.28	60
S8	Manufacturing industries	5,047.21	19	3.36	10	19,409.14	1	3.94	5
S9	Manufacturing industries	9,705.06	7	2.12	19	17,292.97	3	3.76	6
S10	Manufacturing industries	7,943.53	13	3.63	7	18,233.65	2	4.38	4
S11	Manufacturing industries	12,369.49	3	2.75	13	13,561.35	4	2.78	13
S12	Manufacturing industries	15.60	62	0.15	66	402.88	62	0.08	67
S13	Manufacturing industries	2,404.54	37	0.76	49	1,689.59	39	0.60	47
S14	Manufacturing industries	334.22	56	0.58	54	1,262.50	46	0.34	57
S15	Manufacturing industries	172.91	58	0.40	62	871.78	53	0.19	63
S16	Manufacturing industries	1,190.18	48	0.44	60	649.09	59	0.42	53
S17	Manufacturing industries	2,129.91	38	1.03	40	1,500.36	43	1.09	33
S18	Manufacturing industries	3,471.04	28	0.73	51	1,209.74	47	0.82	41
S19	Manufacturing industries	5,771.61	17	2.96	11	5,284.96	9	2.85	12
S20	Manufacturing industries	603.84	53	0.46	59	795.59	55	0.41	55
S21	Manufacturing industries	7,734.36	14	2.21	17	3,970.41	15	2.20	18
S22	Manufacturing industries	2,883.31	31	1.17	37	1,508.71	42	1.14	32
S23	Manufacturing industries	735.53	52	0.57	55	1,652.08	40	0.43	52
S24	Manufacturing industries	1,366.10	45	0.66	53	1,938.15	34	0.51	51
S25	Manufacturing industries	5,888.25	16	1.87	22	2,966.73	21	1.59	23
S26	Manufacturing industries	4,310.33	21	1.49	30	1,943.87	33	1.45	27
S27	Manufacturing industries	4,157.72	24	2.03	20	2,901.49	22	1.65	22
S28	Manufacturing industries	1,804.25	40	0.98	41	1,329.40	45	0.67	45
S29	Manufacturing industries	3,621.14	27	1.42	31	1,980.88	32	1.56	24
S30	Manufacturing industries	2,752.08	34	0.92	45	3,984.63	14	0.95	38
S31	Manufacturing industries	2,614.78	35	1.16	38	2,335.44	27	1.03	34
S32	Manufacturing industries	2,049.66	39	1.37	33	3,086.67	19	1.01	35
S33	Manufacturing industries	49.76	60	2.42	14	821.18	54	0.19	62
S34	Manufacturing industries	3,363.72	30	1.53	28	1,842.36	36	0.72	44
S35	Manufacturing industries	379.68	55	0.38	63	942.14	50	0.22	61

SCN	ISIC-Group Level	Demand side	BL	Demand side Normalized	Normalized BL rank	Supply side	Normalized FL rank	Supply side Normalized	FL rank
S36	Manufacturing industries	1,369.78	44	0.77	48	1,909.80	35	0.56	48
S37	Manufacturing industries	2,438.30	36	0.85	47	991.46	49	1.22	31
S38	Electricity and gas	21,133.80	2	4.10	5	9,597.06	7	3.75	7
S39	Water, sewage, waste management and decontamination activities	22,803.33	1	4.07	6	10,300.34	6	2.52	16
S40	Construction	3,438.81	29	4.90	2	12,130.60	5	3.29	10
S41	Trade; repair of motor vehicles and motorcycles	1,717.06	41	1.23	34	1,736.14	38	0.84	39
S42	Trade; repair of motor vehicles and motorcycles	9,943.00	6	6.14	1	5,656.74	8	8.67	1
S43	Transport, storage and mail	-	65	1.85	23	-	64	3.38	9
S44	Transport, storage and mail	-	65	0.11	67	-	64	0.18	64
S45	Transport, storage and mail	-	65	0.37	64	-	64	0.32	58
S46	Transport, storage and mail	-	65	0.76	50	-	64	1.48	26
S47	Accommodation and food	4,002.83	25	0.87	46	2,233.00	29	0.64	46
S48	Accommodation and food	1,146.84	50	3.58	8	2,399.66	26	0.83	40
S49	Information and communication	4,273.64	22	0.98	42	3,763.71	16	0.95	37
S50	Information and communication	9,239.06	11	1.82	24	3,482.40	17	1.93	19
S51	Information and communication	4,232.07	23	2.21	18	4,208.00	13	1.85	20
S52	Information and communication	5,559.76	18	1.38	32	2,187.36	30	1.37	29
S53	Financial, insurance and related services	8,130.53	12	4.12	4	4,344.08	12	4.78	3
S54	Real estate activities	2,779.88	33	0.94	44	1,105.93	48	1.73	21
S55	Professional, scientific and technical activities	10,680.85	5	2.36	16	2,293.62	28	3.50	8
S56	Professional, scientific and technical activities	7,455.89	15	1.52	29	2,505.62	25	1.39	28
S57	Professional, scientific and technical activities	9,426.20	10	3.52	9	4,913.80	10	2.75	15
S58	Administrative activities and complementary services	10,969.48	4	1.93	21	2,853.85	23	1.28	30
S59	Administrative activities and complementary services	9,669.92	8	2.77	12	2,598.40	24	2.86	11
S60	Administrative activities and complementary services	9,600.61	9	1.62	27	1,343.88	44	0.80	42
S61	Public administration, defense and social security	748.78	51	4.39	3	4,900.41	11	1.50	25
S62	Education	33.53	61	1.19	35	696.18	57	0.18	65
S63	Education	440.99	54	0.68	52	917.22	52	0.38	56
S64	Human health and social services	8.03	63	1.07	39	794.74	56	0.16	66
S65	Human health and social services	91.27	59	0.97	43	1,540.82	41	0.30	59
S66	Arts, culture, sport and recreation	1,699.21	42	0.51	57	3,040.26	20	0.78	43
S67	Other service activities	1,357.82	46	1.71	25	3,387.77	18	0.99	36
S68	Domestic services	0.00	64	0.00	68	-	64	-	68

Source: Authors, 2020.

Table I.3 Bilateral Trade in Value-Added (TiVA) from HEM (2011 BRL million)

Origin (state)		Destination (state level)																										RoW (exports)
		RO	AC	AM	RR	PA	AP	TO	MA	PI	CE	RN	PB	PE	AL	SE	BA	MG	ES	RJ	SP	PR	SC	RS	MS	MT	GO	DF	
North	RO	0	122	1013	20	128	10	15	41	19	100	31	31	110	25	26	160	530	98	426	2554	392	263	636	104	341	234	180	771
	AC	114	0	328	5	37	6	5	18	6	36	11	9	34	15	8	56	130	29	141	623	109	67	170	26	68	85	119	153
	AM	628	172	0	207	1291	129	123	483	177	655	292	233	864	186	158	1471	1521	553	2043	8671	1082	775	1377	226	593	866	1203	3260
	RR	13	5	692	0	26	2	3	11	2	7	4	4	14	3	4	23	38	12	63	225	33	21	77	6	13	24	54	94
	PA	179	51	894	27	0	87	292	343	245	670	187	170	627	127	93	547	2476	471	1445	7958	1129	741	1718	193	420	813	752	24609
	AP	11	7	160	3	72	0	11	24	14	48	14	11	42	10	10	98	123	36	139	542	83	46	147	12	17	49	81	502
	TO	33	7	163	4	286	13	0	183	46	121	38	37	114	31	26	318	350	77	388	1861	235	175	364	50	103	297	579	623
Northeast	MA	94	23	641	15	1396	35	276	0	438	636	173	152	464	127	93	700	848	217	889	4140	541	414	917	115	193	488	567	4290
	PI	35	10	277	8	370	18	55	345	0	428	130	71	273	72	54	509	406	133	483	1630	215	177	374	44	81	212	364	730
	CE	155	50	936	29	1048	76	163	1001	658	0	637	732	2354	172	117	1962	1436	287	762	5278	748	275	896	166	235	710	1146	2300
	RN	35	18	480	16	254	20	18	180	98	1112	0	1128	1513	70	99	1296	282	165	968	2086	195	167	567	19	28	78	318	674
	PB	56	20	256	8	266	19	42	169	71	483	782	0	1831	283	123	729	486	171	521	1942	248	211	408	53	87	207	303	558
	PE	171	47	954	31	794	56	130	748	515	1430	1436	2528	0	1185	497	3809	1503	352	1165	5998	612	256	1039	150	264	771	1487	2930
	AL	45	26	328	7	194	17	40	141	79	311	226	302	1320	0	270	1611	590	90	354	1912	169	82	360	61	115	336	363	2040
	SE	67	20	289	11	241	19	33	140	66	281	174	164	577	292	0	1676	470	193	780	2244	287	175	497	45	100	187	383	523
	BA	99	38	791	33	585	55	159	394	415	1206	418	342	1686	594	1099	0	4152	2127	3568	14347	1505	1025	3091	430	930	2211	4094	9156
Southeast	MG	868	234	2681	132	2236	180	466	1142	477	1815	771	658	2346	721	730	4173	0	3213	9400	49032	5415	4418	5072	1338	1981	9047	5145	48491
	ES	123	34	538	23	640	30	79	313	151	248	161	133	352	129	112	3906	3865	0	10481	8243	1450	627	1263	182	238	682	749	18030
	RJ	487	125	2214	108	1091	139	427	678	485	1157	911	754	1520	509	536	8818	19545	4367	0	92004	13782	6018	10848	1397	2155	4510	5956	43139
	SP	4830	1151	12867	805	10570	1151	3009	6028	2951	9126	4039	3972	10983	3534	2938	26178	74078	11710	72141	0	72204	29610	45727	13355	12300	15011	9037	81522
South	PR	531	125	1223	74	844	81	185	380	206	710	295	298	901	271	257	1891	4355	1276	6185	52746	0	7372	5270	1123	1000	2116	2621	16550
	SC	192	42	701	40	459	50	175	510	215	272	114	241	425	128	150	1388	3216	481	2538	25354	7116	0	8621	555	731	1523	1571	9356
	RS	662	122	1892	107	1455	147	356	1081	467	1059	449	554	1402	366	352	3056	5195	1426	6167	31607	6234	6170	0	1116	1615	2716	3439	17963
MidWest	MS	157	37	417	17	267	24	51	110	53	168	68	66	200	62	51	419	990	248	1126	9556	1194	829	1279	0	433	801	616	3861
	MT	531	88	1126	36	528	39	114	213	91	366	130	125	393	127	93	950	1741	373	1782	7488	1123	918	1796	389	0	1272	867	10934
	GO	304	82	1047	53	983	71	293	451	177	529	207	181	614	199	174	954	4745	721	2599	16288	976	1223	1936	424	904	0	4734	5983
	DF	386	147	1219	57	1325	105	483	737	406	1323	434	333	1329	335	356	1563	4343	1327	2996	12366	1501	1408	3380	391	962	5514	0	1682
RoW (mported)		865	235	6,066	176	4,006	229	600	1,937	828	3,189	2,020	1,143	4,209	1,391	1,633	10,119	22,785	8,183	37,775	88,095	14,644	9,253	15,243	2,459	3,391	5,259	4,538	0

Source: Authors, 2020.

Table I.4 Bilateral Trade in Emissions (TTE) from HEM (Gg CO2 per BRL Million final demand)

	Origin (state)	Destination (state' level)																											
		RO	**AC**	**AM**	**RR**	**PA**	**AP**	**TO**	**MA**	**PI**	**CE**	**RN**	**PB**	**PE**	**AL**	**SE**	**BA**	**MG**	**ES**	**RJ**	**SP**	**PR**	**SC**	**RS**	**MS**	**MT**	**GO**	**DF**	**RoW (exports)**
North	RO	-	24	180	5	29	3	3	13	6	34	10	10	35	8	8	46	116	22	101	594	79	53	120	20	69	48	38	195
	AC	14	-	37	1	5	1	1	3	1	6	2	1	6	2	1	8	15	4	18	86	13	8	20	3	8	8	10	27
	AM	226	68	-	71	493	48	56	185	73	275	107	92	359	71	69	626	622	213	702	3,834	383	370	587	97	229	343	403	1,107
	RR	2	1	79	-	4	0	0	2	0	1	1	1	2	0	1	3	5	2	7	44	4	3	10	1	2	2	6	11
	PA	37	11	177	6	-	22	56	86	57	138	39	40	127	23	22	123	345	68	254	1,636	186	141	301	33	81	140	190	2,012
	AP	1	1	15	0	11	-	1	5	2	6	2	1	6	1	1	13	19	5	17	87	11	7	17	2	3	6	12	69
	TO	6	1	25	1	51	3	-	42	11	29	9	9	26	6	6	69	61	15	72	364	37	30	61	8	18	45	83	109
Northeast	MA	14	3	76	2	190	6	44	-	72	99	27	20	74	19	17	115	125	40	146	665	82	65	130	16	31	62	112	563
	PI	7	2	41	1	82	4	11	79	-	77	23	12	47	14	10	107	63	31	82	287	38	32	57	7	16	32	63	106
	CE	36	11	176	6	254	19	37	236	133	-	128	137	459	38	24	472	267	76	140	1,060	152	57	162	33	54	128	214	407
	RN	6	3	70	3	44	4	4	35	17	192	-	200	260	14	17	166	45	32	112	358	25	31	79	4	6	13	50	151
	PB	15	5	59	2	87	6	10	50	15	103	176	-	368	81	27	224	94	55	104	425	53	45	73	10	23	39	71	140
	PE	45	13	204	7	217	15	36	203	134	392	374	564	-	320	128	1,154	332	106	281	1,653	140	66	234	34	75	167	285	1,145
	AL	12	8	79	2	56	5	11	45	24	97	58	60	281	-	68	452	119	25	78	534	34	20	85	12	33	80	89	1,372
	SE	12	4	43	2	42	4	6	30	13	50	24	32	99	53	-	241	81	37	98	490	37	36	89	8	22	34	78	101
	BA	22	8	147	7	132	12	37	102	98	279	86	74	370	130	251	-	938	520	728	3,592	306	242	664	95	241	475	872	2,193
Southeast	MG	181	47	556	25	455	40	103	258	103	411	167	138	485	157	163	1,015	-	654	2,056	11,905	1,223	992	1,111	288	472	1,986	1,043	6,385
	ES	15	4	64	3	76	4	11	47	22	36	18	19	53	21	18	395	479	-	921	1,073	129	91	137	24	38	91	114	1,636
	RJ	89	22	405	19	204	27	81	131	86	193	134	134	261	108	96	1,288	3,165	893	-	15,054	1,682	1,123	1,487	247	453	848	1,181	4,772
	SP	1,027	242	2,602	160	2,192	237	670	1,302	617	2,007	831	778	2,261	753	617	6,081	16,728	2,638	17,391	-	17,278	6,904	10,625	2,982	2,982	3,413	2,055	23,848
South	PR	106	25	217	13	169	18	40	87	42	156	60	58	177	55	53	438	952	282	1,367	12,648	-	1,621	1,140	237	232	448	465	4,074
	SC	38	8	130	7	88	10	36	109	45	61	25	51	89	27	32	307	673	102	538	5,660	1,535	-	1,769	117	153	308	282	2,350
	RS	139	27	374	20	308	33	82	256	100	246	99	116	294	79	77	738	1,238	331	1,366	7,882	1,474	1,483	-	259	390	607	602	3,940
MidWest	MS	34	8	94	4	60	7	12	31	15	52	20	18	54	15	15	120	223	60	284	2,378	261	185	280	-	95	171	130	976
	MT	127	22	227	9	129	12	31	69	29	122	39	38	116	33	30	285	419	98	457	1,859	264	231	410	92	-	295	213	2,190
	GO	78	21	240	13	263	21	78	132	48	151	54	48	163	53	49	288	1,181	200	714	4,210	235	299	444	102	231	-	1,271	1,690
	DF	48	17	143	7	161	13	57	88	45	143	48	35	143	40	40	189	500	165	329	1,512	175	164	364	44	120	631	-	239
RoW (imports)		172	34	2,016	28	786	43	103	339	152	648	309	269	1,054	324	269	2,491	4,864	828	5,676	21,710	3,359	1,937	3,579	519	666	1,184	624	0

Source: Authors, 2020.

Table I.5 Trade-based Index (TBI)

	Origin (state)	RO	AC	AM	RR	PA	AP	TO	MA	PI	CE	RN	PB	PE	AL	SE	BA	MG	ES	RJ	SP	PR	SC	RS	MS	MT	GO	DF	RoW (exports)
North	RO	0.00	0.94	0.84	1.14	1.06	1.52	1.03	1.49	1.51	1.58	1.52	1.58	1.48	1.44	1.47	1.36	1.03	1.04	1.12	1.09	0.95	0.96	0.89	0.90	0.95	0.96	1.00	1.19
	AC	0.58	0.00	0.53	0.63	0.57	0.64	0.63	0.67	0.76	0.78	0.82	0.72	0.76	0.66	0.78	0.70	0.56	0.67	0.59	0.65	0.56	0.59	0.55	0.53	0.55	0.47	0.40	0.84
	AM	1.70	1.86	0.00	1.61	1.80	1.74	2.15	1.81	1.93	1.98	1.72	1.85	1.95	1.79	2.04	2.00	1.92	1.81	1.62	2.08	1.67	2.25	2.01	2.02	1.82	1.87	1.58	1.60
	RR	0.76	0.75	0.54	0.00	0.68	0.70	0.56	0.68	0.71	0.68	0.86	0.68	0.75	0.68	0.68	0.71	0.61	0.78	0.55	0.92	0.61	0.67	0.64	0.54	0.78	0.47	0.50	0.55
	PA	0.97	0.98	0.93	1.08	0.00	1.17	0.91	1.18	1.09	0.97	0.97	1.10	0.96	0.87	1.13	1.06	0.66	0.69	0.83	0.97	0.77	0.90	0.83	0.80	0.91	0.81	1.19	0.38
	AP	0.66	0.64	0.45	0.68	0.74	0.00	0.66	0.98	0.64	0.58	0.65	0.60	0.69	0.58	0.63	0.63	0.73	0.60	0.56	0.75	0.63	0.69	0.54	0.68	0.75	0.57	0.72	0.65
	TO	0.82	0.89	0.73	0.86	0.84	1.04	0.00	1.08	1.09	1.14	1.14	1.14	1.08	0.99	1.12	1.02	0.82	0.90	0.88	0.92	0.74	0.81	0.79	0.73	0.81	0.71	0.68	0.83
Northeast	MA	0.68	0.67	0.56	0.73	0.64	0.81	0.76	0.00	0.77	0.73	0.74	0.63	0.75	0.69	0.86	0.77	0.69	0.87	0.77	0.76	0.71	0.74	0.67	0.65	0.75	0.59	0.93	0.62
	PI	0.99	0.96	0.69	0.82	1.04	1.17	0.96	1.08	0.00	0.85	0.83	0.79	0.82	0.94	0.88	0.99	0.73	1.09	0.80	0.83	0.84	0.85	0.72	0.79	0.93	0.71	0.81	0.68
	CE	1.08	1.05	0.89	0.92	1.14	1.16	1.07	1.11	0.95	0.00	0.94	0.88	0.92	1.04	0.98	1.13	0.87	1.24	0.87	0.95	0.95	0.98	0.85	0.95	1.08	0.85	0.88	0.83
	RN	0.82	0.82	0.69	0.83	0.81	0.89	0.91	0.91	0.83	0.81	0.00	0.83	0.81	0.93	0.81	0.60	0.76	0.92	0.55	0.81	0.59	0.87	0.65	0.89	0.92	0.79	0.74	1.06
	PB	1.24	1.13	1.09	0.92	1.53	1.59	1.14	1.39	1.02	1.00	1.06	0.00	0.95	1.34	1.04	1.45	0.91	1.51	0.94	1.03	1.00	1.01	0.84	0.91	1.26	0.89	1.10	1.18
	PE	1.24	1.27	1.00	1.12	1.29	1.29	1.32	1.28	1.23	1.29	1.23	1.05	0.00	1.27	1.21	1.43	1.04	1.42	1.13	1.30	1.08	1.21	1.06	1.07	1.33	1.02	0.90	1.84
	AL	1.32	1.40	1.13	1.36	1.37	1.43	1.30	1.52	1.45	1.47	1.20	0.93	1.00	0.00	1.18	1.32	0.95	1.29	1.04	1.32	0.94	1.16	1.11	0.95	1.34	1.11	1.15	3.17
	SE	0.85	0.94	0.71	0.75	0.82	0.91	0.88	1.00	0.93	0.84	0.65	0.93	0.80	0.86	0.00	0.68	0.81	0.90	0.59	1.03	0.61	0.95	0.84	0.83	1.05	0.85	0.95	0.91
	BA	1.03	1.05	0.87	0.96	1.07	1.04	1.09	1.22	1.11	1.09	0.97	1.02	1.03	1.03	1.07	0.00	1.06	1.15	0.96	1.18	0.96	1.11	1.01	1.04	1.22	1.01	1.00	1.13
Southeast	MG	0.98	0.95	0.98	0.90	0.96	1.06	1.04	1.06	1.01	1.07	1.02	0.99	0.97	1.02	1.05	1.15	0.00	0.96	1.03	1.14	1.06	1.06	1.03	1.01	1.12	1.03	0.95	0.62
	ES	0.59	0.58	0.56	0.62	0.56	0.65	0.65	0.71	0.69	0.69	0.52	0.68	0.71	0.75	0.76	0.48	0.58	0.00	0.41	0.61	0.42	0.68	0.51	0.61	0.75	0.63	0.72	0.43
	RJ	0.86	0.84	0.86	0.84	0.88	0.91	0.89	0.91	0.83	0.79	0.70	0.84	0.81	1.00	0.84	0.69	0.76	0.96	0.00	0.77	0.57	0.88	0.65	0.83	0.99	0.88	0.93	0.52
	SP	1.00	0.99	0.95	0.94	0.98	0.97	1.05	1.02	0.98	1.04	0.97	0.92	0.97	1.00	0.99	1.09	1.06	1.06	1.13	0.00	1.13	1.10	1.09	1.05	1.14	1.07	1.07	1.38
South	PR	0.94	0.95	0.83	0.83	0.95	1.02	1.01	1.08	0.95	1.04	0.96	0.92	0.93	0.95	0.97	1.09	1.03	1.04	1.04	1.13	0.00	1.04	1.02	1.00	1.09	1.00	0.83	1.16
	SC	0.92	0.90	0.87	0.87	0.90	0.98	0.97	1.01	0.99	1.06	1.02	1.00	0.98	0.97	1.00	1.04	0.99	1.00	1.00	1.05	1.02	0.00	0.97	0.99	0.98	0.95	0.85	1.18
	RS	0.99	1.02	0.93	0.88	1.00	1.07	1.08	1.12	1.01	1.10	1.04	0.99	0.99	1.01	1.03	1.14	1.12	1.09	1.04	1.17	1.11	1.13	0.00	1.09	1.14	1.05	0.82	1.03
MidWest	MS	1.01	1.05	1.06	1.05	1.06	1.30	1.07	1.34	1.32	1.45	1.36	1.31	1.27	1.17	1.35	1.35	1.06	1.14	1.19	1.17	1.03	1.05	1.03	0.00	1.03	1.01	0.99	1.19
	MT	1.13	1.20	0.95	1.20	1.15	1.48	1.29	1.54	1.47	1.56	1.40	1.43	1.39	1.24	1.50	1.41	1.13	1.24	1.21	1.17	1.11	1.18	1.08	1.12	0.00	1.09	1.16	0.94
	GO	1.21	1.21	1.08	1.17	1.26	1.39	1.26	1.38	1.27	1.34	1.23	1.26	1.25	1.25	1.32	1.42	1.17	1.31	1.29	1.22	1.13	1.15	1.08	1.13	1.20	0.00	1.26	1.33
	DF	0.59	0.53	0.55	0.54	0.57	0.58	0.55	0.56	0.52	0.51	0.52	0.50	0.51	0.56	0.53	0.57	0.54	0.59	0.52	0.58	0.55	0.55	0.51	0.53	0.59	0.54	0.00	0.67
RoW (imports)		0.92	0.67	1.54	0.74	0.91	0.88	0.80	0.81	0.85	0.94	0.71	1.09	1.16	1.08	0.76	1.14	0.99	0.47	0.70	1.14	1.06	0.97	1.09	0.98	0.91	1.04	0.64	0.00

Source: Authors, 2020.

4 THE SUBNATIONAL SUPPLY CHAIN AND THE COVID-19 PANDEMIC: ASSESSMENT OF SHORT-TERM IMPACTS ON THE BRAZILIAN REGIONAL ECONOMY[34]

Abstract

The pandemic outbreak of COVID-19 induced governments to adopt social distance and restricted economic activities to control the disease spread, raising doubts about the effects on supply chains within borders. Therefore, this article analyzes the potential regional effects of COVID-19 mitigation measures on trade in value-added at subnational and international levels for Brazil. The generalized hypothetical extraction method was applied based on the scenario of industry-specific partial constraints, allowing us to understand the spatial spread effects on the domestic supply chain. The results show that the core areas, mainly Sao Paulo and Rio de Janeiro, are more exposed to the COVID-19 trade shocks. However, the peripheries are doubly affected, either by the foreign shock – that damages their agro-export growth model – and by the retraction of subnational demand from core states. This assessment indicates that it is relevant for regional policy to consider the role of value chains to enhance the potential negative effects of COVID-19 on exposed regions.

Keywords: *Regional effects. Hypothetical Extraction Method. Domestic Value Chains. COVID-19 outbreak.*

JEL Classification*: R12. R10.*

4.1 INTRODUCTION

The outbreak of the COVID-19 pandemic is pushing governments around the world to adopt severe restrictions policies based on social distance, applying economic restrictions to activities as a measure to mitigate the spread of disease transmission.

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Despite the consensus on the effectiveness of this type of intervention (Golan, Jernegan, and Linkov, 2020; Porsse, Souza, and Valle, 2020; Surico and Galeotti, 2020), the assessment of the impacts on supply chains at multiple geographical scales is still incipient. The persistent process of dispersion of supply chains rising doubts about the impacts of COVID-19 on the degree of connectivity, trade integration, and regional capacity to dealing with the economic crisis. At the international level, recent evidence suggests transmission effects along value chains, with a tendency for the formation of geographically close networks (Baldwin and Freeman 2020; Javorcik, 2020).

This article aims to assess the regional effects of COVID-19 pandemic control interventions on trade in value-added (TiVA) for both domestic value chains (DVC) and global value chains (GVC), with an interregional input-output application for Brazil. Our starting point is creating a partial constraint at the industry-level related to intermediate inputs uses and interregional final demand, according to a large COVID-19 scenario. The hypothetical extraction method (HEM) is adopted to measure the differentials of the domestic value-added (DVA) on subnational and foreign trade, considering partial restriction to subnational economic activity and also a variation of exports' demand (Dietzenbacher and Lahr, 2013; Giammetti et al., 2020; Haddad, Perobelli, and Araújo, 2020).

Isolation measures tend to reduce labor activity in several productive sectors, affecting the whole economic geography. Therefore, we consider the interdependencies between industries and regions to assess the effects on multiscale trade flows (Caracciolo et al., 2020, p. 10). The Brazilian case is interesting due to their persistent regional inequalities (Azzoni and Haddad, 2018; Silveira-Neto and Azzoni, 2011), associated with the diversity of natural resources and differences in convergence in terms of specialization and diversification of national production. The complexity of regional economies becomes engines for transmitting the effects of COVID-19 mitigation measures, in response to the degree of spatially heterogeneous exposure to short-term exogenous shocks. The direct and indirect costs at the regional level have been distributed along the supply chains, and the interdependencies in production drive as mechanisms of spatial dispersion of the effects on the TiVA flows (Hewings and Oosterhaven, 2015). As a result, regional disparities tend to increase the backward and forward impacts on the potential effects on regions (Cuadrado-Roura and Maroto, 2016; Han and Goetz, 2019).

Related to concerns about the intensity of the transmission of shocks on value chains, the novelty of this paper includes three main aspects. First, focus on the measures of the second generation of trade statistics, based on the TiVA concept (Los, Timmer, and de Vries, 2015; Meng et al., 2017). This approach provides a detailed look at the regional hierarchy of local content transferred on spatial value chains. As the empirical evidence in GVCs is generally analyzed at the national level (Baldwin and Lopez-gonzalez, 2015; Los et al., 2015), the second contribution is the assessment of the transmission shocks at multiple geographical scales, including the interdependencies between DVC and GVC. Third, the analyzes contribute to the formulation of regional policies by identifying the potential impact across spatial value chains in response to supply and demand shocks related to the restrictive scenarios of COVID-19.

This article is structured into five sections. The next section describes some mechanisms that affect the regions' ability to respond to exogenous shocks. In the second, there is a brief of Brazilian regional inequalities as a driven effect of the COVID-19 scenario. The third section details the methodological approach for accounting TiVA in a COVID-19 counterfactual scenario of partial constraints. In the fourth section, the main regional results. The last section shows the main considerations and policy implications of the study.

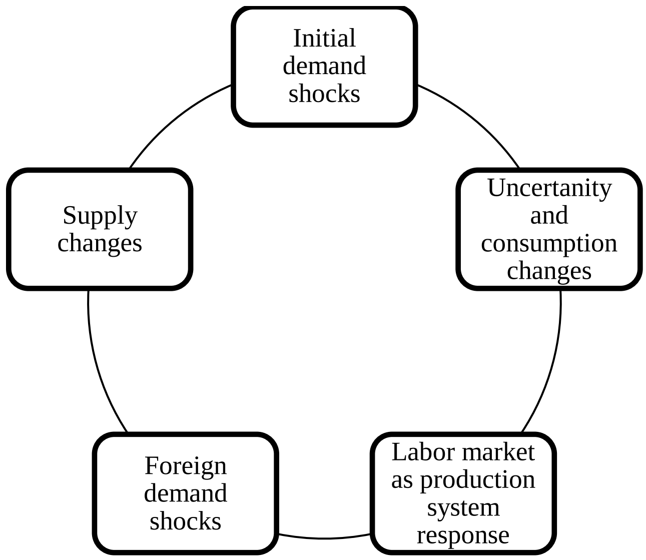
4.2 PATHWAYS OF THE SUBNATIONAL LINKAGES AS COVID-19 TRANSMISSION SHOCKS

4.1.1 Regional drivers of short-term effects

Based on the demand and supply shocks resulting from the restrictive measures of COVID-19 mitigation spread, the classic linkages approach provides relevant elements for understanding how regions are systematically affected. The linkage model emphasizes the effects of pecuniary externalities because of input-output relationships, for both upstream and downstream chaining (Hirschman, 1958; Ciccone, 2002; Acemoglu et al., 2007). The first case occurs due to the supply of inputs, which lead to chains associated with the subsequent processing of the goods. Regions dependent on natural resources become vulnerable to large-size impacts on the demand side in the short-term. In the second case, diversified regions tend to assume a predominantly downstream role in value chains. Differentials in the levels of productive linkages in the production networks indicate heterogeneous impacts in space in response to short-term shocks (Cuadrado-Roura and Maroto, 2016).

The process of production fragmentation is based on the regional contribution in different stages of production, implying the need to incorporate the interdependencies of production systems (Iammarino and McCann, 2013; Atienza, Lufin, and Soto, 2018). Territorial capacities become mechanisms to understand the regional responses to the imposed restrictions. As the industries are heterogeneously affected, regional inequalities drivers the effects. Figure 1 shows a business cycle of effects resulting from restrictive policies to control pandemic dissemination. In the short-term, the degree of confidence in public health control policy is decisive for the level of uncertainty in the agents' decision-making, be it consumption or investment grade. In response to the inequalities of knowledge and technology bases across space, industry-specific constraints measures affect regional production systems in a heterogeneous manner (BONET-MORÓN et al., 2020a; CHEN et al., 2018). The sectors' exposure to social distance affects spatial demand patterns, forcing many companies to reduce labor' demand or even to close their activities. In response, further reductions in the level of consumption affect supply and demand links simultaneously (Haddad, Perobelli, and Araújo, 2020). In parallel to the subnational effects, the external sector tends to respond in a simulated manner, with reduced demand for exports in some sectors, culminating in the recession cycle on the regional economies.

Figure. – Stylized transmissions shocks (*business cycle*)



Source: Elaborated by the authors, 2020.

Factors associated with regional disparities and the complexity of regional innovation systems are key mechanisms for transmitting shocks. As a result, it is expected that the more complex regional economies with greater interregional ties will be proportionally more affected by initial shocks of final demand. According to the OECD (2020), large urban areas are initially most affected, according to the dense production networks with which they are associated.

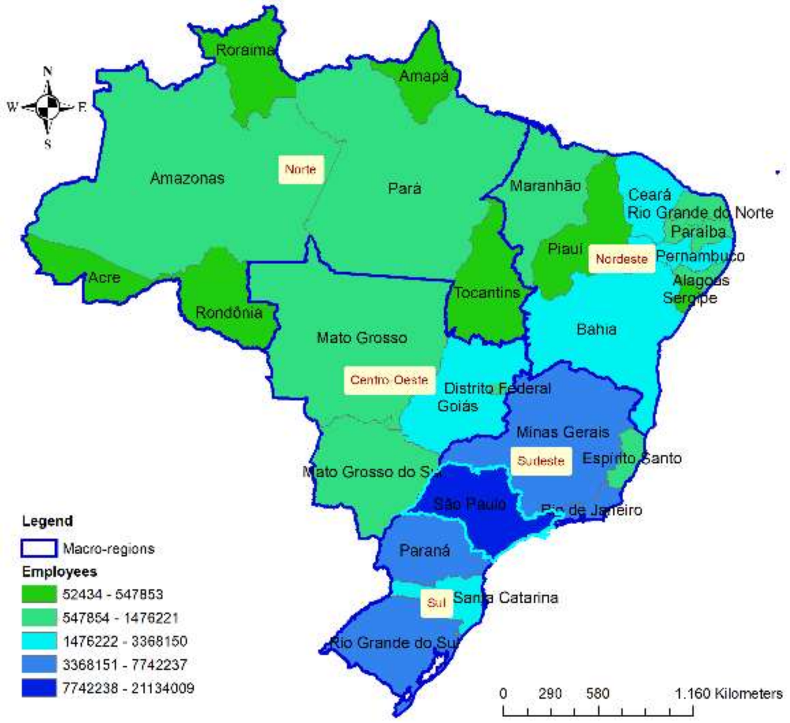
The next subsection presents the Brazilian regional inequalities, allows to shed light on the potential induced spatial effects and the regional capacity to respond to exogenous shocks.

4.1.2 A brief of Brazilian regional inequalities

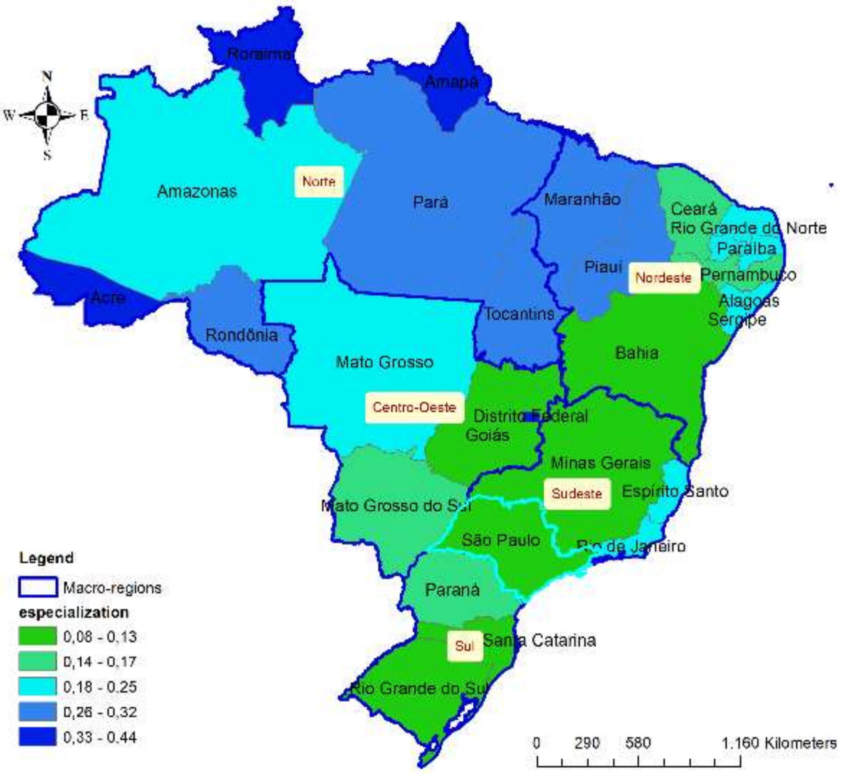
The Brazilian economy is characterized by economic and population concentration. Figure 2 shows the spatial distribution of employment (part a) and an index of productive specialization (part b), as indicators of the degree of complexity inside the country. Therefore, regional inequalities tend to amplify the upstream and backward impacts across value chains. Richer states located at the core-regions (mainly Sao Paulo and Rio de Janeiro) tend to be net exporters to other countries as well as to the subnational economy, while peripheral areas (Northeastern and the Northern States) are relatively more connected to GVC, with the export of natural resources and raw materials (Guilhoto, Siroën, and Yücer, 2015; Lee, Szapiro, and Mao, 2018; Sturgeon, 2016).

Figure 2 – Brazilian regional economy

(a) Regional employment



(b) Specialization Index



Source: Elaborated by the authors based on RAIS (2020).

Territorial vocations and the pattern of industrial development are heterogeneous, implying spatially dispersed regional hierarchies (Azzoni and Haddad, 2018; Santos, Haddad, and Hewings, 2013). It is plausible to expect effects not only on the potential for integration into global chains but also on interregional VA flows, associated with governance aspects by core-regions (Fold, 2014; Niosi and Zhegu, 2010). Regional disparities in the distribution of employment potentially affect the risk of a greater short-term economic recession in regions integrated into more complex value chains, whether domestic or international. Table 1 shows the location coefficients for the 20-ISIC industry group and the five administrative macro-regions of Brazil. It is interesting to note that the core region of the Southeast has specialization in a greater number of industries, showing itself to be more diversified and with more complex production structures at the national level. The peripheral areas, in addition to having a smaller number of industries with specialization, show the highest indexes in primary sectors, such as agriculture, livestock, and mining.

Table 1 – Location Quotient of sectorial gross output at macroregional level[1]

Industry	Midwest	Northeast	North	Southeast	South
Accommodation and food	0.81	1.38	0.83	1.01	0.82
Administrative activities and complementary services	0.76	0.90	0.57	1.18	0.75
Agriculture, livestock, forest production, fisheries and aquaculture	2.40	1.33	1.45	0.52	1.49
Arts, culture, sport and recreation	0.73	0.97	0.42	1.17	0.78
Construction	1.01	1.40	1.38	0.90	0.91
Domestic services	1.05	1.16	1.03	0.99	0.88
Education	1.49	1.40	1.10	0.82	1.03
Electricity and gas	0.98	1.39	1.61	0.81	1.15
Extractive industries	0.21	0.63	2.36	1.36	0.07
Financial, insurance and related services	1.12	0.51	0.29	1.26	0.64
Human health and social services	0.92	1.40	1.15	0.94	0.89
Information and communication	0.72	0.61	0.36	1.31	0.61
Manufacturing industries	0.62	0.75	0.91	1.04	1.29
Other service activities	1.20	1.01	0.71	0.99	1.01
Professional, scientific, and technical activities	0.60	0.67	0.39	1.25	0.79
Public administration, defense, and social security	2.36	1.55	1.44	0.74	0.62
Real estate activities	1.01	1.14	1.03	0.97	0.97

Industry	Midwest	Northeast	North	Southeast	South
Trade; repair of motor vehicles and motorcycles	0.98	1.11	0.92	0.95	1.11
Transport, storage, and mail	0.88	0.95	0.83	1.04	1.03
Water, sewage, waste management and decontamination activities	0.97	1.12	0.45	1.08	0.81

Source: Elaborated by the authors, based on Brazilian IRIO 2011.

Note: 1 – Macroregional state distribution is shown in Annex I.

Besides, the economic impact of the COVID-19 crisis varies according to the degree of exposure of the regions and sectors that are negotiable and integrated into value chains. At the subnational level, regions dependent on exporting natural resources to GVCs tend to be doubly affected. First, the reduction in foreign demand will induce a reduction in economic activity on territories, reducing the spillover effects and trade gains. Second, the supply chains will be affected by changes in other regions and sectors.

4.2 DATA AND METHODS

4.2.1 Data

In this article, an interregional input-output model (Hewings and Oosterhaven, 2015) were adopted for the Brazilian economy for the base-year 2011, including 68 industries and 27 regions (federative units), as representative of the country's productive structure[35]. The database was built by the Regional and Urban Economics Lab at the University of São Paulo (NEREUS-USP) (Haddad, Gonçalves-Júnior, and Nascimento, 2017). The details of the industries and regions are in Annex I.

4.2.2 Measurement procedures

We estimate changes in the regional content of VA incorporated into DVCs and GVCs according to the difference between (1) the current TiVA (baseline) and (2) the TiVA hypothetically extracted (partially). The whole strategy considers two stages. The first is based on the parsimonious hypothetical extraction method (HEM) approach

35 There is evidence in the literature that input-output matrices represent interregional and intersectoral dependence on the economic structure, which changes little over time. For comparison purposes, we deflate the monetary values for December 2019 according to the IPCA price-index from the Brazilian Institute of Geography and Statistics (IBGE).

proposed by (Los, Timmer, and De Vries, 2016), which allows us to measure the TiVA at multiple geographical scales (Haddad, Mengoub, and Vale, 2020) for both DVC (interregional) and GVC (regional exports). After this phase, we can account for the baseline ("real situation") of local content (VA) embedded on production networks. The second stage relies on recent studies applied to COVID-19 (Bonet-Morón et al., 2020; Giammetti, et al., 2020; Haddad, Perobelli, and Araujo, 2020) to build a broad scenario of partial restrictions associated with measures to mitigate the spread of COVID-19, as changing the intermediate consumption and final demand. Based on this broad scenario, we applied the generalized version of HEM (Dietzenbacher and Lahr, 2013) to account for the counterfactual TiVA. Then, we calculate the difference between the baseline and the counterfactual scenario, which represents the relative size of COVID-19 impact on the Brazilian subnational supply chain.

4.2.2.1HEM and their extensions in a broad pandemic scenario

HEM makes it possible to calculate the bilateral TiVA. Compared to the traditional measure based on trade, TiVA provides a more detailed picture, not only of the direct but also indirect, the interaction of the regions along with the regional and international partners (Meng et al., 2013; 2017). Following the traditional IO model, let us consider a single economy with n regions and s industries, the national output can be expressed as:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-\mathbf{1}}\mathbf{y} = \mathbf{L}\mathbf{y} \tag{1}$$

where $\mathbf{x}$ is the gross output, $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-\mathbf{1}}$ is Leontief's inverse, with $\mathbf{I}$ is the identity matrix and $\mathbf{A}$ is the matrix with input coefficients and $\mathbf{y}$ is the final demand. The actual value-added of a region 1 needed to attend their final demand is given by:

$$\mathbf{GDP}_1 = \mathbf{v_1}(\mathbf{I} - \mathbf{A})^{-\mathbf{1}}\mathbf{y}\boldsymbol{i} \tag{2}$$

where $\mathbf{v_1}$ is a row matrix with the first element equal to the ratio between value-added and gross output in industries of region 1 and zeros elsewhere like $\mathbf{v_1} = [\widetilde{\mathbf{v_1}} \quad 0 \cdots \quad 0]$. The elements for other regions are set to zero since we are at this stage interested in 1's regional value in its trade for other regions or exports (other countries). To measure the domestic value-added (DVA) embedded in trade, (LOS; TIMMER; DE VRIES, 2016) consider one hypothetical world where region 1 does not export to region n. The counterfactual as expressed as:

$$\mathbf{GDP}^{*}_{1,\mathrm{n}} = \mathbf{v_1}\left(\mathbf{I} - \mathbf{A}^{*}_{\mathbf{1,n}}\right)^{-\mathbf{1}}\mathbf{y}^{*}_{\mathbf{1,n}}\boldsymbol{i} \tag{3}$$

where the intermediates input and the final demand for the pair origin-destination 1 to n are set to zero. The difference between Equation (4) and (3) results in the TiVA from region 1 to region n, as a result of the VA's decomposition (Miroudot and Ye, 2020). This TiVA measure is our baseline measurement, which operates on two geographical scales: (1) related to interregional flows considering DVC, and (2) VA in exports, accounting for GVC. To complete the trade cycle, we incorporate gross imports carried out by each region and industry of the interregional system. By not adopting a global multiregional database, we assume that imports generate regional VA with the same technology of local production, which is as if they were produced in Brazil. This allows us to incorporate foreign markets from the perspective of purchase, as well as VA sales (Haddad, Mengoub, and Vale, 2020).

Afterward, partial constraints in interregional relations at DVC and GVC levels were considered, including a broad scenario of mitigation policies of the spread of disease. For this, proportional changes in the intermediate inputs use and final demand are included (Dietzenbacher and Lahr, 2013). A generalized version of HEM is adopted to measure the impact in terms of changes in the partial restrictions of VA embedded in trade. This is a conservative strategy that incorporates constraints for supply and demand linkages by companies. An industry-specific risk factor, $0 < \alpha_s < 1$, represents the proportion in which each industry is affected by restrictive and/or isolation measures. Values close to 1 indicate a greater degree of risk in economic activity, while values close to 0 relate to activities that require greater direct contact between workers, increasing the degree of exposure and risk of contamination. The α values were determined similarly to Bonet-Morón et al., 2020), being in Annex I. For a sale and purchasing sector, their relationship is given by:

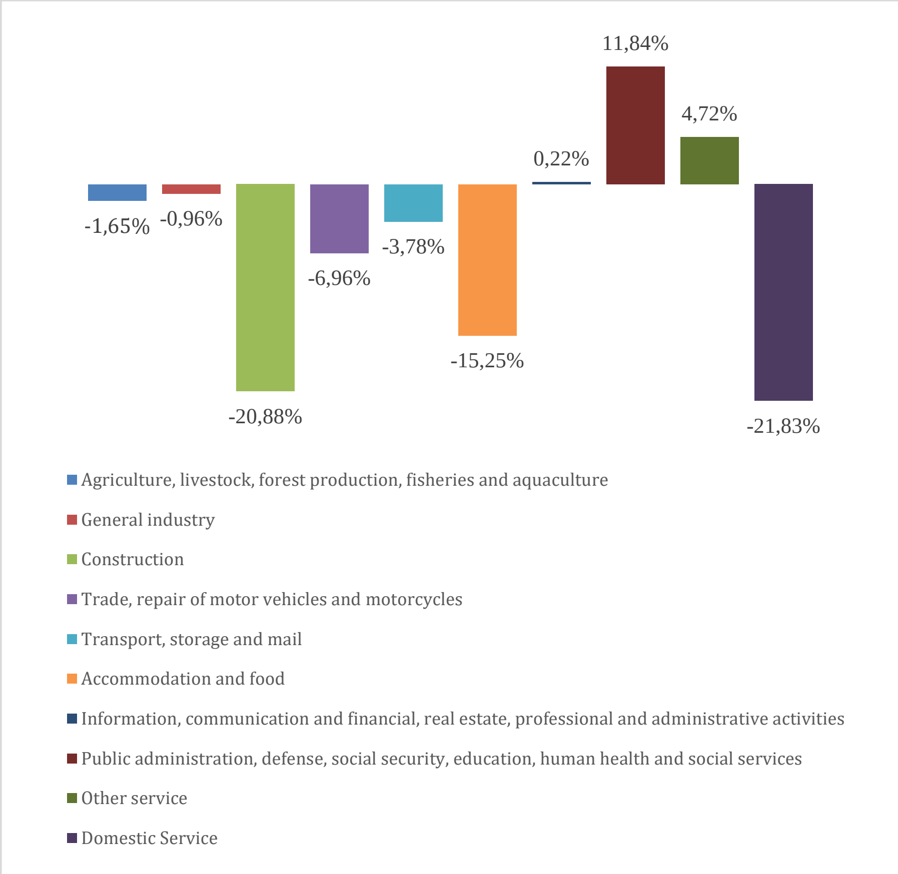
$$\alpha^{a}_{r,s} = \begin{cases} \alpha_s, \text{if } \alpha_s < \alpha_t \\ \alpha_t, \text{if } \alpha_s > \alpha_t \end{cases} \tag{4}$$

where $\alpha^{a}_{r,s}$ is a risk factor. The change generates a new technical coefficient equals to $a^{*}_{sr} = \frac{z^{*}_{sr}}{x_s} = \left(\frac{\alpha_{rs} z_{rs}}{x_s}\right) = \alpha_{rs} z_{rs}$. A matrix $\mathbf{f_a} = [\alpha^{a}_{r,s}]$ is pre-multiplied by A, excluding the diagonal for each region (Los et al., 2016). Then, a new constrained intermediate coefficients matrix is created, given by $\bar{\mathbf{A}} = \mathrm{f_a}\mathbf{A}$. As a result, a new Leontief inverse represents the COVID scenario, $\bar{\mathbf{L}} = (\mathbf{I} - \bar{\mathbf{A}})^{-\mathbf{1}}$.

The final demand shocks are annualized, based on the assumption of temporal constant production function (Haddad, Perobelli, and Araujo, 2020). Thus, changes in household consumption are based on the average of (1) the difference in the expected wages level for the first half of 2020, calculated as a linear projection based on the wages levels of the same period between the years 2012 and 2019, with data from four-monthly National Continuous Household Survey (Pesquisa Nacional de Amostra Domiciliar - PNAD), and (2) the average changing of intermediate consumption given by the matrix $\mathbf{f_a}$ for the region of origin (average of the matrix rows) (GIAMMETTI et al., 2020). Wage bill data of the first four mounts of 2020 for aggregated industries from the PNAD survey used it, as shown in Figure 3[36]. Afterward, exports changes were calculated as the average between (1) the difference from the forecast industry exports (as a linear function of the total sectoral exports for the same period between the years 2015 and 2019, based on monthly data from the Secretariat of Foreign Trade of the Ministry of Economy - SECEX), and (2) the average of partial extractions of the intermediate use given by the matrix $\mathbf{f_a}$ for the region of origin (average of the rows) (Giameni et al., 2020; Dietzenbacher and Lahr, 2013). It was assumed that the total investments and expenses of the government are constant in the short-term.

Figure 3 – Variation in the wage bill[1] (1st quarter of 2020)

36 The breakdown of the PNAD and MDIC industries in IRIO industries was made assuming the industrial distribution of the wage bill for the year 2018 based on compulsory firm-level data from Annual Social Information Report (RAIS) of the Ministry of Economy.



Source: PNAD (2020).
Note: [1] – Compared to the same period of the last three years.

The generalized HEM allows computing the difference between the current gross output and the counterfactual, according to partial constraints in the economic system. The gross output restricted can be expressed as follows:

$$\bar{\mathbf{x}} = (\mathbf{I} - \bar{\mathbf{A}})^{-1}\bar{\mathbf{y}} \tag{5}$$

where $\bar{\mathbf{A}}$ and $\bar{\mathbf{y}}$ represent the new matrices of intermediate technical coefficients and final demand. As a result, the decrease in intermediate and final deliveries sold by each industry and region alters the coefficients and implies changes in the TiVA across networks. In this case, Equation 3 can be rewritten by incorporating the COVID counterfactual scenario, according to:

$$\overline{\mathbf{GDP}}^{*}_{1,\mathrm{m}} = \mathbf{v_1}\left(\mathbf{I} - \bar{\mathbf{A}}^{*}_{\mathbf{1,m}}\right)^{-1}\bar{\mathbf{y}}^{*}_{\mathbf{1,m}}\boldsymbol{i} \tag{6}$$

Note that in this case, instead of assuming that region 1 does not trade with region n (as in the relationship given by Equation 3 and 4), intermediate use and final demand are considered to be partially changed sized by α, as follows in (6):

$$\overline{\mathbf{A}}^{*}_{1,n} = \begin{bmatrix} \mathbf{A}_{11} & \cdots & \alpha_{1n}\mathbf{A}_{1n} \\ \vdots & \ddots & \vdots \\ \mathbf{A}_{n1} & \cdots & \mathbf{A}_{nn} \end{bmatrix} \text{ and } \mathbf{y}^{*}_{1,n} = \begin{bmatrix} \mathbf{y}_{11} & \cdots & \mathbf{f}^{u}_{y}\mathbf{y}_{1n} & \mathbf{y}_{1m} \\ \vdots & \ddots & \vdots & \vdots \\ \mathbf{y}_{n1} & \cdots & \mathbf{y}_{nn} & \mathbf{y}_{nm} \end{bmatrix} \quad (7)$$

The strategy based on partial HEM shows us that the domestic (regional) VA of the trade from region 1 is derived as the difference in the amount of VA in the actual and counterfactual situations. In specific, the TiVA from region 1 to region n is given by:

$$\mathbf{TiVA}_{1,n} = \mathbf{GDP}_{1} - \overline{\mathbf{GDP}}^{*}_{1,n} \quad (8)$$

Likewise, we can extend the analysis at the industry-level. A simulation approach was recently adopted in COVID-19 costs studies, as by Bonet et al. (2020) for the Colombian case following the strategy proposed by Haddad et al. (2020), and Giammetti et al. (2020) for Italy. In our application, the premises described by Dietzenbacher and Lahr (2013) are maintained, where there are k industries with identical establishments, one of which ceases to exist so that the industry's capacity is reduced.

Concerning foreign trade, the VA embedded in exports is then calculated subtracting Equation 7 by:

$$\overline{\mathbf{GDP}}^{*}{}_{1,m} = [\tilde{v}_{1} \quad \mathbf{0}] \begin{bmatrix} (\mathbf{I}-\mathbf{A}_{11})^{-1} & \cdots & (\mathbf{I}-\mathbf{A}_{1,n})^{-1} \\ \vdots & \ddots & \vdots \\ (\mathbf{I}-\mathbf{A}_{n1})^{-1} & \cdots & (\mathbf{I}-\mathbf{A}_{n,n})^{-1} \end{bmatrix} \begin{bmatrix} \mathbf{y}_{11} & \cdots & y_{1,n} & \bar{\mathbf{y}}_{1m} \\ \vdots & \ddots & \vdots & \vdots \\ \mathbf{y}_{n1} & \cdots & \mathbf{y}_{nn} & y_{nm} \end{bmatrix} \quad (9)$$

Note that it is assumed that export destination is exogenous and that only the α factor is applied to the final demand (column of exports). This ensures that the difference is calculated based on the same economic structure as the baseline scenario (without restrictions), with the original Leontief matrix. As in Chen et al. (2018), we calculated the level of regional exposure to VA flows from HEM. The ratio between the VA traded between region 1 and region n in relation to the total GDP of region 1 indicates how much the regions are exposed to fluctuations in interregional demand. We extended the calculation also considering exogenous VA exports as a GVC' integration measure according to Equation 10:

$$\mathbf{GDP}_{\mathbf{1,.}}^{\mathbf{exp}} = \frac{\mathbf{TiVA_{1,n}}}{\mathbf{GDP_1}}, \mathbf{GDP}_{\mathbf{.,n}}^{\mathbf{exp}} = \frac{\mathbf{TiVA_{n,1}}}{\mathbf{GDP_1}} \quad (10)$$

In the empirical section, we extend the general case, based on the idea of measuring how much of the restricted VA (considering the reductions and blocks associated with COVID-19) is destined to provide the DVC and GVC. Besides, the monetary values for December 2019 were corrected to express the purchasing power of economic agents at the same time. The next section presents the main results.

4.3 ANALYSIS

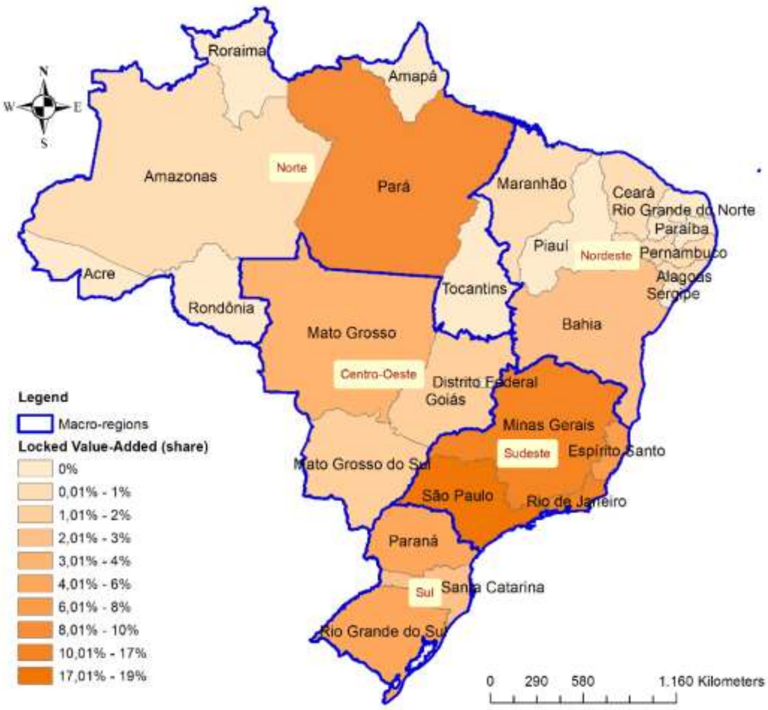
Section 4.1 describes the spatial distribution of the potentially locked VA (LVA) as a result of the partial constraints related to the COVID-19 scenario. The detailing of the VA's changes allows us to understand the regional patterns of the changes in the composition of the VA to be embodied in trade. Afterward, section 4.2 details the changes in bilateral TiVA flows, as well as the VA content exported to the rest of the world.

4.3.1 Changes in VA

This section provides a measurement of the potential changes in GDP by assuming the partial restrictions in intermediate use, **A**, and the interregional final demand, **y**. Important to note that this method is not intended to quantify the real changes in regional GDP due to the COVID-19 pandemic, but to identify the potential losses associated with regional productive dynamics in Brazilian regions. An analysis of this nature would require information on the result of changes in production and the dynamics of demand-supply of companies and their relationship with foreign companies. Besides, it would require assumptions about industrial and spatial standards of substitution regarding the origin of the inputs incorporated into the value chains (Chen et al., 2018). Figure 4 shows the regional distribution of the VA losses, based on the subtraction of GDP (baseline) of each state of the Brazilian economy (Equation 3) and the restricted GDP, in this case, $\overline{\mathbf{GDP}} = \mathbf{v_1}(\mathbf{I} - \overline{\mathbf{A}})^{-1}\overline{\mathbf{y}}\mathbf{i}$. National values result from the sum of regional measures, avoiding aggregation bias (Miller and Blair, 2009). The results indicate of all the VA hypothetically removed from the Brazilian economy; the four states of the Southeast macro-region concentrate 60% of the losses in terms of national GDP. These states have the main large urban and industrial structures in the country, being responsible for most of the inter-regional supply and demand of intermediates so that potential losses generate effects upstream and downstream along with the subnational production networks. Annex II shows the values of bilateral VA flows in the baseline, providing the dimension of regional concentration of TiVA.

To provide empirical evidence on DVC and GVCs, we assume a hypothetical situation in which isolation policies occur at the industry-level (α values). In general, it is noted that the national cost of the pandemic is dependent on the regional production structures. The degree of concentration (or diversification) of regional economies is a relevant component to understand the changes induced by exogenous shocks on interregional input flows to meet final demand, which is also restricted within the country. As the core regions have more complex productive structures, they are proportionally more affected in response to restrictions on the interregional supply and demand side of inputs, given the potential for the contraction of economic activity in multi-agent terms.

Figure 4 – Regional distribution of national reduction in GDP

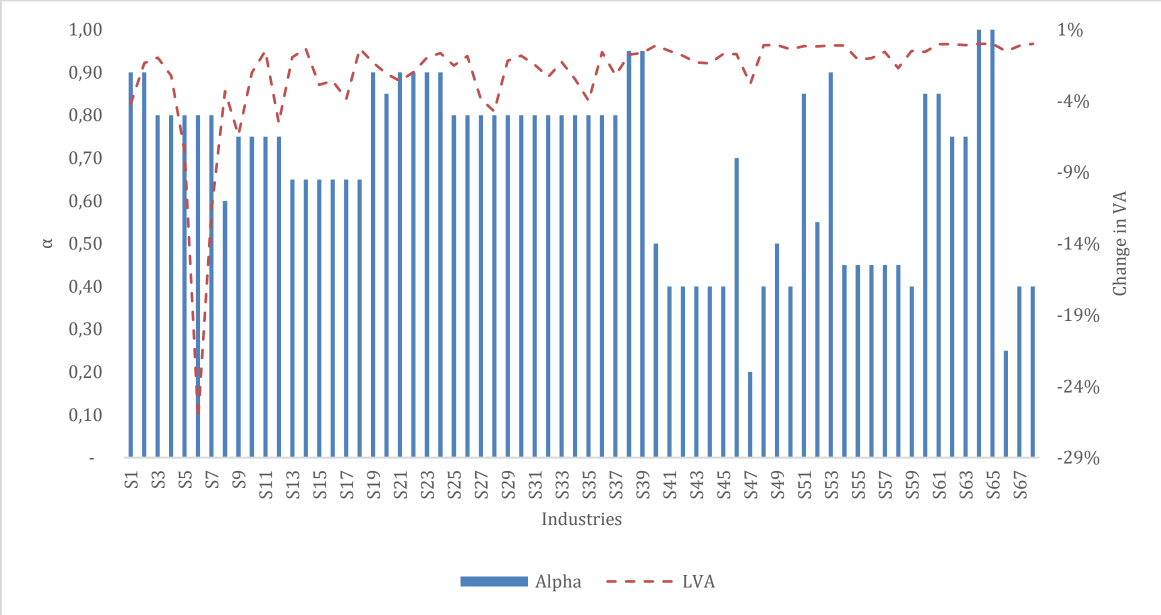


Source: Elaborated by the authors, 2020.

Figure 5 shows the relationship between the values of α and the changes in VA, considering the whole Brazilian economy. The difference between (1) the sum of the VA of the baseline and (2) the sum of the VA in the COVID-19 broad scenario was calculated for all sectors and regions of the IRIO system. It is observed that the sectors are affected by different magnitudes, not always accompanied by the different values of α. It was possible to see that the primary industries (like agriculture and livestock) are strongly dependent on demand from other more advanced sectors in the production chain, with the potential to be affected by both changes in DVC and GVC. In the short-term, however, the potential for relative losses is not so high, given the lower sectorial capacity to incorporate value into production and because they have relatively high values of α (0.9 for agriculture and livestock, and 0.8 for forest production industry), relating to the low risk of exposure of workers in these sectors to COVID-19.

In the mining industries, even with relatively higher α values (with less exposure to the contagion of COVID-19), the productive chains imply greater relative losses for the GDP on these sectors. As they are sectors with a backward linkage pattern, they become sensitive to variations in economic activity in other industries, which require inputs based on natural resources. At the same time, extractive activities tend to incorporate greater VA when compared to other primary industries like agriculture and livestock. Manufacturing in general (S12 to S36), despite having heterogeneous partial blocks (values from α from 0.60 to 0.80) shows negative variations with an average of 2.3% of losses in VA. Tertiary and service activities (S38 to S68) show GDP reductions ranging from 0.10% (for example, real estate activities) to 2.79% (food and accommodation), which are dependent on regional production structures, given their concentration potential. The industries with the lowest relative VA blocks (public and private health activities), were less directly affected in terms of the use of intermediate inputs in the interregional production system.

Figure 5. Hypothetical locked value-added (LVA) at industry-level



Source: Elaborated by the authors, 2020.

Although the blocks associated with COVID-19 mitigation measures are eventually lifted, social distance (both voluntary and selective) implies considerable changes in productive and intersectoral relationships. In this section, potential VA regional and industrial losses were a result of simulating the COVID-19 scenario. In portraying the potential effects of labor force restrictions, the use of capital, and intersectoral links, the next section presents changes to TiVA at DVC and GVC levels

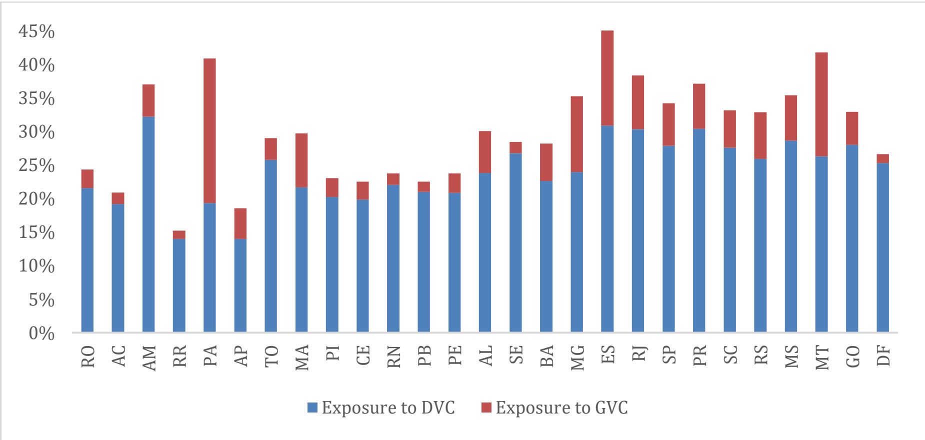
4.3.2 Connectivity effects on DVC and GVC

In this section, we discuss two questions: (1) how do the different regions of Brazil have their integration profile in value chains affected by the restrictive scenario related to COVID-19?; and (2) which regions have the structural potential to better deal with the simultaneous supply and demand shocks of intermediaries. Given that all these issues are uncertain now, we are based on a proposal by Chen et al. (2018), identifying regions and sectors exposed to changes in the structure of production and trade integration.

Figure 6 and Figure 7 show the participation of the restricted (locked) VA (COVID scenario) that is destined to supply the DVC and GVC for each Brazilian state, according to Equation 10. It is interesting to note the regional heterogeneity about the degree of exposure. Some states that have comparative advantages in resource-based industries are highly exposed to GVCs. The states of Pará (northern macro-region of

Brazil), Espírito Santo (Southeast), Mato Grosso (Midwest), and Minas Gerais (Southeast) stand out. All these states have a productive vocation in sectors based on natural resources. Concerning DVCs, the wealthier states (Southeast and South) are heavily dependent on domestic production networks, implying that shocks that occurred at the subnational level generate negative effects (losses) of greater magnitude. It is interesting to note that states with simpler economic structures also have a high degree of exposure to DVCs, with their productive potential dependent on interregional demand, especially in the core areas.

Figure 6 – Exposure of States for DVC and GVC (share of total GDP)



Source: Elaborated by the authors, 2020.

Considering the level of exposure of each state to DVCs, we can see in Figure 7(a) that the patterns and magnitudes are spatially different. These differences reveal that the degree of subnational integration and the extent of the effects may be sensitive to changes in the domestic economic structure. The regions potentially providing intermediate inputs for interregional demand are identified. The spatial extent of the pandemic is driven by this structured pattern, which shows how much each state depends on interregional demand as a mechanism for regional growth. The core, formed by the Southeastern states, extending to the States of the South macro-region and the Amazon (which has the industrial pole of Manaus), shows itself as the ones potentially most affected by variations in the value chains in the short-term, given their degree of relative exposure. Peripheral states, mostly in the North and Northeast of Brazil, are less exposed to subnational chains, indicating less DVC connectivity. Figure 7(b) shows the share of VA embedded to exports as a share of the total state's GDP in the partially restricted scenario (as in Equation 10). It is interesting to note that some peripheral states are dependent on foreign demand for local VA, indicating a higher level of exposure. The effects of changes in the global supply chain tend to have a negative impact with greater intensity in these regions. The potential relative losses tend to be more sensitive in these states, given the complexity of international networks concerning the level of integration of these regions at the subnational level (Mudambi and Puck, 2016).

Recent literature calls attention to the heterogenous capacity of regions lead with recessions situations, which provides the basis for regions to overcome the effects of crises and exogenous shocks of different natures (Cuadrado-Roura and Maroto, 2016; Ivanov, 2020; Pinto, Healy and Cruz, 2019; Santos, Orsi and Bond, 2009). The current debate on the different behaviors at the regional level in terms of the capacity to respond to shocks becomes relevant and necessary, especially in an environment of doubts regarding the global effects of the COVID-19 pandemic. The exposure to shocks is heterogeneous since the regions have complexities of different production networks (Martin and Sunley, 2015; Cuadrado-Roura and Maroto, 2016).

When we incorporate the changes in the intermediate use between the regions, the potential for backward and forward chaining is changed within the country. In Figure 9 we show the relative interregional losses on the outflows side of TiVA inflows. Values below 1 indicate that the losses on the outflows side exceed those on the inflows, while values above 1 indicate the opposite relationship[37]. The core-periphery pattern of the subnational supply chain is identified since poor states have higher inflow losses than outflows. In these cases, changes in the productive structure imposed by the restrictive measures force the peripheral regions to amplify their role of supplying inputs to the central areas of the country (Imori, 2015; Perobelli et al., 2019). The position of the state of Amazonas, where the Manaus Free Zone is located, one of the main industrial centers and free importation area in the country, is noteworthy. The state's productive dependence on interregional demand induces considerable losses on the outflows side compared to inflows (Perobelli and Haddad, 2006; Azzoni and Haddad, 2018).

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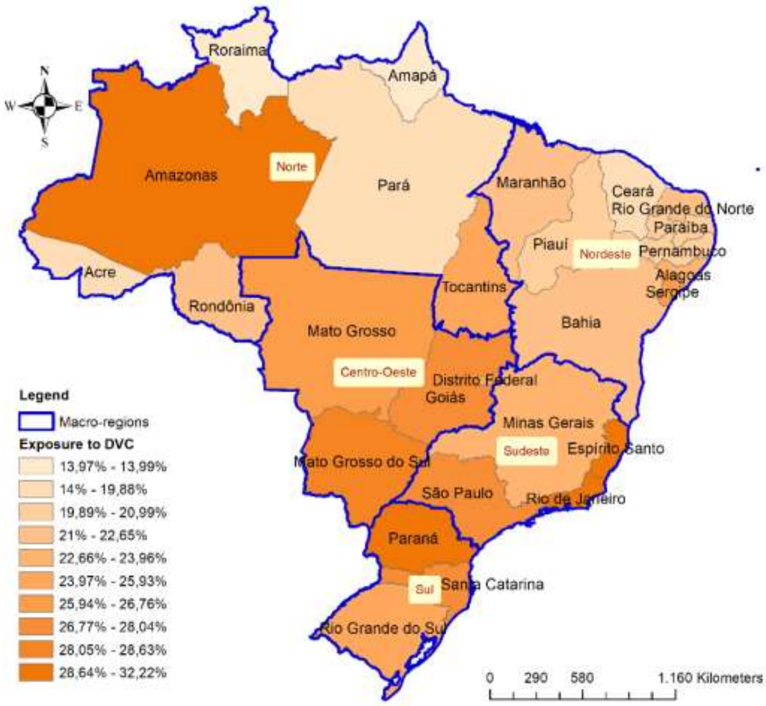
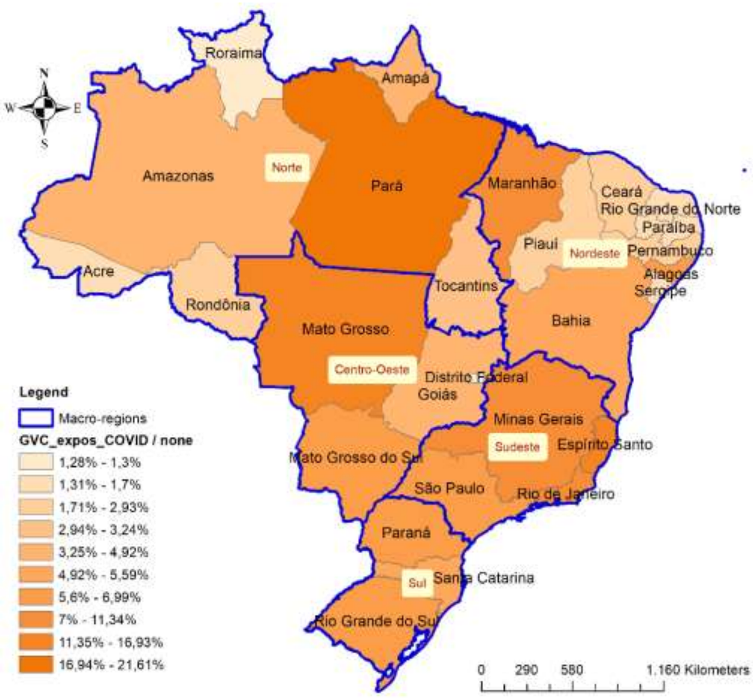
37 In specific $\left[\left(\frac{\Delta inflows_r}{\Delta \text{outflows}_r}\right) - 1\right]$.

Figure 7 – Exposure to DVC and GVC (share of TiVA by total regional GDP)

(a) Interregional

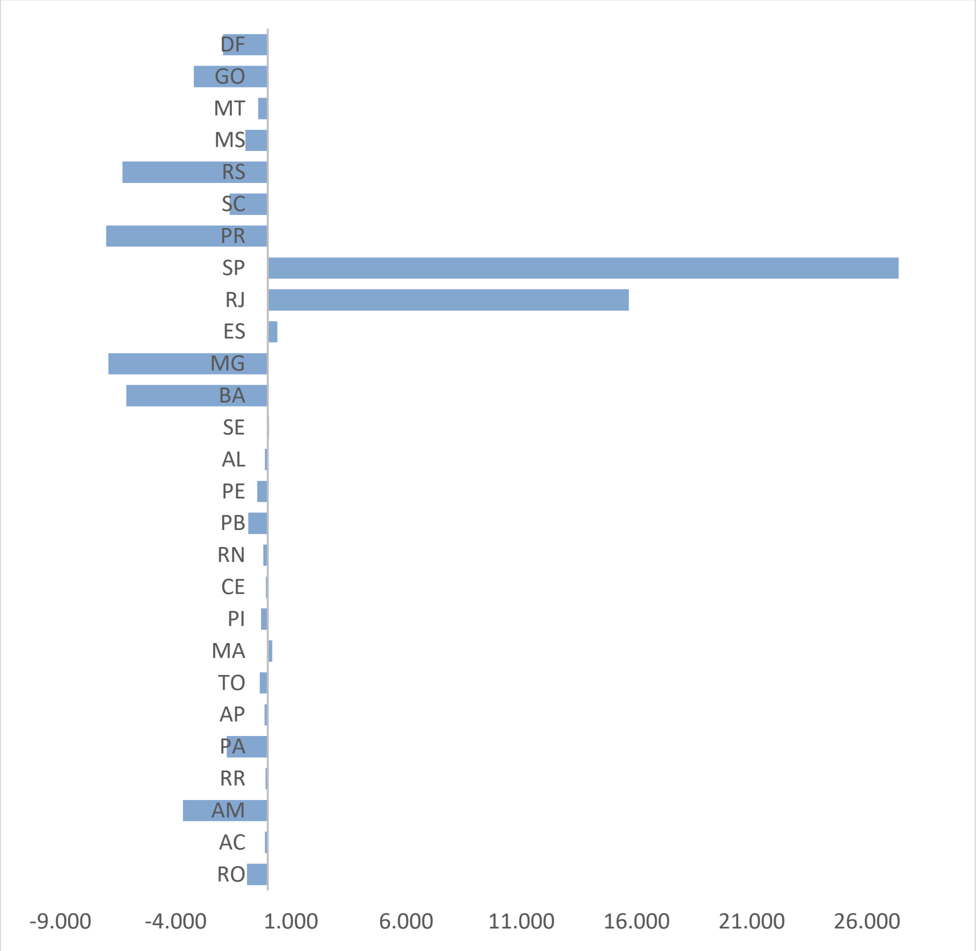


(b) International



Source: Elaborated by the authors, 2020.

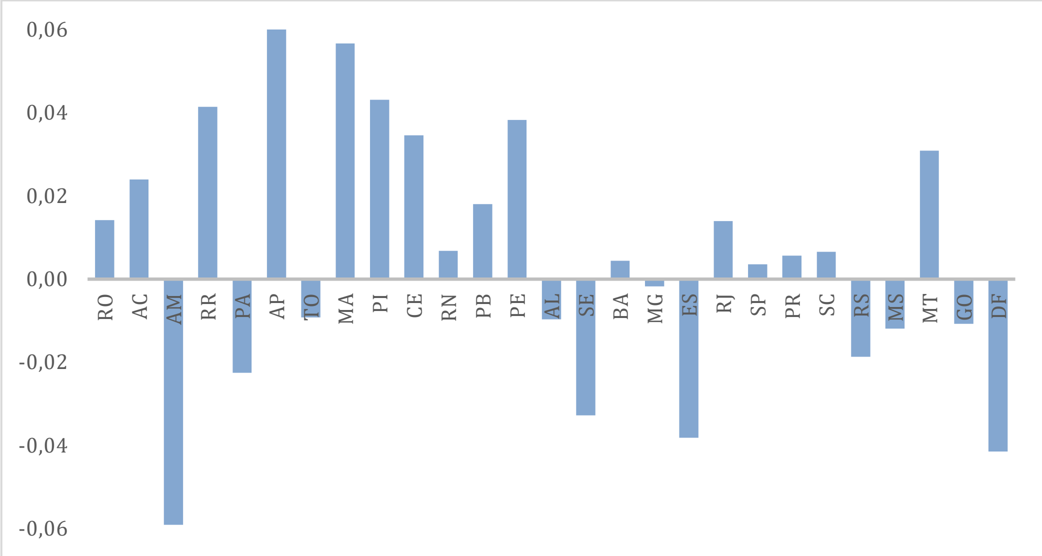
Figure 8 – Net balances of TiVA (with partial constraints) (BRL billions)



Source: Elaborated by the authors, 2020.

On the other hand, it is noted that the wealthier states, which have more complex regional systems and with greater interregional links in the production networks, present losses on the side of outflows higher than inflows. Regions with an industrial vocation in the primary or agro-export sectors, such as Mato Grosso, Pará, and Maranhão, tend to lose interregional ties on the side of VA sales incorporated into the trade.

Figure 9 – Relative losses in DVCs (outflows and inflows at State's level)



Source: Elaborated by the authors, 2020.

The integration profile of the regions to the DVCs and GVCs was heterogeneously affected according to the degree of exposure. Part of the regions is proportionally more affected as a result of changes in interregional demand, compared to international demand. Industrialized states such as Amazonas, Sao Paulo, and Rio de Janeiro tend to alter their profile of integration into domestic markets because of partial constraints. Firstly, the economic activity in the core regions acts as a stronger forward linkage pattern, requiring intermediate inputs from the peripheries. Second, the interregional net balance shows that the core acts as an important supplier for the large Brazilian domestic market. On the other hand, peripheral regions are much more vulnerable to the risks associated with GVC than other states, like the core (southeast) and the south. These results reflect the dependence of foreign trade associated with a model of raw materials suppliers to GVC. At the subnational level, this profile is in the poorest areas of the country, and in some central states that have a productive vocation in the mining sectors (such as Minas Gerais and Rio de Janeiro).

Concerning territorial structures to deal with simultaneous supply and demand shocks, regional imbalances induce the spread of COVID-19 effects from the core towards subnational chains. Economic concentration implies that the Brazilian core acts with governance, orchestrating the consolidation of productive chains within borders (Atienza et al., 2018; Iammarino and McCann, 2013). One of the main implications of this is that the national result of the economic crisis caused by the pandemic is strongly linked to how the most prosperous regions tend to be potentially affected. Thus, when observing the impacts of the interregional demand for intermediate inputs, it is noted that the peripheral states have double dependence: on the one hand, they depend on the economic dynamics of the central areas to be able to provide goods and services; on the other, they depend on international demand. On the other hand, when the central areas are impacted more broadly, the effects on production networks tend to damage local production systems, in response to the break in the business cycle that spills over to regional economies. The main local capacities associated with regional assets, industrial structures, and a leading role in interregional relations are in the Brazilian core.

4.4 FINAL REMARKS AND POLICY IMPLICATIONS

In this study, we show that the mitigation measures of COVID-19 tend to reshape the role of trade at multiple geographical scales, with important implications for the degree of intra-country connectivity. The major engine of Brazilian growth is concentrated on the industrial development of the core regions, which can coordinate DVCs, through the upstream and downstream chains that tend to generate effects that drive the dynamics on peripheral areas. Therefore, the fragility of the most remote areas of the country to the demand in the core states and foreign markets is an important factor in the deeper debate about the implications of exogenous shocks.

The relationship established between the patterns of regional specialization and productivity is straightforwardly revealed, and the magnitude depends on two aspects. The first is the structure of partial constraints simulated; and the second is the regional economic dynamics, which drive the main results. Subnational Brazil has a dichotomous context of (1) concentration of economic activity in core areas and (2) relative dependence on an export-growth model in the peripheries. The regional levels of exposure and vulnerability of local structures to variations in interregional or international demand suggest, at least in purely economic terms, that the core states - mainly São Paulo and Rio de Janeiro - have outstanding territorial capacities to lead with a recession scenario compared to rest of the country. Although the short-term economic loss is concentrated in these regions, the regional productive dynamics allow these regions to benefit from the linkages and the central position of orchestrating domestic production chains.

These variations along the value chains have relevant implications for regional policy. Territorial capacities are highly unequal in Brazil, whether in terms of regional output, innovation systems and development path, being potential determinants for dispersed levels responses in the presence of market shocks. Persistent disparities in the country seem to further increase the impacts of COVID-19 from the perspective of integration into markets (Bolwig et al., 2010; Golan et al., 2020; Ivanov, 2020). As understanding the regional impacts, our results reveal that the VA content into the DVC is proportionally more affected (exposed) when compared to the integration into GVC. Brazil is a country with a large domestic market to supply and has a profile of integration with GVC with little diversification. However, differences in foreign integration operate at the regional level, where the main productive cores incorporate relatively more VA intensive in technology and knowledge, whereas the periphery is strongly specialized in resource-industry exports, implying potentially uneven effects dependent on the local capacities. On the one hand, it can be argued that peripheral areas are less affected in terms of potential changes in local productive dynamics. On the other hand, however, it points out that the simpler production networks (in terms of linkages) make the regions even more dependent on extra-regional productive dynamics, both at subnational and international levels.

Given that the installed capacities can be a relevant analytical approach to begin to understand the pandemic spread effects across states (PINTO; HEALY; CRUZ, 2019), the regional policy aimed at reducing the interregional gaps should consider these differences when designing actions to support the regions in crises, such as those of COVID-19. As seen earlier, the profile (position and size) of integration into value chains and the consequences of the COVID-19 crisis are spatially uneven. The lack of homogeneity of economic losses from integration can be a driver for the expansion of inequalities in Brazil. Regional convergence has never been achieved in the country, and the regions that concentrate most of the population and the industrial activity have the conditions to recover more quickly in the context of exogenous shocks (Silveira-Neto & Azzoni, 2011).

Finally, in a broader sense, the current trends of changes in the dynamics of globalization and industrial localization give a warning to developing countries that have a role strongly associated with the supply of raw materials with little processing and value-added incorporated into trade flows. Our results show that at the subnational level, the degree of exposure of regions specialized in natural resources is high to production networks. From a global perspective, the vulnerability of regional production structures tends to make these regions fragile to economic shocks. Therefore, strategies that include the spatial component of the geographic expansion of business activity considering the new global organization of production is necessary. Qualification of local production systems and increments of local assets (skills, tasks, reducing bureaucracy, etc.) create opportunities for strengthening linkages and mitigating the trade-off in the decision to locate companies (Abonyi, 2006; Atienza, Lufin, and Soto, 2018; Fontagné and Santoni, 2018; Golan et al., 2020; Suder et al., 2015).

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4.5 ANNEX

Table I.1 – Brazilian states

Macrozone	Acronyms	State' name
North	RO	Rondônia
	AC	Acre
	AM	Amazonas
	RR	Roraima
	PA	Pará
	AP	Amapá
	TO	Tocantins
Northeast	MA	Maranhão
	PI	Piauí
	CE	Ceará
	RN	Rio Grande do Norte
	PB	Paraíba
	PE	Pernambuco
	AL	Alagoas
	SE	Sergipe
	BA	Bahia
Southeast	MG	Minas Gerais
	ES	Espírito Santo
	RJ	Rio de Janeiro
	SP	São Paulo
South	PR	Paraná
	SC	Santa Catarina
	RS	Rio Grande do Sul
Midwest	MS	Mato Grosso do Sul
	MT	Mato Grosso
	GO	Goiás
	DF	Federal District

Table I.2 – National accounting industries and values of α

Sector	SCN	ISIC-Group	α
S1	Agriculture, including support for agriculture and post-harvest	Agriculture, livestock, forest production, fisheries and aquaculture	0.90
S2	Livestock, including support for livestock	Agriculture, livestock, forest production, fisheries and aquaculture	0.90
S3	Forest production; fisheries and aquaculture	Agriculture, livestock, forest production, fisheries and aquaculture	0.80
S4	Extraction of mineral coal and non-metallic minerals	Extractive industries	0.80
S5	Oil and gas extraction, including support activities	Extractive industries	0.80
S6	Iron ore extraction, including beneficiation and agglomeration	Extractive industries	0.80
S7	Extraction of non-ferrous metallic minerals, including processing	Extractive industries	0.80
S8	Slaughter and meat products, including dairy and fishery products	Manufacturing industries	0.60
S9	Sugar manufacture and refining	Manufacturing industries	0.75
S10	Other food products	Manufacturing industries	0.75
S11	Beverage Manufacturing	Manufacturing industries	0.75
S12	Manufacture of tobacco products	Manufacturing industries	0.75
S13	Manufacture of textile products	Manufacturing industries	0.65
S14	Manufacture of clothing artifacts and accessories	Manufacturing industries	0.65
S15	Manufacture of footwear and leather goods	Manufacturing industries	0.65
S16	Manufacture of wood products	Manufacturing industries	0.65
S17	Manufacture of cellulose, paper and paper products	Manufacturing industries	0.65
S18	Printing and playback of recordings	Manufacturing industries	0.65
S19	Oil refining and coking plants	Manufacturing industries	0.90
S20	Manufacture of biofuels	Manufacturing industries	0.85
S21	Manufacture of organic and inorganic chemicals, resins and elastomers	Manufacturing industries	0.90
S22	Manufacture of pesticides, disinfectants, paints and various chemicals	Manufacturing industries	0.90
S23	Manufacture of cleaning products, cosmetics / perfumery and personal hygiene	Manufacturing industries	0.90
S24	Manufacture of pharmaceutical chemicals and pharmaceutical products	Manufacturing industries	0.90
S25	Manufacture of rubber and plastic products	Manufacturing industries	0.80
S26	Manufacture of non-metallic mineral products	Manufacturing industries	0.80
S27	Production of pig iron / ferroalloys, steel and seamless steel tubes	Manufacturing industries	0.80
S28	Nonferrous metal metallurgy and metal casting	Manufacturing industries	0.80
S29	Manufacture of metal products, except machinery and equipment	Manufacturing industries	0.80
S30	Manufacture of computer equipment, electronic and optical products	Manufacturing industries	0.80
S31	Manufacture of electrical machinery and equipment	Manufacturing industries	0.80
S32	Manufacture of machinery and mechanical equipment	Manufacturing industries	0.80
S33	Manufacture of cars, trucks and buses, except parts	Manufacturing industries	0.80
S34	Manufacture of parts and accessories for motor vehicles	Manufacturing industries	0.80

Sector	SCN	ISIC-Group	α
S35	Manufacture of other transport equipment, except motor vehicles	Manufacturing industries	0.80
S36	Manufacture of furniture and products from different industries	Manufacturing industries	0.80
S37	Maintenance, repair and installation of machinery and equipment	Manufacturing industries	0.80
S38	Electric power, natural gas and other utilities	Electricity and gas	0.95
S39	Water, sewage and waste management	Water, sewage, waste management and decontamination activities	0.95
S40	Construction	Construction	0.50
S41	Trade and repair of motor vehicles and motorcycles	Trade; repair of motor vehicles and motorcycles	0.40
S42	Wholesale and retail trade, except motor vehicles	Trade; repair of motor vehicles and motorcycles	0.40
S43	Ground transportation	Transport, storage and mail	0.40
S44	Water transportation	Transport, storage and mail	0.40
S45	Air Transport	Transport, storage and mail	0.40
S46	Storage, auxiliary transport and mail activities	Transport, storage and mail	0.70
S47	Accommodation	Accommodation and food	0.20
S48	food	Accommodation and food	0.40
S49	Editing and editing integrated with printing	Information and communication	0.50
S50	Television, radio, cinema and sound / image recording / editing activities	Information and communication	0.40
S51	Telecommunications	Information and communication	0.85
S52	Development of systems and other information services	Information and communication	0.55
S53	Financial intermediation, insurance and private pension	Financial, insurance and related services	0.90
S54	Real estate activities	Real estate activities	0.45
S55	Legal, accounting, consulting and corporate headquarters activities	Professional, scientific and technical activities	0.45
S56	Architectural, engineering, technical testing / analysis and R & D services	Professional, scientific and technical activities	0.45
S57	Other professional, scientific and technical activities	Professional, scientific and technical activities	0.45
S58	Non-real estate rentals and management of intellectual property assets	Administrative activities and complementary services	0.45
S59	Other administrative activities and complementary services	Administrative activities and complementary services	0.40
S60	Surveillance, security and investigation activities	Administrative activities and complementary services	0.85
S61	Public administration, defense and social security	Public administration, defense and social security	0.85
S62	Public education	Education	0.75
S63	Private education	Education	0.75
S64	Public health	Human health and social services	1.00
S65	Private health	Human health and social services	1.00
S66	Artistic, creative and entertainment activities	Arts, culture, sport and recreation	0.25
S67	Membership organizations and other personal services	Other service activities	0.40
S68	Domestic services	Domestic services	0.40

Source: Elaborated by the authors, 2020.

Table III.1 Bilateral trade in value-added (TiVA) for DVC and GVC in a partial extraction scenario, by state of origin (2011 BRL millions)

State	RO	AC	AM	RR	PA	AP	TO	MA	PI	CE	RN	PB	PE	AL	SE	BA	MG	ES	RJ	SP	PR	SC	RS	MS	MT	GO	DF	**RoW**
RO	-	103	805	17	98	8	12	31	15	78	24	24	86	19	20	123	405	75	336	2,007	313	206	509	81	261	181	153	681
AC	96	-	270	4	31	6	5	16	5	30	9	8	29	13	6	46	106	23	123	509	92	56	141	21	56	72	114	149
AM	503	141	-	169	1,016	106	101	378	143	513	227	190	677	148	126	1,123	1,162	396	1,493	6,446	809	600	1,049	181	459	701	1,028	2,848
RR	11	5	586	-	22	2	2	10	2	6	4	3	12	3	3	19	32	10	55	181	29	18	67	5	11	21	52	95
PA	137	43	692	22	-	69	238	248	197	531	144	134	480	98	73	413	1,637	318	1,039	6,058	882	558	1,354	149	322	636	633	19,674
AP	9	6	133	3	58	-	9	19	12	42	11	10	35	8	9	81	93	26	107	433	69	38	126	10	14	41	72	411
TO	27	6	133	3	228	11	-	152	38	100	31	31	94	25	21	256	280	63	327	1,512	196	143	301	40	82	242	534	572
MA	70	18	481	12	1,028	27	218	-	353	518	133	119	370	100	75	558	647	168	727	3,204	437	322	740	88	151	381	485	3,825
PI	27	8	217	6	288	15	45	278	-	358	108	59	225	57	44	407	320	105	400	1,306	176	141	302	35	64	167	323	706
CE	122	41	731	24	831	63	132	811	536	-	509	584	1,904	139	93	1,557	1,126	223	626	4,153	599	212	700	128	183	564	1,007	2,133
RN	28	15	374	13	197	16	15	140	81	883	-	912	1,221	55	76	959	213	122	718	1,585	145	129	432	15	22	62	279	664
PB	45	17	206	7	211	16	36	136	59	388	640	-	1,506	234	100	584	382	136	432	1,544	205	166	330	42	70	166	269	530
PE	131	38	726	25	606	45	104	596	414	1,143	1,128	2,034	-	931	390	2,973	1,160	266	943	4,649	495	198	818	116	202	611	1,322	2,842
AL	36	22	259	6	156	14	33	116	65	256	179	251	1,075	-	219	1,257	466	71	283	1,500	134	66	289	48	89	267	317	1,853
SE	54	17	227	9	188	16	27	114	55	229	134	133	472	231	-	1,253	367	150	589	1,750	219	138	388	36	80	149	339	463
BA	76	30	597	27	433	43	124	296	327	937	320	269	1,312	455	842	-	3,104	1,558	2,748	10,729	1,145	774	2,357	324	690	1,693	3,455	8,194
MG	653	185	1,947	106	1,679	139	365	862	377	1,408	590	518	1,804	558	561	3,155	-	2,231	7,084	35,716	4,046	3,203	3,693	990	1,469	6,793	4,293	40,182
ES	94	26	376	18	473	23	62	245	119	192	116	102	269	97	84	2,806	2,687	-	7,387	5,906	1,036	471	917	136	181	522	645	14,487
RJ	364	98	1,572	84	780	102	332	494	376	899	664	573	1,151	375	399	6,298	14,031	3,019	-	66,046	9,790	4,566	7,980	1,041	1,559	3,307	4,717	35,221
SP	3,619	897	9,407	634	7,796	876	2,323	4,501	2,290	6,972	3,071	3,088	8,324	2,671	2,213	19,527	53,500	8,186	53,636	-	53,160	21,729	33,455	9,731	8,922	11,070	7,030	72,653
PR	415	101	932	61	652	64	148	295	167	562	232	240	719	215	204	1,474	3,295	959	4,992	40,079	-	5,641	4,049	850	755	1,615	2,234	14,829
SC	149	34	533	33	355	39	140	396	171	208	88	190	332	101	117	1,072	2,420	354	1,992	18,821	5,413	-	6,499	416	557	1,166	1,315	8,141
RS	524	99	1,465	89	1,137	117	287	846	380	838	354	447	1,134	294	281	2,401	3,944	1,079	5,022	23,857	4,839	4,721	-	855	1,230	2,098	2,992	15,564
MS	122	30	326	14	208	19	41	87	42	132	53	53	159	49	40	327	763	189	914	7,439	940	646	1,009	-	332	624	531	3,335
MT	403	70	853	29	400	31	89	162	71	279	98	96	302	97	71	721	1,314	274	1,384	5,727	861	700	1,383	291	-	962	721	9,707
GO	238	68	830	44	768	58	235	359	145	430	167	148	496	159	139	752	3,691	562	2,090	12,885	782	973	1,548	328	697	-	3,961	5,296
DF	321	130	1,025	50	1,092	89	428	623	351	1,172	377	288	1,159	286	306	1,343	3,728	1,120	2,593	10,718	1,334	1,225	3,007	339	816	4,637	-	1,811

Source: Elaborated by the authors, 2020.

5 CONSIDERACIONES FINALES

5.1 SINTESIS

Desde Gereffi (1994), el fenómeno analítico de la fragmentación productiva y de su organización global ha ganado espacio en el área del comercio exterior, sociología, geografía económica y de los negocios internacionales (COE; YEUNG, 2015; GEREFFI, 2018; GEREFFI; HUMPHREY; STURGEON, 2005). La mirada tradicional y nacional de las CGV oculta el impacto en los territorios y en los sistemas de producción locales dónde se ubican partes importantes de la cadena. La exportación de bienes finales puede ocurrir dentro de un país, dónde el proceso de fragmentación pasa a ser interno, generando cadenas de valor domésticas que interactúan o no con las globales (LOS, 2013; LOS; TIMMER; DE VRIES, 2015).

En esta línea, la tesis se ha enfocado en la extensión analítica del enfoque CGV, manteniendo la estructura de análisis de la participación regional en los flujos intermediarios de VA. Si bien el debate de las Redes Globales de Producción (*Global Production Networks – GPN*) permite analizar las redes intra e inter-empresas (en lugar de cadenas lineales), el enfoque CGV amplía las posibilidades de desglosar la dispersión geográfica en varias partes de la cadena de valor, así como enfatizar las diferencias espaciales. Con esa estratégica metodológica, se ha evidenciado el rol de las vocaciones territoriales en la posición del contenido transferido a largo de la cadena de valor, sea en actividades primarias, las de apoyo, las más sofisticadas que requieren un uso intensivo de conocimientos e innovación, o mismo las intensas en contaminantes, que complejizan el rol del espacio en la integración en CGV.

De hecho, un punto clave presentado es que el suministro de insumos intermedios y materias primas para el producto final que se vende en el extranjero pasa a depender de la organización de la red de economías regionales y sus formas de interactuar con los mercados globales. La gobernanza de las relaciones verticales dentro de la cadena de valor es el elemento explicativo para la forma como se llevan a cabo los vínculos entre regiones y empresas en la cadena (GEREFFI; HUMPHREY; STURGEON, 2005b; GU; HUMPHREY; MESSNER, 2008). La mirada hacia las regiones en las CGV ha sido asociada a un nexo de funciones y operaciones interconectadas a través de las cuales se producen, distribuyen y consumen bienes y servicios entre diferentes regiones (ATIENZA; ARIAS-LOYOLA; PHELPS, 2020;

ATIENZA; LUFIN; SOTO, 2018; COE et al., 2010; HADDAD; ARAÚJO, 2020). Al evaluar él VA local incorporado al comercio, se ha explicitado la organización espacial de las redes productivas, que conectan desde las áreas más periféricas hasta los grandes aglomerados económicos y a los mercados globales. Como resultado del grado de conectividad regional, hay un aumento en la demanda de contenido local integrado en los flujos de VA, ya sea asociado con cadenas de valor interregionales o globales. Las extensiones del análisis del componente regional en el comercio se han revelado importantes para comprender el potencial de desarrollo regional en base a los patrones de conectividad e integración productiva.

El primer artículo ha revelado que el proceso de fragmentación impone funciones de bajo valor agregado a los países en desarrollo latinoamericanos, lo que permite que grandes nodos globales se especialicen en etapas altamente complejas y de mayor valor agregado. La política comercial orientada a la liberalización comercial ha se vuelta un inductor de la explotación de recursos naturales para socios extrarregionales, limitando el desarrollo de los países y la integración dentro de la propia América Latina. A nivel supranacional, se ha demostrado que el alcance geográfico real de las CGV no es necesariamente global, sino a menudo bastante regional (continental). Incluso si los bienes finales se venden en el mercado global, la mayoría de sus actividades productivas, especialmente en el núcleo manufacturero, se reparten entre países pertenecientes a la misma región (BALDWIN; VENABLES, 2013). La geografía de la participación en las CGV es afectada pelos acuerdos comerciales, abriendo espacio para oportunidades de mayor integración intrarregional – entre países de AL – así como los socios del "sur global".

A nivel subnacional, dos artículos han permitido identificar las tendencias espaciales del valor agregado en Brasil. El segundo articulo presentó nuevas perspectivas para comprender el proceso de interdependencia espacial en las cadenas de valor, analizando la interacción entre las redes subnacionales y los vínculos globales en términos de gases de efecto invernadero implícitamente incorporado a las cadenas multiescalares de valor. Al incluir la naturaleza espacial en el análisis de TiVA, se ha señalado la relevancia de las variaciones regionales del proceso de creación y transferencia de valor, y sus implicaciones para la mirada espacial del grado de responsabilidad de las regiones subnacionales en las emisiones totales producidas y transferidas por Brasil. El potencial o el enclave contaminante hacia el desarrollo ambiental sostenible es claramente determinado por la jerarquía regional, y por la forma como las redes son organizadas en el espacio. La regionalización de la integración productiva de los estados brasileños ha apuntado al potencial de lidiar con la trayectoria de las cadenas contaminantes de valor. Interesante notar que el grado conectividad del núcleo (áreas más ricas y diversificadas) tanto con el interior como con los mercados externos es un importante canal para determinar la arquitectura de los roles espaciales en la responsabilidad ambiental.

A pesar de la creciente preocupación por redes de producción ambientalmente sostenible, la investigación aplicada carece de elementos explícitos de análisis de los recursos territoriales en la contabilidad socioambiental. Al contrario de los análisis puramente nacionales – que ocultan el rastreo de huellas de carbono dentro del país – nuestros resultados son relevantes para la discusión de políticas de desarrollo regional sostenible, pues identifican en rol territorial donde tienen lugar las políticas de mitigación y adaptación. El punto relevante es la identificación de los patrones de contaminación espacial desde la perspectiva multiescalar hacia la geografía económica. Este vínculo se hizo contabilizando los gases de efecto invernadero incorporados para cada par de origen-destino del TiVA, sea dentro del país (a través de los flujos interregionales de las DVC) o hacia las cadenas globales (por él VA en las exportaciones regionales). De hecho, los patrones de encadenamiento e intensidad de CO2 en la interacción de cadenas de valor multiescalares ha revelado el carácter espacial de la coordinación y gestión (gobernanza) de los flujos bilaterales de GEI, permitiendo al mapeo de las cadenas más intensas en contaminantes en respecto al VA comercializado.

La arquitectura de la DVC se vuelve aún más relevante para un país grande como Brasil, que se enfrenta a rutas de desarrollo industrial heterogéneas, lo que proporciona limitaciones espaciales a las ganancias de una estrategia de integración de cadenas de valor. Interesante que las macrozonas del país han generado un patrón espacial de integración productiva, siendo relevante para la promoción de estrategias de desarrollo orientadas a reducir disparidades regionales, considerando la posición espacial en las cadenas de producción, sean ellas domesticas o globales.

En ese sentido, el tercero ha apuntado que las medidas de mitigación de COVID-19 tienden a remodelar el papel del comercio a diferentes escalas geográficas, con implicaciones para el grado de exposición y conectividad regional. El principal motor del crecimiento brasileño se concentra en el desarrollo industrial de las regiones centrales, que pueden coordinar los DVC, a través de las cadenas *upstream* y *downstream* que tienden a generar efectos que impulsan la dinámica en áreas periféricas. Por tanto, la fragilidad de las zonas más remotas del país ante la demanda de los estados centrales y los mercados exteriores es un factor importante en el debate más profundo sobre las implicaciones de los shocks exógenos. La organización de las redes de producción frente a shocks apunta a capacidades territoriales altamente desiguales en Brasil, ya sea en términos de producción regional, sistemas de innovación y trayectoria de desarrollo, implicando en respuestas espaciales diversas ante la presencia de restricciones de oferta y demanda intermediaria.

Las disparidades persistentes en el país parecen incrementar aún más los impactos del COVID-19 desde la perspectiva de la integración en los mercados. Al comprender los impactos regionales, nuestros resultados revelan que el contenido de VA en el DVC se ve proporcionalmente más afectado (expuesto) en comparación con la integración en CGV. Brasil es un país con un gran mercado interno para abastecer y tiene un perfil de integración con CGV con poca diversificación. Sin embargo, las diferencias en la integración extranjera operan a nivel regional, donde los principales núcleos productivos incorporan relativamente más valor agregado intensivos en tecnología y conocimiento; mientras que la periferia está fuertemente especializada en exportaciones de industrias de recursos, lo que implica efectos potencialmente desiguales.

Las evidencias generadas en este documento se insertan en el umbral entre los límites de las aplicaciones nacionales de las CGV y el carácter amplio de las *GPN*. Se ha argumentado que, a pesar de la crítica constante a la linealidad metodológica de las CGV y la atención a los flujos verticales sus aplicaciones permitieron construir un retrato amplio del rol de las empresas y la estructura productiva dominante en la coordinación y gobernanza en los diferentes niveles de especialización asumidos por las regiones en los flujos de valor agregado.

5.2 EXTENSIONES ESPACIALES DEL ENFOQUE CGV

En general, se ha mostrado que los activos regionales y subnacionales incorporados en las CGV son elementos analíticos relevantes. Para comprender mejor la fragmentación de la producción y el comercio en el contexto de las cadenas de valor globales, la literatura ha introducido marcos metodológicos distintos para descomponer los intercambios regionales en tablas de insumo-producto. Mirándose las medidas de comercio de valor agregado derivada de la demanda final se puede eliminar el doble conteo de las exportaciones brutas, así como explorar dimensiones de otras naturalezas del comercio interregional. La aplicación insumo-producto interregional ha permitido determinar el patrón espacial de creación y distribución de valor en base a las ventajas competitivas y la capacidad tecnológica de los territorios.

El contenido local transferido a través del comercio ha señalado la relevancia en explorar las interacciones a diferentes escalas, y las aplicaciones IO han permitido incluir diferentes dimensiones y naturalezas que caracterizan el rol del espacio en la integración productiva. En el marco general basado en extracción hipotética se pudo avanzar en la descomposición del VA a nivel subnacional. Como en Los y Timmer (2018), la perspectiva bilateral proporciona términos de la calidad del VA regional transferido dentro y hacia el exterior de un país. La interpretación económica de las diferentes perspectivas ha permitido responder a diferentes preguntas sobre el rol del espacio en la producción y en el comercio, así como al potencial de desarrollo en base a las estructuras comerciales existentes. La perspectiva bilateral parece adecuada en el marco de la extracción hipotética, ya que el contenido doméstico de VA es calculado en base a la reestructuración del consumo intermediario y demanda final, revelando el rol de cada par de origen-destino, sea en valor agregado, en la producción industrial, el grado de CO2 incorporados, o en el nivel de exposición regional en base a las transferencias interregionales específicas.

5.3 OTROS AVANCES EN LA LINEA DE INVESTIGACIÓN

En el cuerpo de esta tesis se presentaron tres estudios específicos que han ampliado la mirada desde las CGV, explorando las variaciones de las escalas geográficas de la integración productiva. En paralelo al desarrollo de dichos estudios, se ha avanzado en analizar nuevas perspectivas del proceso de interdependencia espacial en las redes de producción bilaterales[38]. Al explorar la naturaleza espacial del TiVA, se ha generado una visión más detallada de la importancia de la integración de la red para el crecimiento regional.

Un artículo en desarrollo analiza patrones espaciales de integración en múltiples escalas, proponiendo una tipología de las redes subnacionales y globales que Brasil hace parte. Otro análisis considera el rol de las habilidades en el mercado laboral – basado en la desagregación del VA comercializado bilateralmente – avanzándose en la línea de investigación

[38] Em efecto, dos artículos están en etapas avanzadas de construcción siendo necesario someter a revistas para que puedan estar en esta tesis y así cumplir el artículo 29 del Reglamento del Doctorado en Economia Aplicada con mención en estudios regionales de la UCN. Esos dos estudios tienen las contribuciones del Dr. Carlos Azzoni, a cuál agradezco mucho por el apoyo y soporte.

sobre especialización funcionales de las regiones en las redes de producción. Extensiones de esas naturalezas son relevantes en dos aspectos principales:

1. Primero, incorporan una comprensión más profunda de los diferentes entornos localizados y estructuras espaciales asociadas con los encadenamientos productivos desde una perspectiva multiescalar. Esto se hizo manteniendo la estructura central metodológica aplicada globalmente, permitiendo generalizar el enfoque del marco de CGV, principalmente en lo que respecta a la integración vertical entre empresas, clústeres y mercados.
2. En segundo lugar, sugiere que la integración depende de las estructuras regionales, las capacidades territoriales, los activos y la especialización industrial, incluido él VA local incorporada en la tercera generación de estadísticas comerciales. Se hizo evidente que los impulsos para el desarrollo son desiguales en el espacio, y es importante considerar la diversidad de potenciales regionales para la integración económica.

En general, se revelan varios hallazgos al explorar los vínculos entre las dotaciones regionales y la integración de las cadenas de valor: las oportunidades de desarrollo y mejora ocurren en diferentes escalas y dimensiones espaciales. En todos los casos analizados - integración de los estados - la regionalización reveló el potencial de conectividad del núcleo (áreas más ricas y diversificadas) tanto con el interior como con los mercados externos - parece ser de gran interés para los estudios y políticas regionales.

5.4 IMPLICACIONES DE POLITICA

Ese tipo de análisis brinda implicaciones políticas relevantes para construir estrategias de desarrollo para fortalecer los vínculos interregionales, permitiendo que los territorios se muevan hacia actividades de mayor VA tanto para DVC (origen-destino interregional) como para GVC (origen nacional – destino internacional). La importancia en construcción de estrategias de desarrollo basadas en los territorios permite aprovechar de manera más eficiente los vínculos económicos existentes y fortalecer la posición regional en las cadenas de valor, sean ellas subnacionales o globales. De hecho, la capacidad de absorción de las empresas locales es un punto relevante para considerarse, ya sea en regiones basadas en recursos o en grandes aglomeraciones urbanas. Como los vínculos entre capacidades territoriales y perspectivas de integración (y *Upgrading*) están relacionados, debido al potencial de transmitir estímulos al desarrollo a través de las redes de producción, es necesario abordar las diferentes escalas espaciales para crear bases de convergencia.

Es relevante que el diseño de las políticas – principalmente las que operan a nivel local – considere la complejidad espacial y las posiciones desiguales (y de dependencia) en la red de producción. Esas variaciones implican en posiciones de bajo VA en las periferias globales que se reproducen a nivel subnacional, dada la distancia de los grandes centros económicos. La forma como las regiones se conectan es determinante para generar oportunidades orientadas al desarrollo territorial, sino hay una tendencia de retroalimentación del crecimiento en las áreas centrales, implicando en enclaves periféricos. Los resultados revelan responsabilidades ambientales desiguales entre la DVC y el contenido territorial suministrado a las CGV. Al incluir una dimensión espacial en la contabilidad ambiental, proporcionamos una evaluación útil sobre la necesidad de considerar redes subnacionales para diseñar políticas de mitigación y adaptación asociadas con el cambio climático y el desarrollo regional sostenible.

5.5 LIMITACIONES Y AVANCES EN AL AREA DE ESTUDIO

A pesar de los avances en resaltar la variedad escalar de beneficios de la integración, deben destacarse dos limitaciones importantes: una agregación administrativa espacial y la no inclusión de actores no económicos. Por mucho que el corte administrativo geográfico pueda abarcar aspectos relacionales específicos, los resultados aplicados al Brasil indican patrones espaciales claros. El papel de los actores no económicos se aplica a la construcción de capacidades locales para el arraigo territorial, ignorado en nuestra evaluación. Sería necesario combinar métodos cualitativos y cuantitativos para explorar las relaciones no económicas detrás de la integración. Además, la variedad espacial a nivel subnacional abre espacio para futuras investigaciones. Nuestros hallazgos revelan el potencial analítico de explorar la geografía de las transferencias de valor como un mecanismo para promover los activos regionales y permitir la sofisticación de VA integrado tanto en DVC como en GVC. Es fundamental profundizar el análisis para que las regiones rezagadas se conecten a diferentes escalas espaciales, generando bases de arraigo y aprovechando los beneficios de las cadenas productivas como motor del desarrollo local.

En sentido teórico, las diferentes líneas que estudian las CGV nunca han generado una visión única. Este campo de investigación es claramente interdisciplinario, abriendo posibilidades para ampliación del conocimiento – tal como se intentó en esta tesis. Las direcciones hacia el *Upgrading* son heterogéneas en el espacio y en los sectores productivos, ya que presentan patrones de integración de naturalezas distintas. El rol de los servicios también es un aspecto para explorar, ya que actúa como un sector de ligación entre a producción y los consumidores, así como de soporte a la manufactura. El tamaño de las empresas y su contribución a la conectividad en el espacio es otro tema pertinente al campo de los estudios regionales y CGV. La identificación detallada de los activos locales se transfiere a las diferentes escalas geográficas de la configuración de las redes es relevante para la ciencia regional – habilidades, recursos naturales, innovación, tecnología, sofisticación, etc. – pueden ser fácilmente incorporados al análisis cuantitativo. De hecho, al explorar los vínculos entre los sistemas de innovación y las perspectivas de desarrollo basado en CGV, el principal punto es que los procesos de integración y desarrollo ocurren en diferentes escalas espaciales, ya que existen diferencias subnacionales en los sistemas de innovación. Eso es muy más evidente en grandes economías, que pueden tener diversos patrones de propiedad de las empresas en las cadenas de valor mundiales transfronterizas pueden generar diversos resultados de *Upgrading*.

Es importante rescatar que la geografía económica ha avanzado mucho en la inclusión de los fundamentos subnacionales de los sistemas productivos (FOLD, 2014) – que permiten a los países crear condiciones para integrarse y absorber ganancias de competitividad en un contexto de producción fragmentada. Un aspecto crítico de esta literatura lo sustentan los estudiosos de la geografía económica y el enfoque de las redes de producción global (*Global Production Networks – GPN*) (BAIR et al., 2005; COE et al., 2010), que aborda el desarrollo regional desigual. En este campo analítico, la evidencia indica que el valor creado localmente es a menudo capturado por agentes externos, no convirtiéndose en un desarrollo local en torno a la especialización en funciones específicas, como es la prerrogativa dominante en el campo de las CGV (ATIENZA; ARIAS-LOYOLA; PHELPS, 2020; LÜTHI; THIERSTEIN; BENTLAGE, 2013; PHILLIPS, 2016).

Al alejarse de los marcos metodológicos y conceptuales de las CGV, las contribuciones asociadas con la literatura de las GPN generalmente se restringen a evaluaciones cualitativas o estudios de casos específicos (FOLD, 2014; KANO; TSANG; YEUNG, 2020). Por ende, la elección teórica asumida en este documento propone extender en enfoque CGV – así como el principal marco metodológico de medir él VA comercializado – para retratar la realidad subnacional, a través del rastreo de la ruta de propagación de los bienes de las exportaciones regionales y la identificación de las interacciones productivas en diferentes escalas y dimensiones (ambiental y estructural, en este caso).

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