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Implicaciones de la estructura productiva en el desarrollo económico de América Latina y el Caribe

MEMORIA PARA OPTAR AL GRADO DE DOCTOR

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IMPLICACIONES DE LA ESTRUCTURA PRODUCTIVA EN EL DESARROLLO ECONÓMICO DE AMÉRICA LATINA Y EL CARIBE

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"Así como el sol alumbra igualito a todos, hombres o mujeres, así la educación debe alumbrar a todos sean ricos o pobres, amos o peones"
Dolores Cacuango (1881–1971)

Resumen

América Latina y el Caribe (ALC) ha atravesado por numerosas etapas de desarrollo, entre otros, el modelo primario exportador que se instituye en la producción y exportación de materias primas hacia los países ricos y recientemente a China. En consecuencia, la región se ha constituido en un espacio territorial que crecientemente alimenta al mundo, pero que al mismo tiempo reproduce una estructura social y económica desigual respecto a otras regiones del mundo. Bajo este contexto, la tesis incluye tres artículos científicos previamente publicadas en diferentes revistas de economía. El propósito es contribuir a la discusión sobre los problemas del desarrollo económico de ALC, prolongadas por la forma de inserción en la estructura de la división internacional del trabajo que separa al mundo en países productores de bienes industriales y productores de materias primas. La relevancia radica en que el comercio internacional arroja pérdidas en los precios de las materias primas frente a los bienes industrializados, fenómeno que es conocido por el estructuralismo latinoamericano como deterioro de los términos de intercambio. Ante ello, desde el estructuralismo se plantea que la industrialización es un proceso inevitable para el desarrollo económico de un país, y que los estados nacionales deben establecer políticas que promuevan su desarrollo.

Es así, en primer lugar, haciendo uso de la literatura económica del pensamiento estructuralista —hipótesis Prebisch-Singer— se demuestra que ALC presenta un nuevo intercambio desigual denominado 'intercambio calóricamente desigual' que se refiere al aumento más rápido en los precios de las importaciones de alimentos en comparación con las exportaciones de ellos mismo, ambas medidas en calorías. Sin embargo, más allá del empeoramiento de los términos de intercambios de alimentos, la importancia radica en que los resultados abren la posibilidad de extender la discusión del comercio internacional en sentido integral, incluyendo los problemas nutricionales, de calidad de la dieta y aspectos económicos. En segundo lugar, teniendo en cuenta los efectos de la relación de intercambio favorables en el crecimiento económico se analiza las brechas económicas y de conocimiento entre ALC y demás regiones del mundo. Para ello, se usan variables como el ingreso per cápita (PPA ajustada la inflación) que se define como un indicador de bienestar, y como elementos de desarrollo técnico sostenido regional (proxi de conocimiento): número de solicitud de patentes, gasto público en educación, número de publicaciones científicas y técnicas, gasto en investigación y desarrollo, y exportaciones de manufacturas de alta tecnología. De este análisis, contrario a la teoría neoclásica, los resultados muestran que la escasa industrialización e inversión en conocimiento amplia desigualdades económicas y de conocimiento. Finalmente, la tesis reflexiona sobre la coordinación e integración económica para el comercio de alimentos como una estrategia para mejorar la productividad y la diversificación de la producción con alto valor agregado. Al respecto, bajo la hipótesis de que la región prioriza la complementariedad de productos que son más baratos de adquirir dentro de la región, el ahorro sería de aproximadamente 2.700 millones de dólares.

Abstract

Latin America and the Caribbean (LAC) have gone through numerous stages of development, including the primary export model that is instituted in the production and export of raw materials to rich countries and, recently, to China. As a result, the region has become a territorial space that progressively feeds the world, but at the same time reproduces an unequal social and economic structure with respect to other regions. In this context, the thesis includes three scientific articles previously published in different economics journals. The purpose is to contribute to the discussion on the problems of LAC's economic development, prolonged by the structure of the international division of labor; it separates the world into a group of countries that produce industrial goods and another group of producers of raw materials. The difference between them lies in the fact that international trade shows constant losses in the relative value of raw materials, compared to industrialized goods, a phenomenon that is known by Latin American structuralism as the deterioration of the terms of trade. In view of this, structuralism states that industrialization is an inevitable process for the economic development of a country, and that national states must establish policies that promote the development of countries.

Thus, first, making use of the economic literature of structuralist thinking – the Prebisch-Singer hypothesis – it is shown that LAC presents a new unequal exchange called 'calorically unequal exchange' which refers to the faster increase in the prices of food imports compared to exports of food itself, both measured in calories. However, beyond the worsening of the terms of food trade, the importance lies in the fact that the results open the possibility of extending the discussion of international trade in a comprehensive sense, including nutritional problems, diet quality, and economic aspects. Second, considering the effects of the favorable terms of trade on economic growth, the economic and knowledge gaps between LAC and other regions of the world are analyzed. To this end, variables such as per capita income (PPP adjusted for inflation) are used, which is defined as an indicator of well-being, and as elements of sustained regional technical development (knowledge proxies): number of patent applications, public expenditure on education, number of scientific and technical publications, expenditure on research and development, and exports of high-tech manufactures. From this analysis, contrary to neoclassical theory, the results show that low industrialization and investment in knowledge widens economic and knowledge inequalities. Finally, the thesis reflects on complementary economic coordination and integration for food trade as a strategy to promote spaces of competitiveness, improvements in productivity and diversification of production with high added value. In this regard, under the hypothesis that the region prioritizes the complementarity of products that are cheaper to acquire within the region, the savings would be approximately 2,700 million dollars.

Capítulo 1. Introducción

1.1. Introducción y motivación del tema de investigación

Los primeros economistas, como Adam Smith, Ricardo y Mill no hablaban de desarrollo, pero implícitamente se referían a este concepto al enfocarse en aspectos como el progreso, civilización, evolución, riqueza y crecimiento (Márquez et al. 2019). Smith (1776) creía que el libre comercio favorece la especialización productiva de los países con ventaja absoluta, en tanto que Ricardo (1817) planteaba la existencia de beneficios en países con ventaja comparativa. Al respecto, Reinert (2007) argumenta que la especialización en ciertos sectores económicos puede generar desigualdades significativas entre las naciones. Según su planteamiento, la teoría económica clásica reconoce la existencia de rendimientos decrecientes en la producción de bienes y servicios. Sin embargo, al mismo tiempo, dicha teoría ignora los rendimientos crecientes que pueden surgir de sinergias productivas e innovaciones tecnológicas. Estos rendimientos crecientes, cuando se generan, permiten que las economías basadas en la industria y la tecnología se beneficien de ventajas competitivas sostenibles y acumulativas, exacerbando las diferencias entre países ricos y pobres.

De este modo, los clásicos equívocamente creían en la idea de que todos prosperan por igual (Nahón, Enríquez, y Schorr 2006). Por lo tanto, los estados debían garantizar el libre mercado para alcanzar bienestar y desarrollo en sus economías. Incluso, los subsiguientes ortodoxos, tampoco cambiaron de parecer, pues, seguían creyendo en la nula necesidad de la intervención estatal y fomento de actividades estratégicas en pro de una estructura productiva[1] que sea capaz de modernizarse en términos tecnológicos (Pérez-Santillán y Salgado 2023). Más adelante, en la década de los 70 del siglo XX, entre los economistas neoclásicos lograron cierto consenso sobre el crecimiento económico impulsado por las exportaciones (Tyler 1981).

Asimismo, en el análisis excluyeron preocupaciones relacionadas con las diferencias en la estructura productiva y su heterogeneidad, diferencias institucionales y dependencia externa. Tampoco se ocuparon de los mecanismos de acumulación, de avance tecnológico, de asignación de recursos y repartición del ingreso (Sunkel 1970). De modo que, en oposición a ello a mediados del siglo XX, dentro de la disciplina de las ciencias sociales surgió la economía del desarrollo, un campo de estudio que centra su atención en el desarrollo de los países con bajos ingresos (Schteingart 2017), entre ellos, los países latinoamericanos.

A finales de la década de los años 40 del siglo anterior, con la publicación de Raúl Prebisch —El desarrollo económico de América Latina y sus principales problemas— (Prebisch 1949) dio origen al pensamiento estructuralista latinoamericano que, a su vez, se constituyó en la base de la teoría de la dependencia, el neoestructuralismo y la macroeconomía estructuralista.

[1] Actividad económica de un país —primario o de extracción, secundario o de transformación y terciario o de servicios—.

En el marco de esta teoría, el contexto global fue entendida como un sistema compuesto por economías centrales (desarrollados) y periféricas (subdesarrollados), donde las estructuras productivas de los países centrales se distinguen de las economías periféricas porque las primeras son homogéneas, diversificadas y de alta productividad, mientras que la segundas son heterogéneas, especializadas y de subsistencia[2] (Prebisch 1949). Las estructuras productivas del centro y la periferia tienen distintos niveles de aprovechamiento del progreso técnico (CEPAL 1951) y su relación entre ambas se desarrolla por la división internacional del trabajo, donde los países centrales se especializan en la producción y exportación de bienes industrializados y los periféricos en la producción y exportación de materias primas (Prebisch 1949), por lo que las relaciones de poder entre los dos (centro – periferia) son asimétricos y crecientes en el tiempo (Prebisch 1949). Abiertamente, este planteamiento desdice de la teoría de David Ricardo sobre los beneficios del libre comercio y reducción de desigualdades (Ricardo 1817), incluso de los subsiguientes exponentes como Heckscher-Ohlin que creía que el comercio conducía a igualar internacionalmente las retribuciones de los factores de producción (Heckscher 1919).

Según el pensamiento cepalino varias son las razones de esta realidad. Quizá la más importante resuelte ser el deterioro de los precios relativos de intercambio —exportaciones de materias primas en comparación con las importaciones de bienes industriales—(Prebisch 1949; Prebish 1950). Según Prebisch, el deterioro de los precios se asocia a varias características propias en materia de desarrollo de los países de la región, tales como: a) una estructura productiva concentrada en la exportación de recursos naturales; b) por las diferencias en el funcionamiento del mercado de trabajo en los países del norte y en los países del sur; y c) por los bajos niveles de elasticidad ingreso-demanda de materias primas de los países centrales. Es decir, cuando las personas o los países se vuelven más ricos, la proporción de ingresos para gasto en alimentos es menor. En consecuencia, la demanda de alimentos disminuye en relación con la demanda de bienes manufacturados. Por lo tanto, también se puede esperar que el precio de los productos agrícolas disminuya en relación con los productos manufacturados (Feenstra y Taylor 2016). Adicionalmente, en el caso de los productos minerales, es posible que los países industrializados encuentren continuamente sustitutos para el uso de minerales en su producción de bienes manufacturados (Feenstra y Taylor 2016). Por ejemplo, en la actualidad se utiliza menos acero en los automóviles porque los productores han optado por el uso de plástico y aluminio en la carrocería y el bastidor (Feenstra y Taylor 2016). Claro, la sustitución de productos minerales puede considerarse como una forma de progreso tecnológico y, a medida que avanza, puede provocar una caída en el precio de los minerales en bruto.

Como salida a esta problemática, Prebisch propuso la industrialización por sustitución de importaciones (ISI). Su pretensión fue reducir la caída de los términos de intercambio, desconcentrar el progreso técnico, generar fuentes de empleo, reducir la

[2] En su análisis, la especialización se refería a la limitada diversificación productiva e industrializadora.

pobreza y mejorar la productividad laboral de la industria, para con ello, mejorar salarios y aumentar la demanda interna (Pelit 2013). Asimismo, se consideraba que el ente responsable de esta transformación debía ser el Estado y sus empresas con inversión pública, incentivos, políticas de protección de mercado interno, restricciones al mercado internacional y control cambiario. Esta estrategia de desarrollo —Estado como actor clave— contraria al planteamiento neoclásico se justificaba por la desigual reproducción del sistema capitalista (Ormaechea y Fernández 2020).

Posteriormente, en la década de los 60s, a fin de fortalecer el proceso de industrialización por sustitución de importaciones, la teoría estructuralista instituyó políticas del ámbito fiscal, financiero, agrario y administrativo (Bielschowsky 2010). Así, el eje industrializador se orientó a producir bienes intermedios y de capital y exportar manufacturas (Agustina 2012). Sin embargo, los resultados adquirieron fuertes críticas debido a la falta de competitividad y dependencia externa de la tecnología. A su vez, debido al aprovechamiento y apropiación de multinacionales, saturación del mercado interno, y consecuentemente desequilibrios en la balanza de pagos. Mientras tanto, en los mismos países subdesarrollados, la atracción implícita generada por la abundancia de recursos naturales y mano de obra poco cualificada desestimulaba la diversificación productiva con contenido tecnológico.

Por ello, la Comisión Económica para América Latina y el Caribe (CEPAL) condujo a nuevas interpretaciones teóricas. Consecuentemente, surgió la teoría de la dependencia. Entre otros, se tiene aportes de exponentes como Celso Furtado (Furtado 1964, 1970), Osvaldo Sunkel (Sunkel 1970), Fernando Cardoso – Enzo Faletto (Cardoso y Faletto 1967, 1969), André Gunder Frank (Frank 1971), Samir Amin (Amin 1974), Ruy Marini (Marini 1973).

Esta teoría representa la perspectiva donde los países del sur mantienen dependencia económica respecto a la economía mundial (Samad 1996). Es decir, el subdesarrollo de los países del sur es consecuencia del desarrollo de los países industrializados, por tanto, el subdesarrollo no puede entenderse como una etapa inicial para alcanzar el desarrollo, sino, resulta ser una condición en sí misma. Más allá de ello, Cardoso y Faletto (1969) señalan que existen factores políticos sociales internos vinculados a la dinámica de centros hegemónicos que favorecen el crecimiento económico. Asimismo, el desarrollo subordinado al capital extranjero y a la importación de tecnología profundizan la dependencia. Además, debido a la capacidad que tienen las élites para aprovechar la inversión extranjera, este desarrollo podría concentrarse en ciertos sectores con poder económico y político, lo cual perpetúa la estructura de dependencia y desigualdad interna de los países subdesarrollados (Blomström y Hettne 1990).

Posteriormente, como respuesta crítica a las políticas neoliberales de la década de los 80s, a finales de los años 1980 y principios de los 1990, en la CEPAL se instauró el debate bajo el nuevo paraguas teórico denominado neoestructuralismo. En palabras de Ramos y Sunkel (1993) el neoestructuralismo comparte la idea

estructuralista básica de que las fuentes del subdesarrollo de América Latina no se encuentran principalmente en las distorsiones de los precios relativos inducidas por las políticas, sino que tienen su raíz en factores estructurales endógenos. Igualmente, tomó fuerza el análisis de la distribución desigual del ingreso y la riqueza como características de desigualdad social-económica y limitados niveles de inserción internacional, modernización institucional y democratización de la educación. Sin embargo, el análisis centro-periferia planteada por el estructuralismo perdió relevancia (Fernández y Ormaechea 2020), pasando a considerarse como un desarrollo sistémico de competitividad o fortalecimiento de ventajas competitivas, que va más allá de las ventajas comparativas propuestas por el neoliberalismo. El propósito fue establecer una estructura productiva que permita incrementar la participación de ALC en el comercio internacional, expandir el empleo, disminuir la heterogeneidad productiva, incrementar ingresos y reducir la pobreza (ECLAC 1990). Sin embargo, tampoco fue ajena a otras ideas como políticas de desarrollo desde aperturismo económico y políticas públicas en alianza con empresas privadas (Fernández y Ormaechea 2020). A ello, se sumaron políticas macroeconómicas como la política fiscal, tipo de cambio, crecimiento de inversión, ahorro e incentivos (Bresser-Pereira y Gala 2010).

En el contexto de este debate, aunque la relación de América Latina con el mundo ha cambiado profundamente, la evolución de sus economías ha sido desiguales (Bértola y Ocampo, 2013, 2022). La división internacional del trabajo sigue reproduciendo dinámicas de desigualdad entre países desarrollados y subdesarrollados, aunque con matices distintos debido a la globalización. Es cierto que las cadenas globales de valor han integrado a los países en desarrollo en la producción global, pero también es cierto que muchos de ellos aún siguen atrapados en eslabones de menor valor como la extracción de materias primas o manufactura básica. Ante ello, el planteamiento del estructuralismo latinoamericano resulta fundamental para comprender las complejidades del desarrollo en la región. Su enfoque histórico-estructural, su crítica a modelos dominantes y sus propuestas para abordar el subdesarrollo hacen de esta corriente una referencia crucial en el análisis económico y social contemporáneo. En este sentido, el objetivo central de esta tesis es ampliar la discusión sobre los problemas del desarrollo económico de América Latina y el Caribe (ALC), prolongadas por la estructura de la división internacional del trabajo que separa a la economía del mundo en países industrializados (países del norte) y países abastecedores de materias primas (países del sur).

Como se ha señalado, la diferencia entre ellos radica en que el comercio internacional arroja constantes pérdidas del valor relativo de las materias primas frente a los bienes industrializados, fenómeno conocido por el estructuralismo latinoamericano como deterioro de los términos de intercambio. De esto, los países productores de materias primas deben incrementar su producción y exportación para comprar la misma cantidad de bienes, lo que significa una descapitalización en favor de los países ricos. De este modo, se plantea que en ALC, la estructura productiva no aporta

suficientemente a la reducción de desigualdades en materia de desarrollo regional, principalmente por su insuficiente nivel de industrialización y progreso técnico que resultan ser fundamentales para el crecimiento económico; además, se plantea que existen oportunidades de crecimiento y desarrollo económico a través de mecanismos de integración regional y políticas de protección creados en el marco de la complementariedad entre los países de Latinoamérica y el Caribe. Es decir, la región podría potenciar sus industrias locales y aumentar su competitividad en base a un mercado ampliado y políticas coordinadas.

La importancia de esta investigación radica en su contribución al debate sobre los objetivos 8 y 9 de la Agenda para el Desarrollo Sostenible (ODS) 2030, que respectivamente promueve el crecimiento económico y la industrialización inclusiva y sostenible (United Nations General Assembly 2015). Al mismo tiempo, su importancia arraiga en la necesidad de comprender el rezago real de ALC en términos de especialización productiva (CEPAL 2016). Situación que es crucial para abordar los desafíos estructurales en materia de pobreza, industrialización y la distribución de ingresos. En estos términos, la discusión en pro del desarrollo económico de ALC enfocado en la producción de bienes con altos niveles de conocimiento y tecnología y de una integración regional por sí mismo tiene un carácter fundamental para el bienestar de la sociedad.

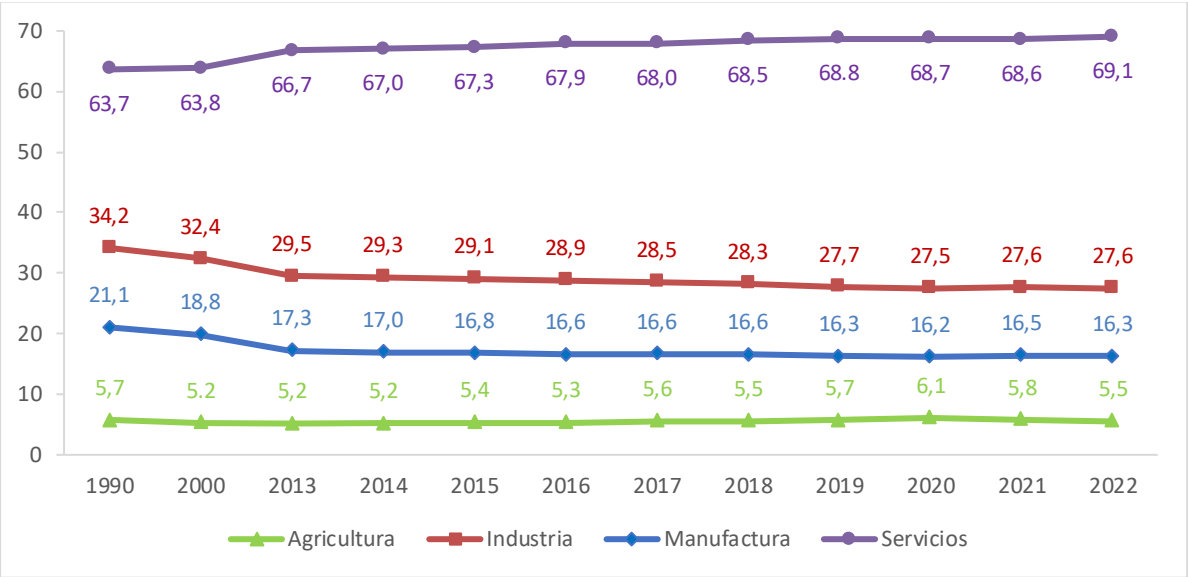
1.2. Implicaciones de la estructura productiva e inserción internacional de América Latina y el Caribe

Según el estructuralismo latinoamericano, la estructura económica determina la forma de inserción internacional y consecuentemente esta determina el tipo de desarrollo económico - tecnológico de países o regiones. La figura 1 muestra que en los últimos años ALC presenta fuertes cambios en su estructura productiva, especialmente debido a la reorientación notable hacia el sector servicios. Entre 1990 y 2022 el sector servicios incrementó 5,4 puntos porcentuales, mientras que la industria[3] disminuyó 6,6 puntos porcentuales y manufactura y agricultura 4,8 y 0,2 puntos porcentuales, respectivamente (ver figura 1).

A corolario de lo anterior, en la figura 2 se observa una diminución de la industrialización, valor agregado[4] (% del PIB), que en 1965 representaba el 24%, en 1988 el 25%, pero, para 2022 este se redujo al 17% (Banco Mundial 2023). Sin embargo, la misma base de datos de Banco Mundial (2023) muestra que las exportaciones de bienes y servicios de la región han aumentado del 13,4% (% del PIB) al 28,2% en 2022.

[3] La industria corresponde a las secciones 05-43, que incluye a la manufactura (divisiones 10-33) de la Clasificación Industrial Internacional Uniforme (CIIU) revisión 4 (Banco Mundial 2024).
[4] El valor agregado es la producción neta de un sector después de sumar todos los productos y restar los insumos intermedios (Banco Mundial 2024).

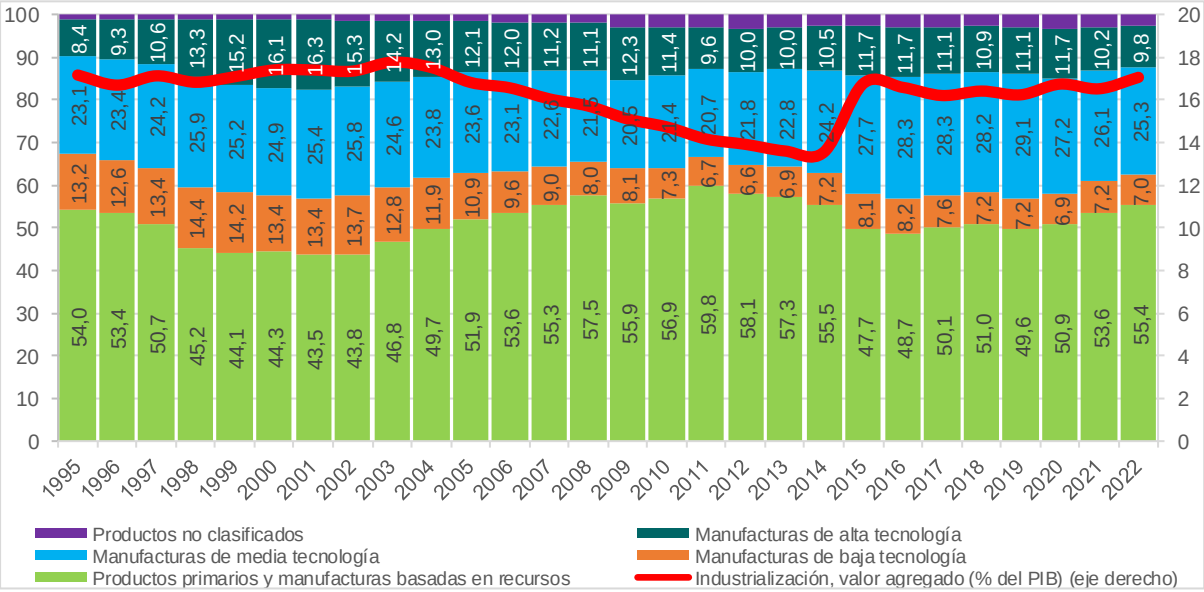
Figura 1. ALC: Composición sectorial de la producción (% del PIB), 1990-2022



Fuente: Banco Mundial (2023).

En este marco, las exportaciones por intensidad tecnológica ratifican que América Latina y el Caribe sigue altamente dependiente de las exportaciones de materias primas y manufacturas basadas en recursos naturales, que en 2022 representó el 55,4% (United Nations 2024). Igualmente, en términos de su evolución, se observa que la región, además de su alto nivel de dependencia de las exportaciones de materias primas y manufacturas basadas en recursos naturales, ALC presenta un proceso de reprimarización. Contrario a esta realidad, el peso de las exportaciones de alta tecnología se redujo en la última década.

Figura 2. ALC: Industrialización y exportaciones de productos por nivel de intensidad tecnológica, según participación en el total (%), 1995-2022



Fuente: (UNCTAD 2023) y Banco Mundial (2023).

Según el estructuralismo, la especialización productiva se explica por el comportamiento cíclico de los precios. Aparte de ello, el aporte significativo para la

literatura económica fue demostrar la existencia del deterioro de los términos de intercambio (Prebish 1950; Singer 1950), mediante el cual se ha señalado que en el tiempo el precio de las importaciones (bienes industrializados) de los países pobres crece más rápido que el precio de las exportaciones (materias primas) de ellos mismo.

De este modo, el deterioro de los términos de intercambio, entre otros factores promueve la especialización productiva de los países de la región, principalmente por su débil proceso de industrialización y exportaciones sin valor agregado relativo (concepción, diseño, investigación y desarrollo, marketing y servicio posventa) que mantienen las economías avanzadas, mientras que los procesos manufactureros se externalizan a los países en desarrollo con bajos salarios relativos (Lima y Zaclicever 2013). Situación que conlleva a un obstáculo para la reducción de las brechas económicas y de conocimiento (capítulo 3), dado que el sector primario exportador se convierte en un componente crítico de la capacidad de acumulación e innovación (Sunkel, 1987). Esto estaría en consonancia con la idea de Cardoso y Faletto (1969) quienes consideraban que la dependencia tecnológica se daba gracias a la concentración en los países industrializados de los procesos de producción. Bajo este contexto, la relación desigual de intercambio afectaba los ingresos y la capacidad para financiar el desarrollo (Prebish 1950; Singer 1950).

En ALC la dependencia de las exportaciones de *commodities* y su consecuente deterioro de los términos de intercambio se mantienen. Incluso, como una forma de compensar las pérdidas creadas por el deterioro de los términos de intercambio, los países se ven obligados a incrementar exportaciones y contar con recursos necesarios para financiar importaciones, pago por servicio de deuda, políticas públicas, etc., es más, la inversión en conocimiento (educación, formación profesional e investigación) ha dejado de ser una prioridad, situación que ha provocado mayores diferencias de productividad y el comercio desfavorable (capítulo 3). Según datos de Banco Mundial (2023), entre 1991 y 2022 las brechas en el PIB por empleado de las distintas regiones y América Latina y el Caribe aumentaron. Con Norteamérica de 2,7 a 3,4 veces, con Europa y Asia Central de 2 a 2,9 veces, con Medio Oriente y África del Norte de 1,4 a 1,6 veces, y con Asia Oriental y del Pacífico de 0,3 a 1,2 veces.

1.2.1. Del deterioro de los términos de intercambio, al intercambio desigual, intercambio ecológicamente desigual e intercambio calóricamente desigual

A partir de la teoría del deterioro de los términos de intercambio (Prebish 1950; Singer 1950), a mediados de la década de los 70s del siglo anterior, en la literatura de desarrollo latinoamericano apareció el debate sobre el intercambio desigual (Amin 1976; Emmanuel 1972) que engendró la discusión sobre comercio y relaciones de poder a través del cuestionamiento a los procesos de acumulación de capital entre el centro y la periferia. Es decir, aunque el comercio entre dos países pueda estar equilibrado, existe intercambio desigual cuando uno de ellos intercambia una gran

cantidad de trabajo escasamente remunerado (periferia), por una pequeña cantidad de trabajo altamente remunerado (centro) (Peinado 2015). A esta discusión, a mediados de la década de los 80 se sumó una nueva forma de intercambio desigual denominada intercambio ecológicamente desigual (Bunker 1984, 1985, 2007; Hornborg 1998) que permitió vincular el comercio con los problemas ambientales, esto es, el comercio internacional donde los países de la periferia exportan bienes con alto contenido de sus recursos naturales a cambio de exportaciones de bienes producidos en el centro con bajo contenido de recursos naturales (Peinado 2015).

En esta línea, el capítulo 2 contextualiza este debate para insertar una nueva categoría de intercambio desigual denominada 'intercambio calóricamente desigual' (Falconí, Ramos-Martin, y Cango 2017), que además de aportar a la literatura económica sirve de puente para demostrar una vez más, que la forma de desarrollo no es conveniente para la región. El intercambio calóricamente desigual constituye un estudio sobre el deterioro de los términos de intercambio de los alimentos por unidad de caloría (kcal) exportada e importada. La importancia radica en las nuevas posibilidades de comprender los temas nutricionales y calidad de la dieta, en el sentido de que ALC exporta calorías buenas nutricionalmente e importa calorías caras y deficientes nutriciamente (Falconí et al. 2017; Ramos-Martín, Falconí, y Cango 2017), lo cual, desdice del planteamiento de las Naciones Unidas en el marco de que todas las personas tienen derecho a una alimentación adecuada que no solo satisfaga los requisitos mínimos para la supervivencia, sino que también sea adecuada desde el punto de vista nutricional para la salud y el bienestar (UN General Assembly 2012).

En esta perspectiva, el primer objetivo busca determinar la existencia o no del intercambio calóricamente desigual. Para este fin, se usaron matrices de datos disponibles en FAOSTAT (FAO 2016) en el periodo de 1986 – 2013. Asimismo, se desagregó el análisis para 14 grupos de productos conforme a la clasificación de productos de la misma FAO. Los resultados presentados incluyen valores en términos de volumen, valores monetarios (dólares constantes de 2005) y calorías. Cabe señalar que, para cuantificar las unidades físicas en calorías se usó la tabla de composición de alimentos (FAO 2001).

El segundo objetivo busca examinar la pérdida de autosuficiencia alimentaria entendida como el aumento de la dependencia externa de la región. En términos generales, la autosuficiencia alimentaria se constituye en una estrategia que asegura el abastecimiento de alimentos dentro de las economías, así como también protege a los países de las posibles crisis del comercio mundial y de las fluctuaciones de los precios. En palabras de Clapp (2017), la autosuficiencia alimentaria puede medirse en calorías, en volumen o en función de valores monetarios.

De este modo, usando datos de FAO en el periodo 1961-2011, este indicador fue calculado como 1 - (calorías importadas /consumo interno de calorías)*100. Si la región no importa sería autosuficiente en un 100%, lo contrario ocurre si las importaciones son altas con relación al consumo. El punto clave es que los países

autosuficientes en alimentos producen una cantidad de alimentos igual o mayor que la cantidad de alimentos que consumen (Clapp 2017).

Con este análisis, el capítulo 2 confirma que la senda de desarrollo latinoamericano y caribeño insertada en el comercio mundial como exportador de materias primas crea desventajas respecto a los países industrializados. Por un lado, a través del deterioro de los términos de intercambio vistos como el intercambio desigual e intercambio ecológicamente desigual ampliamente revisado en la literatura y ahora con el intercambio calóricamente desigual que se incluye por primera vez. Vale señalar que, a partir de esta investigación en el contexto de la literatura científica ya se han desarrollado nuevos estudios, por ejemplo, en 2017 se analizó el intercambio calóricamente desigual para el Ecuador (Ramos-Martín et al., 2017) y en 2021 para el caso de América del Sur (Cango et al. 2021). Sin embargo, sigue siendo un desafío transitar hacia un modelo de desarrollo, que favorezca al fortalecimiento productivo y la competitividad de la región. Por otro lado, visto desde la pérdida de la autosuficiencia alimentaria de la región, que sin lugar a duda no deja de ser una preocupación para los países latinoamericanos y caribeños, en el capítulo 4 se amplía a más productos y se profundiza la discusión para reflexionar la viabilidad de la complementariedad agrícola a partir de la integración regional.

1.2.2. Implicaciones de la estructura productiva en el crecimiento económico y creación de conocimiento

La propuesta de industrialización de Prebisch se sustenta en dar respuesta a las consecuencias que generan las asimetrías de la demanda mundial de materias primas que produce la periferia, en contraposición con la demanda de los países periféricos (bienes industriales) producidos por las economías centrales (Prebisch 1949, 1981). Es decir, Prebisch establece que la elasticidad-ingreso de la demanda resultan desfavorables para los países empobrecidos, principalmente debido al lento crecimiento de la demanda de los países desarrollados, en comparación con el nivel de crecimiento de la demanda que hacen los países subdesarrollados cuando el ingreso mejora. Potencialmente, dichos efectos giran en torno al desequilibrio estructural en la balanza de pagos, con efectos adversos en la inflación y la continuidad del crecimiento económico, que se acentúan con el deterioro de los términos de intercambio (Bielschowsky 2010).

La caída en la relación de intercambio muestra que la dinámica histórica de desigual generación y apropiación de los frutos del progreso técnico entre el centro y la periferia propicia una relación reproductiva desigual en cuanto a la capacidad de captura del excedente (Fernández y Ormaechea 2020). Es decir, de mantenerse en el tiempo estables los volúmenes disminuye la capacidad de la región para financiar importaciones con exportaciones y su recuperación depende de la variabilidad positiva de los términos de intercambio y de subsecuentes incrementos en el volumen de las exportaciones (Prebisch 1949; Singer 1950). Esto, conlleva a los problemas de

ampliación de brechas económicas y de conocimiento que se analizan en el capítulo 3 (Jarrín-V et al. 2021).

Al respecto, varias investigaciones muestran que los términos de intercambio favorables para los países exportadores de materias primas tienen efectos positivos en materia de desarrollo. Entre ellos, Oviedo y Sierra (2019) evidencian que los términos de intercambio tienen efectos significativos de 5% en la variación de la producción, 8% en la inversión y 6% en la balanza comercial. De igual modo, Schmitt-Grohé y Uribe (2018) al evaluar en 38 países en vías de desarrollo y desarrollados encuentran que los términos de intercambio explican una variabilidad del PIB en un 30%. En tanto que, Broda (2004) al valuar en 75 economías en vías de desarrollo encuentra que los términos de intercambio tienen efectos en al menos un 10% en el PIB real. De otra parte, un estudio realizado para los países como Argentina, Chile, Colombia, Ecuador, Brasil, México y Perú muestran que el efecto de los términos de intercambio explica la variabilidad de la producción en un 25% (Ben Zeev, Pappa, y Vicondoa 2017). En estos términos, Krugman, Obstfeld, y Melitz (2014) mencionan que “un aumento en la relación de intercambio incrementa el bienestar de un país, mientras que una reducción en la relación de intercambio reduce el bienestar”.

En esta línea, el estructuralismo planteó que la dependencia de las exportaciones de materias primas genera un crecimiento económico poco vigoroso, y un deterioro de los términos de intercambio un crecimiento económico lento (Prebisch 1986a). A ello se suma el planteamiento de la teoría de la dependencia que establece que la economía mundial es desigual y perjudicial para los países del sur dedicados a la producción de materias primas con bajo valor agregado, en tanto que las decisiones y beneficios se concentran en países centrales denominados como economías industrializadas. A parte de ello, Cardoso y Faletto (1979) sostienen que el subdesarrollo es parte de la influencia y dominio exterior de las estructuras políticas, económicas y sociales de los países desarrollados. Incluso, se plantea que es el resultado de la influencia y dominación cultural, es decir, los países subdesarrollados se someten a una dependencia cultural que limita su capacidad para desarrollar y valorar su propio progreso. En palabras de Aníbal Quijano esta relación desarrollo-subdesarrollo se conoce como “la colonialidad del poder” (Quijano 2000).

Al contrario, la escuela neoclásica no considera la estructura productiva y afirma que las economías partícipes en el comercio mundial convergen económicamente entre sí, como respuesta al estado estacionario provocada por el nivel de tecnología, el ahorro y el crecimiento de la población en edad de trabajar (Solow 1956; Swan 1956) o debido a los rendimientos marginales decrecientes (Barro y Sala-i-Martin, 1995, 1992, 1990; Barro, 1991; Baumol, 1986). En otras palabras, basado en la libre circulación de capitales y en la igualación de la productividad marginal del capital las fuerzas de mercado y la competencia conducirían a la convergencia y la reducción de desigualdades entre los países (Piketty 2014).

Al amparo de estos antecedentes, cabe preguntarnos. En la actualidad ¿Existe convergencia económica entre ALC y las regiones más ricas del mundo?

De este debate se ocupa el capítulo 3, que centra su análisis en las brechas económicas y de conocimiento (Jarrín-V et al. 2021). Metodológicamente, usando la función *trapz* del paquete *pracma* en R (Borchers 2019), se integraron las curvas de crecimiento del ingreso per cápita (PPA ajustada la inflación) a través de la regla del trapezoide con puntos de base en el eje X (Kincaid y Cheney 1991). Asimismo, para probar las diferencias entre regiones en el mundo se utilizó el análisis de la covarianza ortogonal de tipo III (ANCOVA), implementada en la función *aov* de R (R Core Team 2018). El tiempo es una variable común utilizada en las tendencias de crecimiento y se consideró como un cofactor cuantitativo en los modelos lineales, con las regiones del mundo como predictor discreto. Seguidamente, usando la función *multcomp* de R (Hothorn, Bretz, y Westfall 2008), se realizó comparaciones múltiples de las regiones del mundo, a través de la prueba de medias de Tukey. En estas pruebas se consideraron el efecto de la covariable y el término de interacción. Sin embargo, debido a datos limitados y fragmentados (como los relativos al gasto en educación) o términos de fuerte interacción se utilizaron los paquetes *broom* (Robinson y Hayes 2019) y *tidyverse* (Wickham et al. 2019) para manipular matrices originales y tabular los resultados estimados.

A parte de ello, usando el método de "*SuperImposition by Translation And Rotation*" (SITAR) (Cole 2019), se obtuvo un modelo de curva de crecimiento promedio, invariante en la forma y de ajuste único (es decir, regresión *spline*). Al hacer coincidir espacialmente las curvas de crecimiento de cada región con la curva de crecimiento promedio, se extrajeron de la curva de crecimiento tres parámetros estimados como efectos aleatorios específicos de la región: 1) el tamaño (*size*) diferencia en el crecimiento medio (desplazamientos a lo largo del eje vertical de las curvas con respecto al crecimiento promedio estimado), 2) el momento (*tempo*) año en que la región tuvo la velocidad máxima de crecimiento, en comparación con el promedio, o el año en el que una región estaba creciendo más rápido (es decir, se desplaza a lo largo del eje horizontal de las curvas hacia la media) y 3) la intensidad (*intensity*) tasa de crecimiento en comparación con el promedio, o la pendiente de cada curva (es decir, la compresión del eje de tiempo a la media) (Cole, Donaldson, y Ben-Shlomo 2010).

De este análisis, se muestra que América Latina y el Caribe se encuentra por debajo del crecimiento de las regiones ricas, mismas que definen la brecha en tamaño e intensidad del crecimiento económico. Claro, contrario a las regiones ricas, ALC muestra un estancamiento en su desarrollo.

Más allá de los factores que explican la divergencia económica, la idea ricardiana de las ventajas comparativas que boga por el libre comercio, desdice de la prosperidad de los países en desarrollo. Ante ello, el pensamiento estructuralista plantea que la inserción internacional impide el progreso técnico e invoca a la industrialización como

una forma de captar el fruto del progreso técnico y elevar el nivel de vida de la sociedad (Prebisch 1986a; Prebisch 1986b; Prebisch 2012).

Cabe señalar que, el progreso consiste en el lento y gradual perfeccionamiento de diversos conocimientos técnicos, artísticos y científicos (Nisbet 1998). Desde el punto de vista económico, el conocimiento se define como un conjunto de ideas, habilidades e información relevante y procesable que pueden desarrollarse y aplicarse para agregar valor a los productos (Liang, OuYang, y Power 2007). Al respecto, sin desconocer la importancia que tiene el conocimiento, el pensamiento latinoamericano argumenta que por sí mismo no resuelve las limitaciones estructurales que perpetúan la dependencia económica (Furtado 1970). Bajo esta discusión, el neoestructuralismo, en la década de los 90 incorporó al debate la preocupación por la trasformación productiva, que incluye el desarrollo y adaptación de la tecnología, mejoras en la gestión organizacional e inversión en talento humano (Rosenthal 1994). Por lo tanto, la inversión en capital humano[5] concentró mayor preocupación en el pensamiento cepalino, aunque dejaron claro que su efectividad en el desarrollo depende de las políticas públicas activas para la transformación productiva, generación de empleo formal y el fomento de la innovación tecnológica (Bértola y Ocampo 2010).

A corolario de lo anterior, la competitividad pasó a ser la expresión de los avances en el sistema educativo, infraestructura tecnológica, energética, transportes, relaciones humanas, alianza público-privado y sistema financiero. En tanto que, la I+D y la ciencia al ser generadoras del conocimiento y de avances científicos resultan ser fundamentales para la humanidad. De este modo, por su importancia, usando la misma metodología para la estimación de brechas económicas, en el mismo capítulo 3, se desarrolla una primera aproximación sobre brechas de conocimiento entre ALC y demás regiones del mundo. Cabe señalar que la generación de conocimiento responde a la inversión en I+D, mientras que el volumen de ideas depende de manera directa del número de investigadores (Romer 1990). Así, tomando como referencia la Metodología de Evaluación del Conocimiento del Banco Mundial (Chen y Dahlman 2005; Robertson 2009) y los indicadores de conocimiento utilizados en el Índice Global de Innovación de 2019 (Cornell University - INSEAD - WIPO 2019) se seleccionaron cinco indicadores cuantitativos: Número de solicitud de patentes (residentes y no residentes por millón de habitantes), número de publicaciones científicas y técnicas por millón de habitantes, gasto en investigación y desarrollo per cápita (dólares constantes de 2010), gasto público en educación (dólares de 2010) (Banco Mundial 2020), y exportaciones de manufacturas de alta tecnología (miles de millones dólares constantes de 2010).

[5] En línea con el planteamiento de Bértola y Ocampo (2010), el capítulo 2 de la tesis incluye el término "capital humano", pero, su dimensión es el desarrollo humano y la apropiación de capacidades, que, difiere de un mero componente de la función de producción o determinante de la competitividad de una economía.

Al igual que en el ingreso por habitante, los resultados muestran que el conocimiento de América Latina y el Caribe se encuentra por debajo del crecimiento de regiones ricas como Norte América. Entonces, si analizamos sus determinantes podemos decir que la divergencia económica creciente de las regiones ricas y América Latina y el Caribe puede atribuirse, por un lado, a las limitaciones generadas por el desarrollo endógeno que por sí mismo ralentizan avances en el conocimiento y el know-how que no se adquieren fácilmente (Landes 1990). Por otro lado, la diferenciación creciente entre el norte rico y el sur pobre ya sea por diversificación del primero o por estancamiento de los segundos puede atribuirse al deterioro de los términos de intercambio en los países del sur (Ortiz 2001), que devienen de la ausencia de un proceso de industrialización, donde se generen encadenamientos productivos, aprendizaje mediante la experiencia en la producción, creación de ideas innovativas y producción con alto valor agregado de conocimiento y tecnología.

Es más, según el modelo estructuralista el deterioro de los términos de intercambio y las disparidades en el crecimiento económico es causado por la inserción internacional, por lo que, según esta teoría el Estado puede constituirse en un agente que incide en las relaciones sociales de producción de los países a través del diseño, impulso y estrategia industrializadora (Prebisch 2012). Este postulado es compartido por la teoría del desarrollo endógeno que insta la intervención del Estado para corregir fallas de mercado. Un ejemplo de ello, son los resultados obtenidos por los gobiernos del Asia Oriental que con sus intervenciones han logrado corregir fallas de mercado y acelerar el proceso de acumulación de capital, de progreso técnico y de transformación estructural de la economía (Naciones Unidas y CEPAL 1998). En palabras de Wade (1990) y (Cherif y Hasanov (2020) los países menos desarrollados (en su momento) como Taiwan, Corea del Sur, Hong Kong, y Singapur- han logrado crecimiento industrial utilizando un modelo orientado hacia el exterior e impulsado por el Estado con políticas proteccionistas. Fundamentalmente, políticas asociadas a la intervención estatal para direccionar recursos hacia industrias estratégicas (por ejemplo, la electrónica) que aseguren mejoras competitivas e incremento de exportaciones. Contario a ello, el modelo neoclásico asume que los precios y las disparidades económicas son corregidas automáticamente por el mercado, es decir que la política del “laissez-faire, laissez-passer” sigue siendo la fórmula adecuada para que los países puedan inmiscuir en el desarrollo.

1.3. Integración regional y cambio estructural

En el marco de la política de desarrollo estructuralista, la relación entre industrialización, integración económica regional y crecimiento hacia afuera están implícitos (Agustina 2012; Salazar 1993; Urquidi 1966). El elemento fundamental es la creación de condiciones para que el comercio sea beneficioso para los países del sur (subsesarrollados). Por ello, según el planteamiento de Prebisch, la industrialización junto con un mecanismo de sustitución de importaciones eficiente

como la integración económica regional, permitiría a los países del sur alcanzar un comercio recíproco. En otras palabras, a través de la industrialización los países del sur podrían atacar las diferencias en la elasticidad ingreso de materias primas versus manufacturas y aprovechar las externalidades positivas que traen consigo la industrialización.

Adicionalmente, en el marco de la transformación productiva, junto con las mejoras en la inversión en los sistemas de transporte, comercio y servicios, el neoestructuralismo también apuesta por la integración latinoamericana y caribeña (Rosenthal 1994). Sin embargo, por las estrategias necesarias para transitar de una economía primario-exportadora a una economía industrializada, entre otras surgen las siguientes dudas, ¿ALC podría promover su desarrollo a través de una integración regional? ¿Cuáles son las principales barreras que impide alcanzar la unificación regional? ¿Conviene la aplicación de estrategias de protección interna?

Antes de responder estas interrogantes, vale mencionar que una integración regional no significa que las importaciones se cierren por completo, sino que regionalmente se avance hacia la desviación eficiente de comercio (Barenstam 1965), donde los países que requieren importar bienes que no se producen, lo pueden hacer (por ejemplo, bienes de capital), pero, para la importación de bienes que se producen internamente debe gravarse aranceles. Según Hix (2001) esta opción puede encaminarse a través de procesos de integración regional entre los países. Como resultado, la integración económica podría ser la formación de un área de libre comercio, una unión aduanera, un mercado común o una unión económica entre un conjunto de países (Salvatore 1992).

Un ejemplo de ello es la cristalización de la Unión Europea (UE) que desde el punto de vista económico estuvo encaminada a favorecer el desarrollo de la UE en su conjunto y reforzar la tendencia hacia la homogeneización del bienestar entre todos los países miembros. No obstante, en ALC también ha existido un potencial interés en la cooperación intrarregional, y en especial, en los acuerdos formales de integración económica como un instrumento de política para promover la diversificación de la economía hacia sectores con más elevada intensidad tecnológica (Porcile y Cimoli 2014). Una primera experiencia de ello fue en 1960 cuando la Asociación Latinoamericana de Libre Comercio (ALALC) inició un proceso de negociación, mismo que años después fue dejado de lado. En los subsiguientes años hubo otros intentos que tampoco tuvieron éxito. En palabras de Porceli & Cimoli (2014) la propia búsqueda del cambio estructural dejó relegada la propuesta de integración, en especial desde 2003 año en que inició la bonanza de las *commodities*. Más adelante, en 2011 se creó la Comunidad de Estados Latinoamericanos y Caribeños (CELAC) que incluye a 33 países miembros de América Latina y el Caribe[6].

[6] CELAC, está conformada por Antigua y Barbuda, Argentina, Bahamas, Barbados, Bolivia, Brasil, Belice, Chile, Colombia, Costa Rica, Cuba, Dominica, República Dominicana, Ecuador, El Salvador, Granada, Guatemala, Guyana, Haití, Honduras, Jamaica, México, Nicaragua, Panamá, Paraguay,

Según la declaratoria de constitución, esta instancia es un espacio de integración regional y cooperación para reducir desigualdades sociales (CELAC 2011).

Más allá de ello, en la actualidad la Unión Europea continuamente avanza en la regulación y análisis del impacto regulatorio (Micossi 2016), que inclusive es ejemplo en el mundo sobre la aceptación regulatoria y económica al amparo de una comunidad regional. Bajo esta idea de desarrollo, el capítulo 4 aborda la integración regional como oportunidad para fomentar la complementariedad agrícola entre los países latinoamericanos y caribeños (Cango, Ramos-Martín, y Falconí 2022). El estudio, incluye tres análisis importantes. En primer lugar, usando datos de FAO (2020d) analiza la trayectoria del uso del suelo, mismo que se complementa con el análisis de la evolución de los niveles de productividad en la producción agrícola por unidad de hectárea de 9 grupos de productos[7], según regiones clasificadas por el Banco Mundial.

En segundo lugar, aunque el comercio puede contribuir a la estabilidad de los suministros y precios de los alimentos y, por ende, a la dimensión de estabilidad de la seguridad alimentaria (Zimmermann y Rapsomanikis 2023), la investigación busca determinar el nivel de autosuficiencia alimentaria en unidades físicas. Para ello se usó la matriz detallada de comercio (FAO 2020a) y el balance alimentario (FAO 2017, 2021).

Finalmente, en tercer lugar, se analiza las oportunidades de complementariedad agrícola. Para ello, se usó la matriz detallada de productos (FAO 2020a), mediante el cual, se determina los grupos de productos que la región muestra superávit o déficit. Los productos con superávit se denominan productos con oportunidades de complementariedad agrícola para los cuales se plantea que los países de la región sustituyen importaciones desde el resto del mundo por exportaciones de la región hacia el resto del mundo.

Como resultado, el estudio demuestra que la evolución de la frontera agrícola y el deterioro de los bosques de Latinoamérica y el Caribe es más preocupante en comparación con las demás regiones del mundo. Al mismo tiempo, esta reorientación en el uso del suelo no viene acompañada de mejoras en la productividad que fortalezca el desarrollo productivo regional, sino esta dinámica reorienta al deterioro de la autosuficiencia alimentaria. Además, el estudio evidencia que, si la región priorizara la complementariedad de productos para los que son más baratos intrarregionalmente que los del resto del mundo, el ahorro sería de aproximadamente 2.700 millones de dólares, es decir, el 6,8% del total de las importaciones del resto del mundo. Mientras tanto, el valor monetario de las exportaciones disminuiría en aproximadamente 1.300 millones.

Perú, Saint Kitts and Nevis, Santa Lucía, San Vicente y las Granadinas, Surinam, Trinidad y Tobago, Uruguay y Venezuela.

[7] Cereales – excluida cerveza; almidón de raíces; cultivos azucareros; legumbres secas; nueces; cultivos oleaginosos; hortalizas; frutas – excluso vino; estimulantes.

Aunque la propuesta de complementariedad agrícola encaminada a través de un proceso de integración regional no muestra un nivel de ahorro elevado, esta opción de desarrollo contribuiría a reducir los efectos del intercambio desigual y de las brechas económicas y de conocimiento, a través del fortalecimiento de las cadenas de valor y de capacidades tecnológicas que crean competitividad de los sectores más intensivos en conocimiento. Por otro lado, se abren las puertas para la transformación de la estructura productiva mediante el aprendizaje, difusión tecnológica, incentivos de capacitación, creación de instituciones dedicadas a la investigación y desarrollo, el entrenamiento y la educación (Porcile y Cimoli 2014). En otras palabras, la integración contribuiría a la industrialización y la diversificación productiva con mejoras en la productividad, oportunidades laborales, reducción en la salida de divisas y costos de transporte.

En la práctica, la discusión de esa política regional podría encaminarse desde la organización latinoamericana y caribeña vigente (CELAC), principalmente respaldada en el potencial productivo de la región. Actualmente, ALC representa el 14% de la producción mundial de alimentos y el 45% del comercio agroalimentario internacional neto (FAO y ECLAC 2020). La importancia es la expansión de la demanda y consecuentemente el crecimiento económico, la absorción del desempleo y mejoras distributivas. A su vez, el consumo intrarregional y consumo externo en sentido complementario, es atractivo para la inversión e industrialización, incluido las pequeñas y medianas unidades productivas.

Sin embargo, pese a ser una política de desarrollo atractivo, presenta ciertas limitaciones que vale mencionarlas. Por un lado, la creación de un mercado común no garantiza la eliminación de deficiencias, distorsiones y barreras que podrían afectar negativamente la capacidad de estimular y fomentar la inversión. Es decir, a parte de la eliminación de aranceles, libre circulación de bienes, servicios, capitales y personas y la unificación de normativas, no descarta las múltiples formas de mantener la competencia, tales como, la competencia fiscal (reducción de impuestos), política industrial (apoyo sectores estratégicos), diferencias regulatorias (especialmente al momento de implementar las normativas comunes) y competencia en innovación y tecnología, especialmente al momento de atraer industrias de alta tecnología e innovación. Por otro lado, la inacción de estrategias que consolide los objetivos de desarrollo regional podría presentar otras implicaciones como aumento de precios a los bienes importados desde fuera de la región, reducción de opciones de consumo, ineficiencia y débil innovación, deterioro de las relaciones comerciales (represalias comerciales), pérdida de empleo del sector importador, etc.

A la inversa, también puede contribuir con el fortalecimiento a las industrias nacientes y en consecuencia crear nuevas opciones de empleo, crecimiento económico y competitividad. Empero, no se descartan situaciones que limiten esta integración como las deficiencias internas, intereses políticos, ruptura de tratados y convenios internacionales, etc. Pero, la discusión y el debate es el primer paso, más aún cuando

la región puede valerse de la experiencia de la entidad geopolítica “Unión Europea” única en el mundo que por cierto le tomó más de 40 años para su consolidación.

En este sentido, la tesis se organiza en tres capítulos, además de la introducción y las reflexiones finales. El capítulo 2 centra su análisis en la existencia de un intercambio desigual entre países ricos y pobres e inserta una nueva categoría sobre el deterioro de los términos de intercambio para productos alimenticios denominado “intercambio calórico desigual”, mientras que el tercer capítulo demuestra que la estructura de desarrollo de ALC amplía la brecha económica y de conocimiento frente a otras regiones en el mundo, en tanto que, la tercera investigación exterioriza la inexistencia de un proyecto de integración regional y demuestra una oportunidad de complementariedad agrícola entre los países latinoamericanos y caribeños para reducir los efectos del intercambio desigual y propender un crecimiento económico sostenido.

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CAPÍTULO 2.

"CALORIC UNEQUAL EXCHANGE IN LATIN AMERICAN AND THE CARIBBEAN"

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Analysis

Caloric unequal exchange in Latin America and the Caribbean

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ABSTRACT

The existence of an unequal exchange between rich and poor countries has been well studied in the literature, explained by differences in labour costs that were reflected in the prices of traded goods. Research has also demonstrated that the failure to include environmental impacts in prices of traded goods concealed an ecologically unequal exchange. This paper contributes to the discussion with the newly coined concept of caloric unequal exchange that defines the deterioration of terms of trade in food in units of calories. Exports and imports to and from Latin America and the Caribbean are analysed for the period 1961 through 2011 in volume, value, and calories, for different groups of products. The study concludes that although calories exported by the region to the rest of the world are more expensive than those imported, the ratio is deteriorating over time. This trend is found to be dependent of the trading partner involved. The region is helping the rest of the world in supplying their diets at a lower cost. A side result is that globalisation is homogenising diets over time, concentrating most food consumption in a reduced number of products, and therefore increasing interdependency among countries and affecting food security.

1. Introduction

The insertion in global markets often induces changes in production patterns that go against the goal of self-sufficiency, understood as the situation in which food needs are covered with domestic production (FAO, 2002). This is a trend found in many Latin American countries which until now have prioritised production for exports instead of internal supply (Pengue, 2009). This trend has implied a gradual loss in food self-sufficiency and an increase in vulnerability to external factors, such as international prices. This is not the case for all areas of the world, as food self-sufficiency is one of the main goals of many countries or regions. This is the case of the European Union, which has achieved that goal through the Common Agricultural Policy (Guinea, 2014). The EU actually produces more food than it consumes, thus avoiding a supply side problem in recent decades (Candel et al., 2014).

Latin America and the Caribbean (LAC) is increasingly feeding the world. As it happens with other commodities, the terms of trade in the case of food products have been deteriorating over time (Section 4). This fact, along with the dependency the region has on exports to obtain foreign currency, induces countries to engage in a race-to-the-bottom as they compete with each other to sell the same products, driving export prices even lower. This is known as unequal exchange, which translates into the need for exporting more volume over time to be able to import the same volume.

This deterioration of the terms of trade was a concept advanced by economists in the region such as Prebish (1950, 1959), Singer (1950), or Furtado (1964, 1970), and gained the attention of authors such as Emmanuel (1972) or Amin (1976). Soon the concept evolved and incorporated environmental concerns, giving birth to the concept of ecologically unequal exchange, according to which exports of natural resources were not accounting for environmental externalities produced in exporting countries.

Many other studies have followed and contributed to this discussion in Latin America (Eisenmenger et al., 2007; Falconí and Vallejo, 2012; Giljum, 2004; Hornborg and Jorgenson, 2010; Hornborg, 1998, 2009; Machado et al., 2001; Muradian and Giljum, 2007; Pérez-Rincón, 2006a; Samaniego et al., 2014; Vallejo, 2010), and acknowledged by studies also measuring the loss of nutrients involved in food exports (Grote et al., 2005; Pengue, 2005). Through analysing the energy balance of agriculture (Pérez-Rincón, 2007), we decided to explore the unequal exchange of food trade, with an understanding that trade is not bad in itself, but unequal exchange is, as it means that many side-effects of production and trade of food are not accounted for .

It is in this regard that the article introduces the concept of caloric unequal exchange, which could be defined in the following way. It expresses the deterioration in the terms of trade of food traded when considering the cost of exported and imported calories. If unequal exchange allowed for discussions of power relationships in international trade,

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and ecologically unequal exchange allowed us to incorporate trade-derived environmental externalities into the debate, it is our belief that caloric unequal exchange will allow for discussions of nutritional issues and diet quality when analysing food trade.

The paper explores this concept in the case of Latin America and the Caribbean with respect to the rest of the world, for the period 1961–2013, using the latest available data published by FAO.

The paper has two specific objectives:

1) To test the existence of caloric unequal exchange as defined above both in volume terms but also considering the cost of exported vs imported calories and their evolution over time.
2) To examine the loss of regional food self-sufficiency or the increase in external dependency.

2. Unequal Exchange, Ecologically Unequal Exchange, and Caloric Unequal Exchange

The concept of ecologically unequal exchange builds on the concept of 'unequal exchange' developed by Emmanuel (1972) and Amin (1976) and earlier by the work of structuralists Raúl Prebish (1959, 1950) and Furtado (1970, 1964). At that time, the concept focused on the unequal relationship found in traded goods between countries in terms of embodied labour time, which was reflected in prices being different and therefore developing countries showing deteriorating terms of trade. Ecologically unequal exchange put the focus on embodied land, natural resources and pollution (Bunker, 1984, 1985, 2007; Dorninger and Hornborg, 2015; Hornborg, 1998, 2009, 2014; Hornborg et al., 2007; Muradian and Giljum, 2007; Røpke, 2001). Exports of developing countries would be intensive in natural resources. However, their prices would not account for the value of the environmental externalities involved, implying a de facto transfer of wealth from poor to rich countries. Externalities would not be seen then as market failures, but rather as 'cost-shifting-successes' (Muradian and Martinez-Alier, 2001).

In fact, Hornborg (1998: 127) sees unequal exchange as emerging from an inverse relationship between productive potential and economic value. In his own words, "'*production' (i.e. the dissipation of resources) will continuously be rewarded with ever more resources to dissipate, generating ecological destruction and global, core/periphery inequalities as two sides of the same coin*".

The work of Bunker helped understanding how natural resource extraction shaped the underdevelopment of the Amazon in earlier decades (Bunker, 1984, 1985), opening room for new studies in what is today called political ecology, which deals with ecological distribution conflicts (Martinez-Alier and O'Connor, 1996).

Much work showing evidence of the imbalances in international trade and the burden of the exploitation of natural resources has been conducted, particularly in Latin America. A few examples for this growing literature follow. In the case of Brazil, Machado et al. (2001) showed that exports of non-energy goods had more embedded energy than imports. Embodied pollution in exports was also analysed (Muradian et al., 2002). The authors presented environmental load displacement from developed to developing countries. They estimated embodied pollution from 18 industrialized countries belonging to OECD versus the rest of the world, with the result that more air emissions were embodied in imports than in exports by rich countries. A study using material flow accounting in Chile showed how the burden of the exploitation of natural resources was unequally distributed and remained with the exporter (Giljum, 2004). Similarly, Pérez-Rincón (2006a) found a biophysical trade balance deteriorating and worsening terms of trade in the case of Colombia.

(Jorgenson, 2009, 2012; Jorgenson et al., 2010) conducted a series of tests on the existence of ecologically unequal exchange. He first tested the hypothesis for 66 lower-income countries, finding that those countries with high levels of primary exports to high-income countries, showed, at the same time, lower consumption-based environmental demand, measured by their ecological footprint (Jorgenson, 2009). Later he extended the analysis to deforestation (Jorgenson et al., 2010) and CO_2 emissions (Jorgenson, 2012).

Most of the analyses, though, focus on traditional extractive sectors such as mining and oil, with minor exceptions such as Austin (2010), who showed how developed economies transferred the environmental costs of their beef consumption to developing nations, the origin of their imports.

Our work contributes to this debate with the newly coined term 'caloric unequal exchange'. By this we mean the deterioration of the terms of trade when calories of foodstuff instead of volume are used. Our hypothesis is that, developing countries, and in our case, the countries of Latin America and the Caribbean, are increasingly exporting food products to the rest of the world at a lower cost to the calorie, expressing a new form of unequal exchange.

Analysing caloric unequal exchange is important as it brings together other issues regarding trade and food production globally, such as dietary diversity and malnutrition, food security and environmental concerns. Clearly, nutrition is not just about calories; however, calories can be used to bridge different scales of the analysis. Volume allows us to link the monetary value of food exports with production and therefore with land use and environmental impacts, as in ecologically unequal exchange. Calories allow us to link the former with nutrition. We are aware, though, that we are subject to simplification by using just one indicator, but we believe caloric unequal exchange may be expanded in the future to account for macro- and micro-nutrients.

3. Material and Methods

This study focuses on the region of Latin America and the Caribbean as defined by the UN Statistics Division.[1] The time window considered depends on the availability of data. For data on consumption, self-sufficiency, and variety of consumption, we use the period of 1961–2011. In the case of trade and terms of trade, we use data for the period 1986–2013 as reported by FAO.

The main source of data is FAOSTAT (FAO, 2016). We have used both data on food trade (starting in 1986) as well as food balances (starting in 1961). We present data in terms of volume, monetary values (in constant USD of 2005) and calories (kcal). Analysing LAC as a region means deducting intra-regional trade from trade statistics, as we are only interested in the relationship of the region as a block with the rest of the world. It is important to mention that, due to lack of data, Mexico is absent from the analysis for the year 1996, a fact that materialises in both tables and figures.

Several steps for processing data were followed, which are described below.

First, We use FAO's 14 major food groups: cereals (excluding beer), sugar crops, sugars and syrups, pulses, tree nuts, oil crops, vegetable oils, vegetables, fruit (excluding wine), roots and tubers, stimulants, spices, alcoholic beverages, miscellaneous. In this way, we focus our analysis on those groups that are more relevant for the region in terms of calories consumption. The study disaggregates the analysis for six major food product groups, according to their relative importance in terms of consumption: cereals (excluding beer), sugar and syrups, roots and tubers, pulses, vegetable oils and fruits (excluding wine).

Second, we used FAO's food composition tables (FAO, 2001) for calculating the energy content of traded goods. It is worth mentioning that our analysis only accounts for calorie content of food products and does

[1] Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, St. Lucia, St Vincent and the Grenadines, Suriname, Uruguay, Venezuela. (See http://unstats.un.org/unsd/methods/m49/m49regin.htm)

Table 1
Food trade balance for LAC with the rest of the World, volume, value and calories, 1986–2013.
Source: FAO (2016).

Year	Exports (10^3 Tn)	Imports (10^3 Tn)	Exports (10^6 US$ 2005)[a]	Imports (10^6 US$ 2005)[a]	Exports (10^{12} kcal)	Imports (10^{12} kcal)
1986	34,437.5	17,465.6	20,395.2	4122.6	103.6	62.7
1991	37,593.1	19,614.2	14,558.9	4391.8	93.6	69.4
1996	40,595.0	15,799.5	17,109.7	4950.9	112.5	53.4
2001	89,664.5	41,442.4	32,661.0	10,098.6	274.1	143.2
2006	117,566.2	43,880.5	48,499.9	12,696.8	360.1	152.2
2011	155,498.6	41,708.3	62,457.4	16,469.0	469.4	147.2
2013	185,690.9	41,872.9	65,987.1	17,345.8	567.7	144.2

Note: Mexico is absent for 1996 due to lack of data in all tables and figures.
[a] Adjusted to the value added deflator by country for Agriculture, silviculture and fishing (value US$, 2005 prices).

not account for energy required for production as, for instance, found in Arizpe et al. (2011).

In this way, trade indicators (volume, monetary values or calories) for LAC can be expressed as:

$$X \vee M = \sum_{k=1}^{n} p_{kjt} \quad (1)$$

where:

X total exports of LAC
M total imports of LAC
p_{kjt} exports from country k to country j in year t (X); or, imports of country k from country j in year t (M), $\forall k \in LAC$ and $\forall j \notin LAC$.

Moreover, $p_{jkit} = \sum_{k=1}^{n} p_{kjt}$, where i represents the product.

Third, we isolated intra- from inter-regional trade for LAC. The calculations on trade are done considering LAC as a block and in relation to its trade partners, the rest of the world, the US, China and Europe (the continent, as defined by FAOSTAT (FAO, 2016)). This is done by subtracting intra-regional trade from trade data for the aggregate of countries in LAC.

Fourth, using the energy coefficients from FAO's food composition tables (FAO, 2001), we converted trade data (exports and imports) in volume into calories. In order to analyse the Prebish-Singer hypothesis (Prebish, 1950, 1959; Singer, 1950) of the deterioration of the terms of trade in terms of calories, the average calorie content per 100 g reported in the food composition tables was used as proxy for expressing exports and imports in terms of calories, for product i and country k in the year t. The food trade balance in calories is expressed as calories exported minus calories imported, as our aim is to show terms of trade in calories that are comparable with standard terms of trade.

Fifth, using USD prices for 2005, that is, adjusted to FAO's value added deflator by country for agriculture, silviculture and fishing, the value of exported and imported calories were used for calculating the unit cost of calories exported and imported, which allowed us to compute the terms of trade in this way

$$\mathrm{ToT}_t = \frac{X_{\mathrm{US\$2005}_t}/X_{\mathrm{kcal}_t}}{M_{\mathrm{US\$2005}_t}/M_{\mathrm{kcal}t}} \quad (2)$$

where ToT stands for terms of trade, X total exports of LAC, M total imports, while *US*$2005 and *kcal* denote the indicators adjusted to constant prices of 2005 and calories, respectively; and t, the year.

The interpretation of the terms of trade is the following. A value of 1 means that calories exported have the same cost as calories imported. A value larger than one means positive terms of trade, that is, exported calories are more expensive than imported ones. Therefore, the country needs less calories exported to cover for the cost of its calories imported. A value lower than one means negative terms of trade, the country will be compelled to export larger quantities in order to cover for its imports. As stated before, we do not calculate the actual cost of producing a calorie, but the adjusted price at which that calorie (exported or imported) is traded.

Sixth, an indicator for self-sufficiency in food products for the region was also calculated as one minus the share of imported calories over domestic consumption in terms of calories:

$$\text{Self-sufficiency}_t = \left(1 - \frac{M_{\mathrm{kcal}_t}}{C_{\mathrm{kcal}_t}}\right) * 100 \quad (3)$$

where C denotes domestic consumption of calories.

Seventh, we calculated the level of concentration of products in consumption, measured in kcal, by a cumulative distribution of the relative share in consumption of each of the 74 products reported in the food balances.

4. Results

Table 1 presents the food trade balance (for the selected product groups) between LAC and the rest of the world for the period 1986 through 2013. Data is presented in volume, monetary value, and its conversion into calories. Exports in volume increased by 5.4 times their original size in the period, almost the same as in calories (5.5), whereas its monetary value increased by 3.2 times. In the case of imports, they increased by 2.4 times in terms of volume and 2.3 in calories, while they increased by 4.2 times in monetary terms. The surplus has increased fivefold in the period of the 28 years analysed. The region is increasingly feeding the rest of the world.

Food consumption for the selected product groups in LAC is presented in Table 2, in absolute calories content, its share within total

Table 2
Food consumption by product group for LAC, measured in kcal, 1961–2011.
Source: FAO (2016).

Product groups	10^{12} kcal/year						Share of total consumption (%)					Per capita consumption of kcal						
	1961	1971	1981	1991	2001	2011	1961	1971	1981	1991	2001	2011	1961	1971	1981	1991	2001	2011
Cereals - exc beer	75.5	102.2	138.6	167.0	198.7	228.6	48.8	46.7	46.3	46.2	45.7	44.8	924.8	961.9	1032	1020	1029	1048
Sugar and syrups	28.7	40.1	59.6	71.2	80.2	91.2	18.6	18.3	19.9	19.7	18.5	17.9	352.2	377.1	443.9	434.9	415.6	418
Roots and tubers	12.8	19.4	18.6	18.8	22.1	26.0	8.3	8.8	6.2	5.2	5.1	5.1	157.1	182.2	138.3	115.1	114.3	119.4
Pulses	10.7	14.9	17.5	17.4	20.2	22.1	6.9	6.8	5.8	4.8	4.7	4.3	130.9	140.6	130.1	106	104.8	101.5
Vegetable oils	9.1	15.5	32.0	46.5	58.1	72.7	5.9	7.1	10.7	12.9	13.4	14.3	111.7	146.3	238.1	283.8	301.3	333.5
Fruits - exc wine	8.9	13.8	15.5	18.7	23.7	28.9	5.8	6.3	5.2	5.2	5.4	5.7	109.0	129.4	115.6	114.5	122.7	132.4
Alcoholic beverages	4.2	6.1	9.1	11.5	13.8	16.9	2.7	2.8	3.1	3.2	3.2	3.3	51.8	57.7	68.12	70.49	71.42	77.58
Vegetables	2.0	2.7	3.7	4.8	7.1	8.8	1.3	1.2	1.2	1.3	1.6	1.7	24.2	25.4	27.37	29.06	36.96	40.34
Oil crops	1.8	3.0	2.8	3.4	7.0	9.3	1.2	1.4	0.9	0.9	1.6	1.8	22.3	28.4	20.54	20.76	36.33	42.65
Other[a]	0.8	1.3	1.8	2.1	3.7	5.4	0.5	0.6	0.6	0.6	0.8	1.1	9.8	12.4	13.1	12.63	19.11	24.92
Total	154.5	219	299.2	361.4	434.6	509.9	100	100	100	100	100	100	1893.8	2061.4	2227.13	2207.24	2251.42	2338.29

[a] Includes: stimulants, nuts, sugar crops, spices and miscellaneous.

Table 3
Composition of exports and imports in food trade measured in kcal by product group, 1986–2011.
Source: FAO (2016).

	1986		1991		1996		2001		2006		2011		2013	
Product group	% X	% M	% X	% M	% X	% M	% X	% M	% X	% M	% X	% M	% X	% M
Sugar and syrups	42.3	1.2	13.0	4.0	23.8	0.6	23.2	1.2	24.8	2.0	23.0	2.1	22.0	2.1
Cereals - exc. Beer	28.1	77.3	22.2	74.0	19.1	86.6	24.7	74.4	16.0	75.1	23.4	69.8	29.9	71.4
Vegetable oils	14.6	9.3	24.5	8.1	25.3	4.4	17.9	5.7	21.9	4.9	12.6	9.9	9.3	8.7
Fruits - exc. Wine	3.5	0.1	8.1	0.2	7.7	0.3	3.4	0.3	3.5	0.3	2.8	0.4	2.5	0.4
Oil crops	8.3	9.6	27.2	11.5	21.3	4.9	28.4	15.0	31.5	14.6	36.2	14.2	34.6	12.9
Stimulants	1.7	0.0	2.6	0.2	1.6	0.2	0.7	0.3	0.8	0.5	0.7	0.5	0.6	0.5
Pulses	0.5	1.7	0.7	1.1	0.2	1.6	0.4	1.9	0.4	1.3	0.3	1.5	0.2	2.0
Vegetables	0.3	0.1	0.6	0.1	0.2	0.3	0.3	0.2	0.3	0.3	0.3	0.4	0.3	0.5
Alcoholic beverages	0.3	0.3	0.6	0.4	0.4	0.7	0.6	0.3	0.6	0.3	0.5	0.4	0.5	0.5
Other[a]	0.3	0.2	0.3	0.2	0.4	0.2	0.2	0.3	0.3	0.4	0.2	0.4	0.2	0.5
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100

[a] Includes: spices, nuts, roots and tubers and miscellaneous.

consumption and calories per capita. The main result observed here is the notable increase in the consumption of vegetable oil, which, in per capita terms, is 3 times higher at the end of the period, while there is a reduction in pulses and roots and tubers. Sugars also increase over time, representing around 20% of the calorie intake, well above the WHO *strong recommendation* of reducing the intake of free sugars to less than 10% of total energy intake (World Health Organization, 2015).

The relative share of exports and imports in terms of calories by product group is presented in Table 3. The region has reduced its exports of sugar and syrups, which went from representing 42.3% in 1986 to 22.0% in 2013. Cereals still represent almost 30% of total exports. On the other hand, vegetable oil has slightly decreased its share. The biggest rise is in oil crops, which went up from 8.3% to 34.6%, basically from soybean production in the south. The region does not only consume more vegetable oil as we saw above, but it exports increasing quantities of oil seeds. With regard to imports, the region is very dependent on cereals, representing more than 70% of total imports in the period.

The main five products exported by the region in the year 2013 were soy (34.1%), corn (24.7%), sugar (21.4%), soybean oil (7.6%) and wheat (1.8%). Interestingly, some of the main five products imported by the region correspond to products that the region is also exporting, wheat (37%), corn (25.2%), and soy (7.4%).

This overall result hides differential behaviours dependent on the trade partner analysed. In year 2013 the main trade partners for LAC countries were China, Europe and the USA. The corresponding market share for LAC exports was 28%, 12.8% and 6.5% respectively, that is, 47.3% between the three of them. Imports from LAC countries are far more concentrated, with the USA representing 71.3% in the same year. Based on this, we decided to analyse these cases individually.

Thus, in Fig. 1 we can see how the region maintains a negative food balance with the USA, which has doubled in the period and corresponds, in a large part, to cereals, with a maximum in year 2007. In 2013 wheat represented 35.6% of imports and corn 34.1%, while the region exported mainly sugar (32.8%), corn (17.3%) and banana (6.7%).

When analysing the trade relationship with China, Fig. 2, the region maintains a positive and growing balance, which in 2013 reached a value almost three times higher than the deficit reported with the USA. The relationship with China seems not to have suffered the boom and bust of commodities in recent years. Most of the exports to China are soy (83.6%), sugar (9.1%) and soybean oil (6.3%), while the scarce imports from China consisted basically of beans (56.9%).

In the case of trade with Europe, Fig. 3 shows how the region maintained a positive balance during the period, reaching a maximum in 2007. The balance fell abruptly in 2009 when values similar to those in 2000 were attained. Exports to Europe in the year 2013 were dominated by soy (40.3%), sugar (18.7%), corn (12.6%), banana (4.7%) and palm oil (4%), while the small amount of imports from Europe were led by barley (32.6%), wheat (29.2%), olive oil (10%) and alcoholic beverages (5.7%). Clearly, these differences between exported and imported products will be important to understand the terms of trade expressed in calories that are discussed below.

Deepening the data analysis shown in Table 1, Fig. 4 presents the cost of one million kcal exported and imported in real terms (left axis) and the ratio between the cost of the exported calorie and the imported

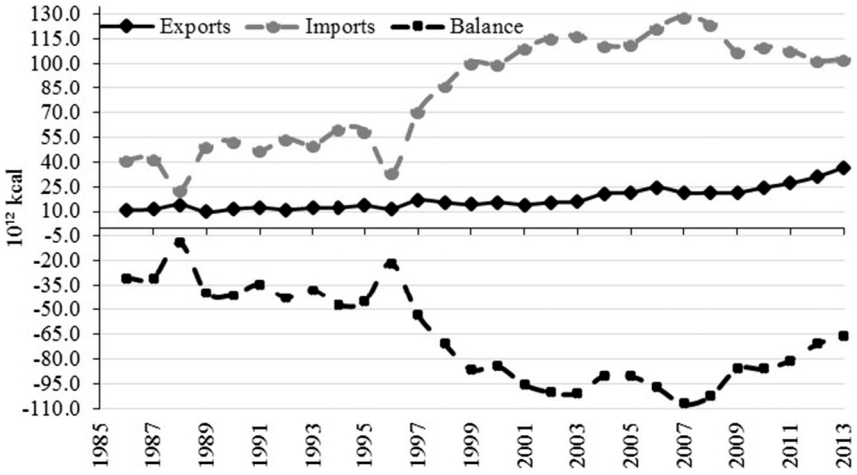

Fig. 1. LAC exports, imports and trade balance for food products with the USA (10^{12} kcal), 1986–2013.
Source: FAO (2016).

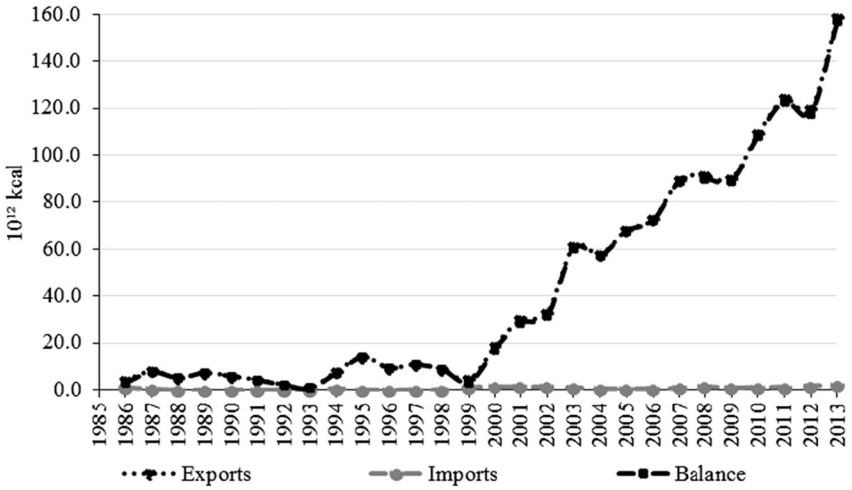

Fig. 2. LAC exports, imports and trade balance for food products with China (10^{12} kcal), 1986–2013.
Source: FAO (2016).

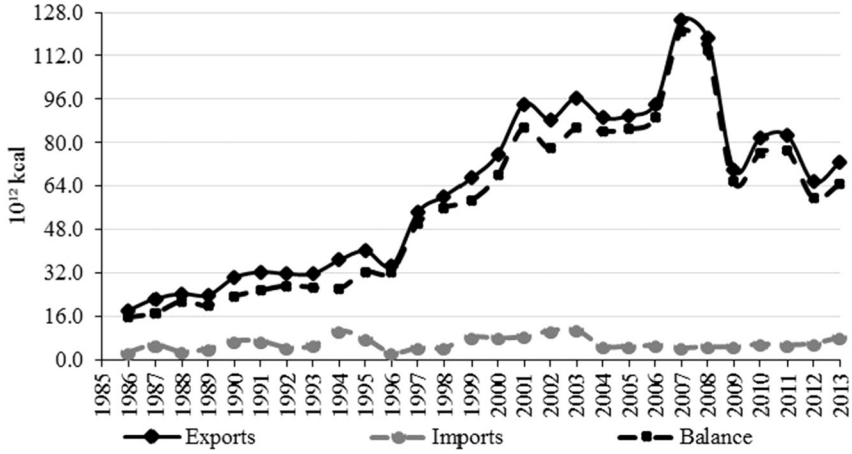

Fig. 3. LAC exports, imports and trade balance for food products with Europe (10^{12} kcal), 1986–2013 .
Source: FAO (2016).

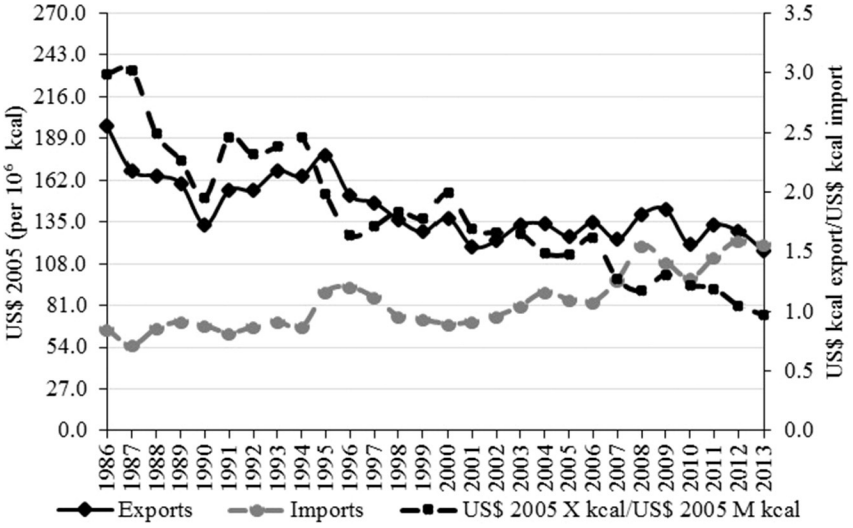

Fig. 4. LAC exports, imports and terms of trade, 1986–2013.
Source: FAO (2016).

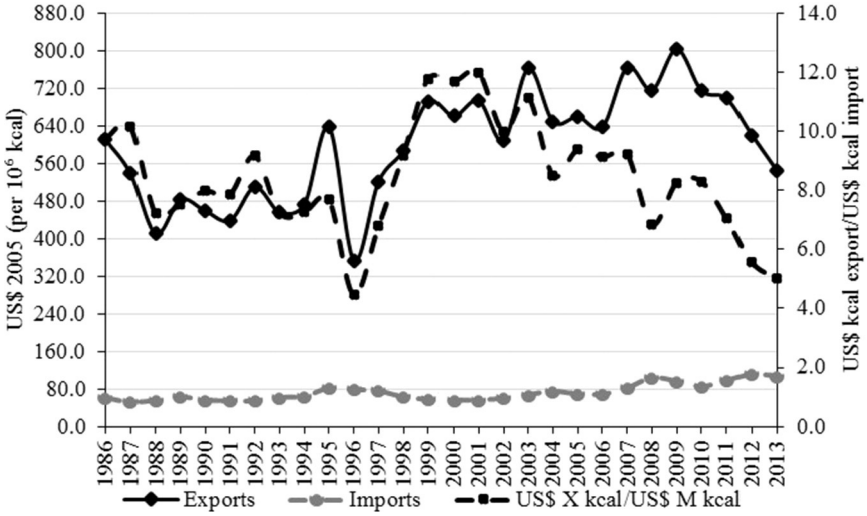

Fig. 5. LAC exports, imports and terms of trade with the USA, 1986–2013.
Source: FAO (2016).

calorie (right axis), that is, an approximation of the terms of trade measured in calories. The trend observed in the figure is a reduction in the cost of exported calories and a slight increase in the cost of imported calories over time, which implies a deterioration of the terms of trade measured in calories, with a decrease of more than 200% in the period analysed. Thus, the region is not only increasingly feeding the rest of the world (Table 1), but it does so at a lower cost over time, despite the recent boom in food prices experienced worldwide.

Again, this result differs depending on the trading partner. Terms of trade are very favourable to LAC with respect to the USA, as seen in Fig. 5, exporting expensive calories (sugar, syrups, banana) and importing cheap ones (corn, wheat). Nevertheless, since year 2001 they tend to worsen over time.

In the case of China, Fig. 6 shows how imported calories (beans) are more expensive than exported ones (soy) for almost all years in the period, showing also a deterioration of terms of trade over time.

Finally, Fig. 7 shows how the terms of trade experienced a drastic change with Europe in 1996. Before that year, calories exported by LAC countries to Europe were more expensive than those imported. However, after that year, the trend reversed and calories imported (olive oil, alcoholic beverages) became increasingly more expensive and calories exported (sugar, soy) became cheaper, deepening the worsening of terms of trade, which deteriorated more than 300% in the period.

Table 4 presents data on self-sufficiency for the region, measured as 1 – (imports/consumption). If a country has zero imports, the index would equal to 1, implying the country is 100% self-sufficient. If a country has a level of imports larger than domestic consumption, the value of the index is negative. If a country, on the other hand, covers half of its domestic consumption with imports, the index would equal 0.5 (or 50%), meaning self-sufficiency is only of 50%. Despite being a net exporter region for most of the product groups, LAC also depends on imports from countries outside the region. The dependency on oil crops is attributable in more than 90% to the case of Mexico. In aggregated terms, the region shows a loss of self-sufficiency, notably due to cereals. Paradoxically, many of the products that are imported are, at the same time, exported to the rest of the world, showing a lack of complementarity

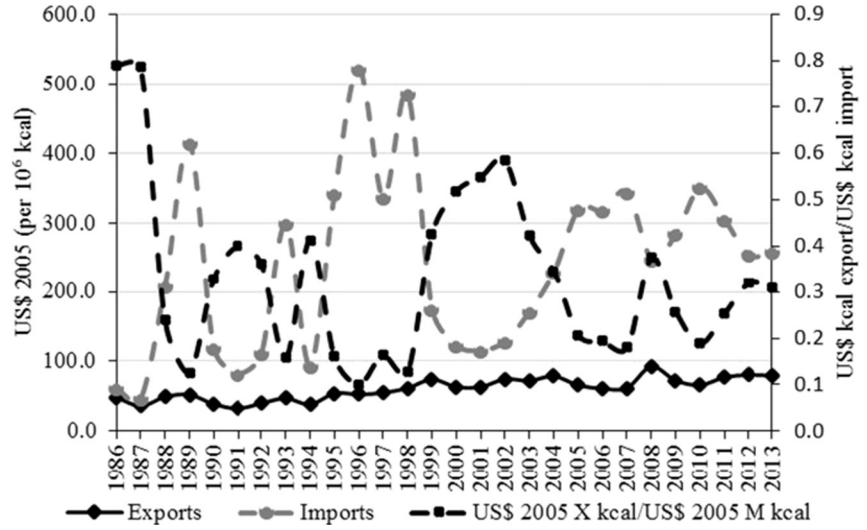

Fig. 6. LAC exports, imports and terms of trade with China, 1986–2011.
Source: FAO (2016).

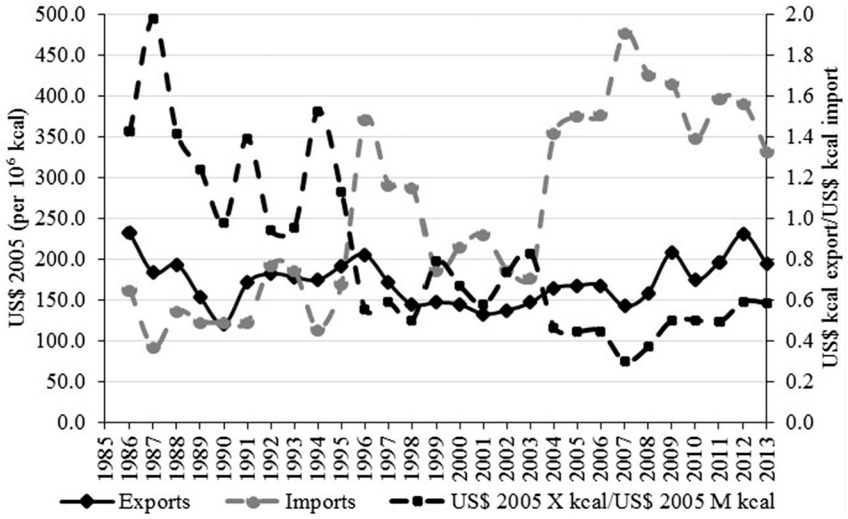

Fig. 7. LAC exports, imports and terms of trade with Europe, 1986–2013.
Source: FAO (2016).

in regional food trade. In particular, Argentina exports cereals to the rest of the world, while most of the countries are importing cereals from the rest of the world. This is also the case for sugar and syrups.

Finally, our research shows (see Table 5) the degree of concentration of consumption of a few products, measured in kcal, comparing 1961 and 2011. This high concentration of a these products did not change much in the period. Only ten products represented 80.5% of calorie intake in 2011. The major changes found are the reduction in importance of beans, cassava and potatoes, the rise of soy bean, oil and palm oil, the increase in importance of beer, and the disappearance of bananas from the top ten products. Apart from the change in the diet, a large fraction of consumption is still concentrated on a very small number of products. Trade has made more food available at the same time, it has encouraged homogenisation (Kennedy et al., 2004; Ogundari and Ito, 2015).

5. Discussion

As shown by Fig. 4, the region as a whole has experienced favourable terms of trade during the period analysed, with the exported calorie being more expensive than the imported calorie. However, this result, apart from being different depending on the trading partner (see Figs. 5-7), is deteriorating over time, leading us to conclude that there is a worsening of the terms of trade in caloric terms.

If we put together the fact that trade balance is increasingly positive in volume terms with the deterioration of terms of trade, we can say that LAC countries tend to be exporting ever cheaper food products to the rest of the world, making the diet elsewhere more affordable. Considering the environmental consequences of some food products adds another perspective that is often neglected. First, the products most

Table 4
Food self-sufficiency index for LAC in kcal, (100 ∗ (1 − (*imports* / *consumption*))), 1986–2011.
Source: FAO (2016).

Year	Aggregate	Cereals – exc. beer	Oil crops	Vegetable oils	Sugar & syrups	Pulses	Alcoholic beverages	Stimulants	Vegetables	Roots and tubers	Fruits – exc. wine	Nuts	Spices	Miscellaneous
1986	81.0	68.5	−135.2	85.3	98.9	93.1	98.2	96.8	98.9	99.2	99.6	91.2	82.8	30.7
1987	80.1	67.6	−264.5	88.2	98.7	95.8	98.4	98.1	99.1	99.5	99.6	93.5	85.0	32.4
1988	91.0	84.2	20.3	96.0	98.5	96.4	99.0	98.6	99.6	99.7	99.8	97.2	90.0	84.0
1989	83.4	74.1	−99.4	88.7	96.4	94.8	90.2	91.6	99.2	99.6	99.6	89.5	92.0	86.2
1990	81.0	70.2	−75.9	87.2	93.5	90.3	95.7	86.5	98.5	99.2	99.4	91.6	88.3	79.0
1991	80.8	69.3	−134.5	88.0	96.2	95.5	97.4	85.9	98.4	99.1	99.3	86.9	84.4	73.6
1992	80.0	67.4	−192.3	89.2	98.8	95.1	96.8	83.9	98.2	98.9	99.3	84.7	88.5	40.2
1993	79.4	67.0	−226.2	87.3	98.9	96.3	96.7	84.2	96.9	98.6	98.9	81.8	85.1	41.0
1994	74.4	58.5	−245.9	86.4	97.9	93.3	96.0	79.7	96.7	99.1	98.3	73.8	82.4	53.8
1995	77.7	64.2	−219.6	85.8	98.7	94.7	97.3	79.5	96.8	99.1	98.7	83.3	82.0	63.1
1996	86.5	74.4	44.1	95.1	99.6	95.8	97.1	90.3	97.5	99.5	99.3	92.5	86.0	69.0
1997	75.6	64.3	−286.7	85.8	98.7	91.7	96.4	75.7	95.8	99.0	98.5	80.8	82.0	58.4
1998	72.2	56.5	−226.1	84.1	99.0	88.5	96.8	75.2	95.7	98.7	98.6	82.5	78.5	53.2
1999	68.3	47.8	−194.8	86.1	98.9	87.2	97.7	59.2	96.0	98.7	98.5	77.7	85.0	46.6
2000	68.5	48.6	−197.0	85.0	98.5	89.3	96.9	57.4	95.7	98.6	98.2	69.2	87.1	46.8
2001	67.0	46.3	−206.7	85.8	97.9	86.6	96.4	70.6	95.7	98.7	98.1	68.3	86.0	34.2
2002	66.8	45.8	−188.9	84.4	98.6	89.5	96.8	60.8	95.5	98.8	98.6	69.6	86.1	50.3
2003	67.8	47.1	−155.1	85.9	98.5	89.4	97.2	59.6	95.7	98.2	98.6	69.5	87.1	56.5
2004	69.5	49.4	−115.8	86.2	98.1	88.7	97.0	66.4	95.3	97.5	98.7	66.4	86.8	64.9
2005	68.5	49.0	−151.3	86.8	97.5	88.1	96.6	60.8	94.2	98.5	98.3	70.5	90.0	61.3
2006	67.9	47.4	−172.7	88.3	96.5	91.2	96.4	51.4	93.8	98.3	98.3	63.7	89.1	52.8
2007	65.2	42.1	−157.4	86.7	95.5	87.7	96.1	37.8	94.0	98.2	98.2	67.2	88.4	65.0
2008	69.0	49.6	−133.9	84.1	97.0	90.4	96.6	46.5	93.1	98.3	98.2	69.0	89.3	74.5
2009	72.1	55.3	−137.7	84.7	97.5	90.5	96.1	46.4	93.5	98.1	98.4	74.5	89.5	72.5
2010	70.8	54.8	−155.9	81.0	96.6	89.9	96.5	53.5	93.1	97.8	98.1	71.4	88.4	77.9
2011	71.1	55.0	−125.1	80.1	96.7	89.9	96.2	55.3	93.3	98.0	98.0	70.8	89.3	77.7

Table 5
Cumulated share of products in consumption, in kcal, 1961 and 2011.
Source: FAO (2016).

Ranking	Main products in 1961	% cumulated 1961	% cumulated 2011	Main products in 2011
1	Corn and products	19.7	16.8	Corn and products
2	Wheat and products	36.9	33.0	Wheat and products
3	Sugar (raw equivalent)	52.0	48.3	Sugar (raw equivalent)
4	Rice (milled equivalent)	62.8	59.3	Rice (milled equivalent)
5	Beans	68.7	67.6	Soybean oil
6	Cassava and products	73.2	71.2	Beans
7	Sugar non-centrifugal	76.5	74.0	Palm oil
8	Potatoes and products	79.0	76.4	Cassava and products
9	Bananas	81.1	78.5	Beer
10	Cottonseed oil	82.9	80.5	Potatoes and products

exported, sugar and syrups, cereals and oil crops, correspond largely to monocultures. These three categories alone accounted for 86.5% of the calories exported by the region in 2013 (see Table 3), showing how trading patterns affect production, by pushing monocultures, which have environmental impacts attached to them (Altieri, 2009; Gomiero et al., 2011; Tilman, 1999) and use large amounts of inputs (Arizpe et al., 2011, 2014). Second, loss of soil and soil nutrients discussed by Walter Pengue (2005) for soy exports in Argentina and Grote et al. (2005) for global trade flows. Third, growing research also shows, an increase in water use from monocultures and the virtual water trade embodied in agricultural products (Aldaya et al., 2010; Duarte et al., 2014; de Fraiture et al., 2008; Giampietro et al., 2014; Hoekstra and Hung, 2005; Pérez-Rincón, 2006b, 2007; Sposito, 2013).

We have also observed that the region faces a loss in food self-sufficiency, as was shown in Table 4. This is to say that the region is increasingly feeding the world at the same time it is losing self-sufficiency in certain products (e.g. cereals, vegetables, pulses, stimulants, nuts), which makes it more vulnerable to international prices, control over seeds and other external factors. The loss in self-sufficiency in cereals may bend to pressures from the external market, by means of bilateral and multilateral trade agreements as shown in Falconi and Oleas-Montalvo (2016). As we saw in Table 3, cereals represented 29.9% of exports from the region in 2013, at the same time that the region is increasingly importing cereals from elsewhere representing 45% of consumption in 2011, as seen in Table 4. This change in production patterns implies a loss of soil and nutrients in the region. If we add the increased use of water, fertilizers and energy, this may be leading to higher environmental impacts.

The change in the consumption pattern observed in Table 2 has implied a drastic increase in fats, precisely one of the products the region has started to export increasingly. Our hypothesis is that this change in consumption has been preceded by a change in production trends, itself a reaction to food trade patterns. We leave for future research the examination of the validity of this hypothesis.

Our research has, at least, two limitations. First, we have analysed only calorie intake, without distinguishing the quality of the calories taken. Future research should expand the analysis and split calories into macro- and micro-nutrients to be able to link caloric unequal exchange to nutritional status. Second, we have focused on the cost of the calorie traded, and we have not accounted for the cost of the calorie produced. Again, future research should deepen the analysis to account for this.

6. Conclusions

This research has contributed to the debate on unequal exchanges, by enlarging the topic with the newly coined term of caloric unequal exchange.

The study concludes that although calories exported by the region to the rest of the world are more expensive than those imported, the ratio is deteriorating over time. This trend is found to be dependent of the trading partner involved. The region is helping the rest of the world in supplying their diets at a lower cost. A side result is that globalisation is homogenising diets over time, concentrating most food consumption in a reduced number of products, and therefore increasing interdependency among countries and affecting food security. There is a loss in self-sufficiency in the region that seems to be linked to trade patterns, that is, production is not focused on domestic demand, but on exports. Unequal caloric exchange is deepening regional dependency, deteriorating the trade balance over time and shifting the diet towards lower-quality products.

We have found that there is a deterioration of the terms of trade of food in terms of calories for the region, of more than 200% between 1986 and 2013. This is in conjunction with an increased volume (and value) of exports, which increased by a factor of 5.4 (and 3.2). This boom in commodity exports results in increasing environmental costs in terms of water use, soil deterioration, export of nutrients, and increased energy consumption and CO_2 emissions for those exports, which fall under the category of ecologically unequal exchange.

A side result of this study, is that there exists a homogenisation of diets; that is, a concentration of consumption of just a few products, which are, effectively, the most traded around the world. In fact, in year 2011 only 3 products (corn, wheat and sugar) accounted for almost 50% of calorie consumption, while 10 products accounted for more than 80%. This entails an ever greater interdependency among countries that increases economic vulnerability and entails a threat for the region's food self-sufficiency. In a context of rising prices of energy inputs and commodities, as well as negative trade balances, and increasing royalties paid to large companies controlling seeds, as in the case of many Latin American countries, reaching food self-sufficiency becomes a political goal in itself. It prevents the countries from increasing vulnerability to international prices and other external factors, as the European Union has done (Candel et al., 2014; Guinea, 2013).

From a nutritional point of view the concentration of consumption also has implications. We observed how consumption of oils and fats grew faster than that of other products, while others decreased, such as cereals, pulses, and roots and tubers. Further research is needed to test the relationship between trade patterns and consumption, and isolate them from demographic factors (as different demographic population structures are associated with different food requirements) and income issues (food intake composition also changes with increasing income levels), which are both demand-side.

The results outlined here suggest that food trade negotiations by Latin America and the Caribbean countries within the WTO would benefit from including the unequal exchange discourse, both ecological and caloric. The recognition of these hidden costs would not be the only advantage, but also the full understanding of the determinants of dietary changes, usually explained by demand-side variables only.

Even if caloric unequal exchange opens new options for understanding international trade, production structures and its impact on consumption, this concept is not a substitute for studying existing power relationships in trade as well as using complementary approaches that involve monetary and biophysical issues, such as physical trade balances within material flow accounting. In fact, unequal caloric exchange occurs precisely because there are political asymmetries between trade partners. Here, the contribution of the structuralist and dependency theory schools in the region is crucial, as they question the fact that trade brings benefits to all parties. There are winners and losers, and the deterioration of terms of trade imposes major efforts on exporting countries in terms of exploitation of soil and natural resources. This is the main conclusion reached by those studying ecologically unequal exchange. The concept of caloric unequal exchange widens this interpretation and shows how there is also an unjust exchange in terms of calories.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ecolecon.2017.01.009.

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CAPÍTULO 3.

“KNOWLEDGE GAPS IN LATIN AMERICA AND THE CARIBBEAN AND ECONOMIC DEVELOPMENT”

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Knowledge gaps in Latin America and the Caribbean and economic development

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ABSTRACT

An economy based on primary products is present in most countries in Latin America and the Caribbean. These remain focused on the export of unprocessed materials and goods, with little added value from knowledge and technology, which creates a development gap with technologically advanced countries and regions. By using a set of 5 quantitative indicators, we provided a novel assessment of growth gaps in the production of knowledge across world regions. Our study interpreted growth curves in terms of their essential constituent components (i. e. size, tempo, and intensity). Latin America and the Caribbean remains a region with average or below-average performance for most indicators of knowledge and most components of growth. The region shows a relatively large intensity for growth in patent applications, high-tech exports, and scientific publications, and this may have to do with recent investment in R&D by some Latin American countries. Although education gaps are slightly closing, research and technological gaps, measured by patent applications and scientific publications, are widening and driving up the resulting gaps in economic growth. Our study adds to other assessments of growth gaps in establishing the existence of an increasing divide between Latin America and the Caribbean and the developed world regions. We also propose strategy recommendations in the context of the current observed gaps in the production of knowledge. Bridging knowledge gaps represents a historical imperative and an unavoidable condition for the economic and social progress of the Latin American region. Therefore, active domestic public policies are urgently needed, along with international agreements that contribute to democratizing access to knowledge and technology.

1. Introduction

How far is the Latin American region from other parts of the world in terms of development in knowledge? Can the historical trajectory of development in knowledge across world regions be measured in terms of how growth curves differ in growth rate, timing, and magnitude? How could such perspective raise further awareness on increasing gaps and ever more difficult catch-up? We address these issues, centered around Latin America and the Caribbean (LCR), to show new evidence on the extent of these gaps and set new parameters and perspectives that could help develop further strategies to overcome an increasing divide.

Knowledge, technology, and innovation have been at the core of the evolution of the world economy and the growth of international economic activity for the last 50 years (Andersson et al., 2016). However, LCR struggles to realize a progressive shift of its economy from the production of simple goods, which are labor or natural resource-intensive, to complex goods, which are often technologically intensive and with demanding capital (Lavopa & Szirmai, 2018). The gap between North and South in several industries remains unmistakably persistent (Fu et al., 2011).

The specialization in primary exports, the absence of internal policies to promote economic development, and the asymmetry in access to knowledge are all factors that perpetuate the historical dependence of LCR in aspects related to the economy, science, and technology (Childs & Hearn, 2017; Hurtado, 1977; Ponce et al.,

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2018). Most LCR nations currently base their economy on primary products, that are focused on the export of unprocessed materials and goods, with little added value coming from knowledge, and technology (Brock, 1981; Carvalho & Flórez-Flórez, 2014).

The industrial revolutions of the 18th and 19th centuries were social, economic, and scientific processes that occurred mainly in Europe and North America and resulted in an increased demand for raw materials from LCR; consequently, these industrial revolutions intensified the economic model based on the exports of primary goods for most countries in LCR (Arocena et al., 2015). For LCR, the implications of the third technological revolution, and by homology, the currently fourth revolution (Schwab, 2017), included the loss of economic and productive autonomy, a widening of the income gap with technologically advanced countries, technological unemployment, regressive income distribution, concentration of power in large technological and transnational corporations, and an imbalance of the external sector of the regional economy (Gallopín, 1992).

Neotechnological approaches, particularly within the theory of technological gaps (Hufbauer, 1966; Posner, 1961), justify comparative advantages based on the ability that countries have to innovate (Bayraktutan & Bıdırdı, 2018; Soete, 1981). This, in turn, results in international trade patterns. Thus, for authors such as Krugman et al. (2014), the goal is to export goods produced with high levels of productivity and import goods with less efficient production processes. This competitive market logic could keep LCR stagnant in the production of raw materials since the primary export sector would become the critical component of accumulation and innovation capacity (Bayraktutan & Bıdırdı, 2018; Sunkel, 1987). The international insertion of LCR countries as producers of raw materials would entail an obstacle to the reduction of knowledge gaps. This would be in line with the statement of Cardoso and Faletto (1969), that technological dependence was due to the concentration of production processes in industrialized countries (Hidalgo & Hausmann, 2009). Thus, the specialization patterns of the countries in LCR are perpetuated; particularly as its production is mostly based on the abundance of natural resources and a low-skilled workforce (Sun et al., 2019). Such asymmetry in production patterns in LCR, between LCR and more economically and technologically advanced regions, would not stimulate the diversification of production towards greater technological use (Deacon, 2011; Henri, 2019); especially, when considering phenomena such as the commodities boom of the early 21st century (Gudynas, 2009).

The classic models of economic development have included, as main drivers for development, not only the differences in resource endowments but also different elements that affect production factors (Solow, 1956; Zhao, 2019). Productivity depends on the application of knowledge and technology to the productive sector (Barro & Sala-i-Martin, 2003). Ideas and creativity (also known as technology, innovation, and knowledge) are an essential part of processes generating value (Solow, 1956), they are at the heart of the industry and business, and their importance has increased dramatically over time (Andersson et al., 2016). The neoclassical growth theory proposes that gaps in per capita income across countries should converge over time because the development of poor countries is not restricted only to the adoption of new technologies, as are high-income countries, but also by catching up with the leading economies through the shift from low to high-productivity sectors (Gollin et al., 2014). However, convergence between rich and poor countries, as expected by neoclassical growth theory, lacks evidence (Fukase & Martin, 2020). If anything, the prevalent form of economic growth since the 19th century has been one of increasing and unrelentless income divergence, with initially poorer countries growing much slower that more advanced countries (Fukase & Martin, 2020; Pritchett, 1997).

More specifically, countries diverge in economic development in the same measure they diverge in knowledge and the production of technology. Divergence in economic performance across countries and regions depends on the realization of structural change and technological catch-up within the economic systems; the former component is understood as the relocation of labor from the traditional sector to a modern part of the economy (Lavopa & Szirmai, 2018). In terms of demography and the distribution of population, the increasing divergence of per capita income levels responds mostly to differences between population growth and labor force growth; in this sense, long-term economic growth strongly depends on the relationship between labor force growth and the amount by which population growth exceeds labor force growth, as a dependency ratio (Sheehey, 1996). However, the transition to a developed modern sector by itself is not a unique condition for economic development and the reduction of the technological gap, as it also requires a process of absorption of technological knowledge (Lavopa & Szirmai, 2018).

Knowledge is stimulated by endogenous development (Lucas, 1988; Romer, 1986), where economic growth is driven by technological improvements that respond to internal potentials and investment decisions in R&D in different countries (Solow, 1956; Zhao, 2019). Even culture and society, considered as environments for innovation, are decisive in reinforcing generational patterns that usually deepen pre-established gaps in the ability to innovate and develop knowledge (Bell et al., 2019). Crucial for learning and innovation, as components of economic development, are cultural conventions that foster the informal and free exchange of ideas and knowledge; thus, social rules, common language, tacit knowledge or "learning by doing", physical proximity and interaction between business parties, trust, honesty, and individual freedom are all part of agglomerated production systems (Kesidou & Romijn, 2008).

Therefore, the generation of knowledge responds to investment in R&D, while the volume of ideas depends directly on the number of researchers or human capital in the modern sector that can freely interact within and among the production systems (Romer, 1990; Wu et al., 2019). However, for developing countries, technological innovation and economic development have been until the start of the 21st century based mostly on passive assimilation, learning, imitation, and adaptation of imported new technologies from developed regions of the world (Kesidou & Romijn, 2008). This system of exogenous influence is not enough in terms of crucial knowledge necessary for technological innovation, as diffusion of knowledge in developing countries does not flow as easily as in the developed ones and may be associated with the "enormous technological gaps" that this region suffers from (Kesidou & Romijn, 2008).

Knowledge gaps are accentuated in recent decades due to the increasing speed in knowledge generation and technological change (Moore, 1965; Roser & Ritchie, 2019). The progress of science, as measured by the number of publications, has experienced yearly growth rates of between 8% and 9% since the Second World War, meaning only 9 years are needed for the body of global knowledge to be doubled (Bornmann & Mutz, 2015). This rapid accumulation of knowledge and information increasingly makes the scientific activity a central axis of social and economic development (Berman, 2014); but, at the same time, it is the cause of what Fochler (2016) calls "epistemic capitalism" or the accumulation of capital through the act of conducting research inside or outside the academy (Rikap & Harari-Kermadec, 2019). By the year 2014, the US and China represented 36% of all the publications in science and engineering (2.3 million as a world total); while Germany, India, Japan, and the United Kingdom contributed with a share between 16% and 20% of all the publications, which is about 100,000 publications each (White et al., 2017). According to Scimago Journal & Country Rank for the year 2019, the list of produc-

tivity by country reported a total of 177,784 publications from LCR countries, with Brazil accounting for more than half that figure. This value represents only 26.2% of the production in the USA. It also reported China, for the first time, as the leading country by the number of publications, overtaking the USA.

Education, understood as a fundamental right (Black, 2019), is a significant component when conducting regressions on the determinants of economic growth (Mankiw et al., 1992); particularly, when measured through academic achievements or quality of the received education (Delgado et al., 2012; Hanushek & Woessmann, 2008). Although econometric models trying to establish a causal relationship between education and economic growth face considerable problems in the design and application of linear models and mathematical relations, a recent analysis suggested that there is "fairly strong empirical support" that quality of education has a sizable effect or even decisive role on economic growth (Boccanfuso et al., 2015; Glewwe et al., 2014). However, the cognitive abilities of secondary education students in Latin America remain consistently in the last positions in standard measurements such as PISA (Hanushek & Woessmann, 2008; OECD, 2016), which is considered as a factor that explains, in a non-negligible and statistically significant way, the gap in technological and economic growth for Latin American countries (Hanushek & Woessmann, 2016).

The historical condition of human capital, measured through the quality of education in decades and centuries, has a long-term effect, with per capita patent applications and current GDP per capita as the two most significant historical factors that explain regional disparities (Diebolt & Hippe, 2019). In general, "the knowledge capital of nations" is singularly necessary as a condition for economic growth and is an essential ingredient for the presence of innovative entrepreneurs and their products, which indirectly stimulate economic growth and development through technological innovation processes (Diebolt & Hippe, 2019; Hanushek & Woessmann, 2015). However, for countries to catch-up along the widening technological gap, new knowledge must not only flow from the international strongholds of technological productivity and knowledge to a few isolated centers in developing countries; it must instead be widely diffused and absorbed throughout the national production systems (Kesidou & Romijn, 2008).

According to the OECD (OECD, 2018), boys and girls entering now the education system will conclude their secondary education in 2030. This generation will face complex social, economic, and environmental challenges as adults (Collin, 2019); Besides, they will need more technological and scientific knowledge, with new skills that allow them to work in jobs that do not yet exist, use technologies that are not yet invented and solve problems that are yet to arise (Ingerman & Collier-Reed, 2011; Stone, 2017). Society is facing changing scenarios that require creative solutions and sustained investments to stimulate the generation of knowledge and innovation in LCR, as a mechanism to break the known barriers that the current specialization in commodities represents for the economy of the region.

Since the beginning of the 21st century, LCR has significantly increased investments in education, research, and development, as a percentage of GDP (Medina-Jerez, 2018; Neidhöfer et al., 2018); However, certain indicators perform far below what is needed to accomplish the UN 2030 Agenda (Acerenza & Gandelman, 2017; Castellani et al., 2019). These gaps not only remain over time, but some of them also increase between world regions (Altinok et al., 2018). A very recent analysis on 182 countries, on the last 50 years of data from the Penn World Table database, and a review of global literature on the subject, concluded that there are broad consensus and evidence of no absolute convergence in per capita incomes across countries (Johnson & Papageorgiou, 2020). The injection of greater economic resources, technology acquisition, or linear transfer of knowledge and innovation does not necessarily reduce knowledge gaps (Hanushek, 2006; Marchand & Weber, 2020; OECD, 2012). Technology can even deepen gaps and inequality if not properly implemented with development in mind (Forestier et al., 2002; Kharlamova et al., 2018). Increasing use of external knowledge is often accompanied by a parallel decrease of R&D activities in industry and private firms (Fu et al., 2011). Thus, when an improved indigenous capability to access innovation and knowledge and higher levels of human capital accumulation are simultaneously combined, it is possible to foster a catch-up process in the technological and knowledge gaps and accelerate economic convergence (Fu et al., 2011; Perez-Trujillo & Lacalle-Calderon, 2020).

Our study is a contribution to understanding gaps in knowledge through an assessment of the historical accumulated difference and the constituent components of growth in the production of knowledge. We present an assessment of the current gaps for growth in knowledge and how these patterns could be understood in terms of components of growth (i.e., size, tempo, and intensity). We provide a diagnosis of the observed trends in the growth curves of each world region and suggest possible alternatives to reduce the currently increasing divide. When we refer to "development" we do it in the context of the growth curves presented in this study and focused mostly on the issue of catch-up among world regions. Although much has been said of the increasing divide between nations and regions, our work in measuring and understanding the current gaps between world regions is a novel quantitative approach with new insights; in the hope of contributing to rising further awareness and perspectives on this global issue (Anand & Segal, 2017).

2. Materials and methods

Our analyses were partly made on the Systema Globalis data set, which is a collection of harmonized and manually curated statistics, and freely available from the Open Numbers community (open-numbers.github.io), which is moderated by the Gapminder Foundation (gapminder.org). Open Numbers compiles all public statistics, from hundreds of sources, and includes local and global information on social, economic, and environmental aspects. Systema Globalis includes hundreds of sources from historians, public agencies, and commercial companies (open-numbers.github.io). Our analyses on Systema Globalis included the largest possible extent of time, whenever available. World Bank regions were used as references for regional growth and were defined as North America (NA), Europe & Central Asia (ECA), Middle East & North Africa (MNA), East Asia & Pacific (EAP), Latin America & Caribbean (LCR), South Asia (SAR), and Sub-Saharan Africa (SSA). Additionally, data was obtained from World Development Indicators of the World Bank (World Bank, 2020) and (Inklaar et al., 2018; Lall, 2000). The datasets for this study and their detailed descriptions are available in Mendeley Data (Jarrin, Cango, Ramos-Martin, & Falconí, 2020).

We used a total of six data matrices, consisting of 1) income per person (GDP per capita, PPP inflation-adjusted), 2) the number of patent applications by residents and nonresidents per million inhabitants, 3) high-tech exports in thousands of millions of 2010 US dollars, 4) total government expenditure on education per capita in 2010 US dollars, 5) the number of scientific and technical journal articles per million inhabitants, and 6) research and development expenditure per capita in 2010 US dollars. The correction by the number of inhabitants was made by the authors. The selection of these matrices, as proxies for knowledge, was based on the Knowledge Assessment Methodology by the World Bank (Chen & Dahlman, 2005; Robertson, 2009) and the knowledge

indicators used in the Global Innovation Index for 2019 (Cornell University - INSEAD - WIPO, 2019). We referred to these six parameters as indicators of knowledge and used short names for each one.

Gaps across regions were measured as the accumulation of differences in growth curves through time; the integration of curves was based on the trapezoid rule with base points on the x-axis, as implemented in the *trapz* function of the *pracma* package in R (Borchers, 2019). The R built-in function *aov* was used for an orthogonal type III analysis of covariance (ANCOVA) (R Core Team, 2018) to test for differences across world regions. Time is a common variable used in growth trends, and this was considered as a continuous cofactor in the linear models, with world regions as the discrete predictor. After the applied ANCOVAs, the *multcomp* package was used for a Tukey multiple comparisons of world region means and associated boxplot graphs (Hothorn et al., 2008). Tukey tests considered the effect of the covariate and the interaction term. Box plot graphs were based on the linear predictor (region by time) and any significant interaction terms. However, because of limited and patchy data (such as for expenditure on education), or strong interaction terms, we suggest caution at the moment of establishing groupings by the Tukey tests. Packages *broom* (Robinson & Hayes, 2019) and *tidyverse* (Wickham et al., 2019) were used for manipulating original matrices and tabulating estimated results.

Growth curve analysis allowed us to understand the patterns of growth across regions in contrast to the estimated average. By the method of "SuperImposition by Translation And Rotation", implemented in the package *sitar* (Cole, 2019), an average, shape-invariant, single-fitted growth curve model was obtained (i.e. regression spline). This fitted model was a cubic regression spline, which required an optimized number of degrees of freedom. The latter was determined by exploring a range of degrees of freedom (1–100) and their effect on the model's Akaike information criterion (AIC). By spatially matching growth curves for each region to the average growth curve, three parameters, estimated as region-specific random effects, were extracted from growth curve analysis: 1) size was the difference in mean growth (shifts along the vertical axis of curves concerning the estimated average growth), 2) timing (or tempo) was the region's year at peak growth velocity, compared to the average, or the year when a region was growing the fastest (i.e. shifts along the horizontal axis of curves to the mean), and 3) intensity was growth rate compared to the average, or the steepness of each curve (i.e. compression of the time axis to the mean) (Cole et al., 2010). To fit a regression spline, transformations to natural logarithms were necessary for the indicators of knowledge that refer to the number of scientific publications, patent applications, and expenditure on R&D. Figures were constructed in *ggplot2* (Wickham, 2016) and *GGally* (Schloerke et al., 2018). All analyses were made in R version 3.5.0 (R Core Team, 2018).

Ideally, particular World Bank regions could have distinct growth patterns, some with large size and intensity (large growth over the average and at high rates), or others with small size but large tempo (small growth over the average, but with marked growth at later stages). In terms of the correlations among size, tempo, and intensity of growth, each scatterplot tile was divided into cartesian quadrants that were centered at the origin. Quadrants allowed for differentiation among groups of regions and their trends of growth. How these patterns of size, tempo, and intensity in growth defined the different regions provided us with insights into the observed gaps of either economic or knowledge growth.

The components of growth (size, tempo, and intensity) were then compared across World Bank regions and indicators of knowledge through the analysis of heatmaps and hierarchical clustering (unweighted pair group method with arithmetic mean, UPGMA). Package *superheatmap* (Barter & Yu, 2017) was used for such comparisons. Values for each indicator of knowledge were normalized to unit standard deviation to enable contrasts on the heatmaps. Our discussion was centered around LCR and, in comparison, to all other world regions. We first applied our approach to income per person, and then expanded this approach to the previously mentioned indicators of knowledge.

3. Results

Based on differences between means, four groups of regions are possible to define in the long-term trend observed for economic growth. Being the region with the fastest and largest growth in the last two centuries, NA is the reference for most comparisons. ECA and MNA are the pair with the second-largest growth. EAP remains just above the pair with the lowest growth overall, which is SA and SSA. The former three pairs of regions show no significant differences ($P > 0.99$) in long-term growth after a fixed-effects ANOVA ($F = 65.71$, df = 6, $P < 0.001$), followed by a Tukey multiple comparison of means. All other Tukey comparisons are significant ($P < 0.001$). Four regions remain on or below the mean trend in economic growth (i.e., SSA, SAR, LCR, and EAP), and three regions above (NA, ECA, and MNA) (Fig. 1). With NA as the reference for largest growth, the estimated gaps in economic growth, integrated through the last two centuries, show that LCR maintains a gap of 70%; only SA and SSA remain further below with gaps of 87% and 89% respectively (Fig. 1). Mean growth, as represented in Fig. 1 corresponds to 25 degrees of freedom, which was the model with the lowest AIC value.

In terms of size and tempo of income per person, SSA and SAR share noticeable small size and late tempo (Fig. 2a, quadrant IV), both have a marked late peak growth rate of economic development. Small economies are also LCR, EAP, and MNA, but share a history of early tempo, all having an early peak growth rate of economic development (Fig. 2a, quadrant III). The two remaining regions, NA and ECA, are the largest in size and have an early tempo (Fig. 2a, quadrant II). A contrast of size and intensity shows a strong correlation, where the largest economies are also the largest in growth rate, and with NA and ECA occurring in quadrant I (Fig. 2b) and LCR, SSA, and EAP in quadrant III as the regions with the lowest growth rate and size (Fig. 2b). Tempo and intensity separate regions into three groups. LCR and EAP are low intensity-early tempo regions (Fig. 3c, quadrant III). MNA, NA, and ECA are large intensity-early tempo regions (Fig. 2c, quadrant IV). SSA and SAR are low intensity-late tempo regions (Fig. 2c, quadrant II). There are no World Bank regions for the categories of large size-late tempo (Fig. 2a, quadrant I), large size-low intensity (Fig. 2b, quadrant II), and large intensity-late tempo (Fig. 2c, quadrant I). A strong correlation is present between size and intensity of growth (i.e., the largest the economy, the faster it grows); however, a weak negative correlation is present between size and tempo or between tempo and intensity (i.e., the largest the economy, the earlier or more intense it grows).

A pattern in which one or two regions (i. e. NA and EAP) dominate the space of growth is also evident for the indicators of knowledge, where regions such as LCR, SSA, and SA are essentially flat lines (Fig. 3). The gap for LCR, as measured by the areas under each curve is large, over 90% for all indicators, except for high-tech exports where it is 62%. There is a scarcity of data for expenditure on education and expenditure on R&D. Particularly, within the available time frame, data for expenditure on education is grainy and discontinuous, which precludes confidence for growth curve analysis. The post-hoc analysis allows for groupings and additional contrasts (Fig. 4). Three groups of regions for patent applications are possible to define, with NA and EAP as the first two leading

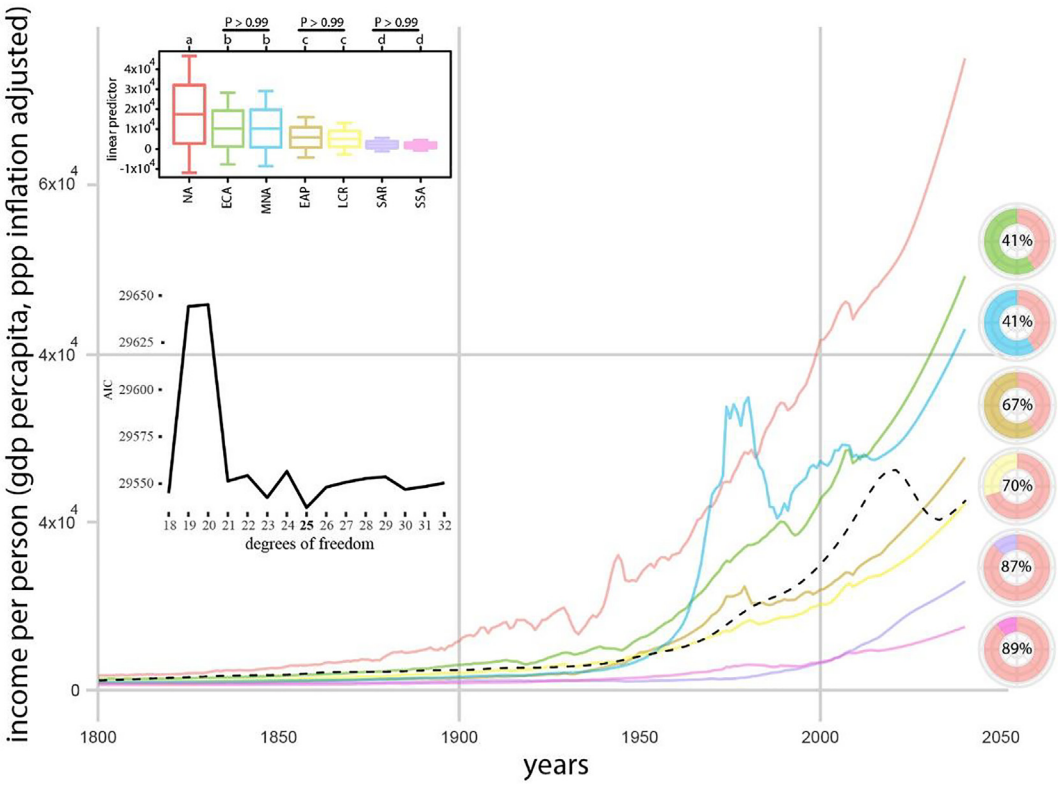

Fig. 1. Two centuries of income per person growth and a comparison of the gaps between World Bank regions. Three pairs of regions, that did not show significant differences, can be grouped according to the results of a Tukey-multiple-comparisons of means test. The donuts show the percentage of the gap maintained with NA, after integrating the areas under each curve. The estimated mean growth is represented by the dashed black line. The inserted line chart shows a subset of degrees of freedom that were considered for the cubic regression spline model (i.e., mean growth – dashed line) and their corresponding AIC values.

groups, and ECA, LCR, MNA, and SAR as the lowest group. For high tech exports, EAP is the leading region with NA in a second position, ECA and LCR occur near the mean trend line (Fig. 3), and MNA, SAR, and SSA with minimum contributions. Essentially, no differences occur for expenditure on education among regions, except for NA and ECA, which dominate this indicator. However, we should highlight that the scarcity of data for this latter indicator precludes finer or reliable contrasts. The trends for expenditure on scientific publications reflect the trends for expenditure on R&D, where both have NA and ECA as the dominant regions. Except for expenditure on education, where LCR is in the third place (Fig. 3), the region occupies the fourth or a lower position in the group of seven regions for all other indicators. LCR remains always below the third quartile for any of the indicators of knowledge, except for R&D expenditure in which it is closer to the median.

The lattice that resulted from the combination of size, tempo, and intensity growth curves provided several insights into how LCR remains as part of those regions with a large gap (Fig. 4). For patent applications, LCR remains in the quadrants of low size, late tempo, and low intensity. In terms of high-tech exports, LCR remains very close to the mean in terms of size and has an early tempo and high intensity. This is the only indicator of knowledge in which LCR remains close to ECA. Low size, early tempo, and large intensity are observed for the production of scientific publications in LCR, although tempo and intensity were not significant ($P > 0.05$). It is a remarkable contrast that for the latter indicator, NA is the lowest region in terms of intensity, but the largest in size and with the earliest tempo. For expenditure on education and expenditure on R&D, either the paucity of data or the lack of structure in the growth curves (i.e., the curves were close to straight lines), precludes a detailed growth curve analysis, particularly for the components of tempo and intensity which were not significant ($P > 0.05$); it is, however, noticeable, the presence of LAC as part of the lowest regions in the size component of growth (Fig. 4).

Correlations provided a sense of how all three indicators for growth interact over all of the World Bank regions. The correlation between tempo and intensity for high-tech exports is noticeably strong but inverse and this had to do with a marked trend by NA of an early large growth curve and a later marked decline, which is slightly like the trend for LCR and ECA. For the latter indicator, size and tempo show a relatively strong negative correlation, which suggests that World Bank regions with a small production of high-tech exports appeared lately. A negligible correlation is found between tempo and intensity for patent applications and suggests no discernable process between the time in which world regions acquired more intense growth to produce patents. Size and tempo are also strongly but negatively related to scientific publications, which points to a process in which certain World Bank regions acquire early dominance over the production of knowledge, and the late appearance of other regions represented minor contributions to the established bulk of production. Tempo and intensity do not seem to have a strong interaction, which implies that a high rate of production of scientific and technical literature may not have depended on time. Because of the lack of consistent time series or structure, correlations for expenditure on education and expenditure on R&D are not fully reliable and should be interpreted with caution.

Classification on the heatmaps (Fig. 5) show for the component of size in growth, across all indicators of knowledge, that NA, EAP, and ECA form one group with the highest values overall. The rest of the regions, including LCR, form the second group with low values in size. Strongly correlated with income per person on the size

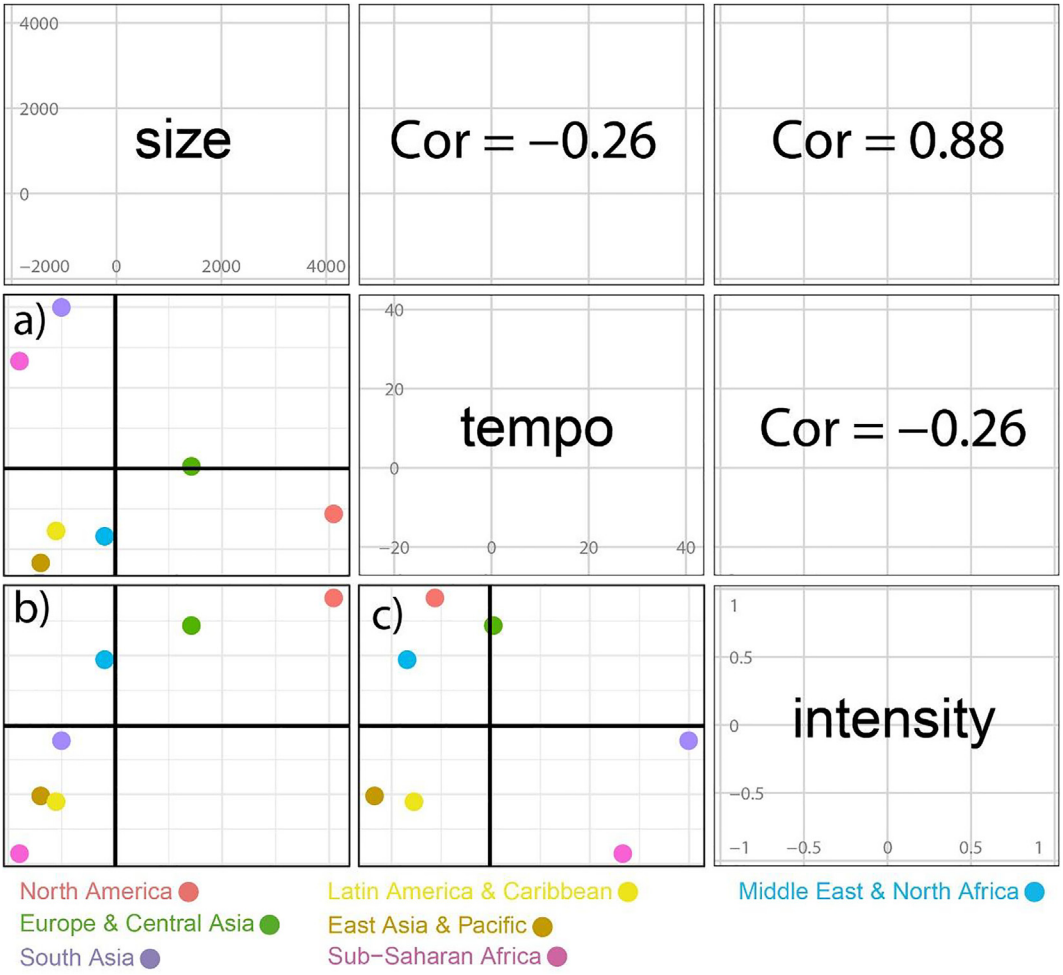

Fig. 2. Scatter plot matrix and Pearson correlations of the size, tempo, and intensity that were extracted from income per person growth curves in Fig. 1. Letters a), b), and c) have been used to identify scatterplots between components of growth.

component of growth are expenditure on education, scientific publications, and expenditure on R&D. However, high-tech exports are not as strongly correlated as the former. Correlation with patent applications was not possible because of missing data for SSA.

For the tempo component of growth, two groups are also possible to define, one with late tempo (i.e., higher values) for patent applications, high-tech exports, and scientific publications, and formed by SSA, SAR, and MNA; and one with a more or less homogenous tempo across the indicators of knowledge and formed by LCR, EAP, ECA, and NA. Of interest is the late tempo exhibited by NA for expenditure on education, a region which shows late bursts of allocation of resources for this latter category. In terms of correlations with the tempo component of income per person, scientific publications are strongly and positively correlated, while expenditure on R&D shows a strong negative correlation. In other words, the later there is a larger income per person, the earlier the expenditure on R&D, and the earlier there is a large income per person, the earlier there is a large production of scientific publications.

The intensity component of growth shows that NA and EAP form one group with the highest values overall, while the rest of the regions form a second group. The stronger the intensity of income per person, the lower the intensity for the number of scientific publications. This trend may have to do with the marked decline in the number of publications, as can be noticed in the curve for NA and EAP during the last years (Fig. 3.). Intensity for income per person is strongly correlated with the intensity of expenditure on education and expenditure on R&D. On the heatmap (Fig. 5), it is noticeable that the region with the highest intensity for expenditure on education is NA, while for patent applications is EAP. Intensity is also large for NA in the indicators of high/tech exports and expenditure on R&D (Fig. 5).

In general, for all cases of size, tempo, and intensity of growth in the components of knowledge, LCR remains an unremarkable region, as part of other regions that often show a negative trend for size and intensity in income per person, when this variable has been normalized.

4. Discussion: drivers of knowledge gaps

The results provided in the present assessment of regional gaps showed that the contrasting extremes in development, which are NA and SSA, define the expanse of the gap in the size and intensity of economic growth; along this gap, LCR remains the second lowest. LCR shows stagnation in its participation in the global economy (CAF et al., 2018). The region represented 7.1% of the global economy in 1960, while its participation in 2019 was only 7.3% (constant US $ 2010, World Bank, 2020). The economic gap (GDP per capita in constant terms) between NA and LCR increased in the last 57 years; a period in which the difference in GDP per capita between the two regions rose from 4.8 to 5.8 times (World Bank, 2020).

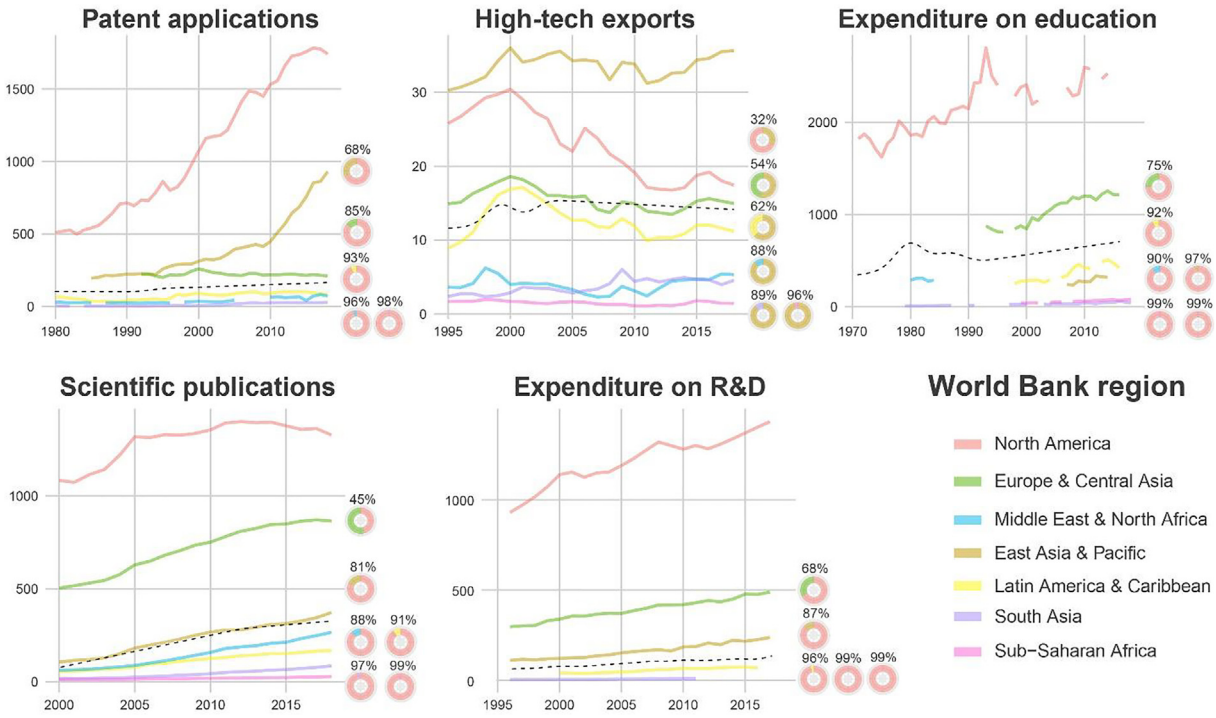

Fig. 3. Growth trends for the indicators of knowledge. The donuts show the percentage of the gap maintained with the leading region, after integrating the areas under each curve. The punctuated black line represents the fitted model (the mean trend line).

A key indicator for explaining economic growth is labor productivity. Population growth exceeding labor force growth results in stagnant productivity for LCR (Pandian, 2016; Sheehey, 1996). The limited stock of human capital in poor countries makes them less efficient at adding to that stock; which, in a vicious cycle. facilitates the reproduction of further lack of human capital accumulation; however, as labor force growth rates get larger with population growth, a reduction in the gap of per capita income levels is expected across world regions or countries (Nell, 2020; Sheehey, 1996). The GDP per person employed in the region shows a decline when compared to other countries and regions. In 1991, world productivity was 23.2% lower than that of LCR. In 2019, world productivity was 8.5% higher than that of LCR (World Bank, 2020).

Knowledge increases rapidly in the world, and this growth should favor larger economic, social, and technological development throughout the world regions. However, the potential benefits offered by globalization and liberal trade regimens for the international diffusion of technology can only be effectively delivered with a complementary effort for indigenous innovation and the presence of modern institutional and government structures that are devoted to promoting innovation systems (Fu et al., 2011; Gao, 2015). Yet, the historical insertion of LCR economies—which are based mostly on primary export products—in the international markets, intellectual property asymmetries, and the weakening of the integration project in the LCR region are all factors that preclude proper assimilation of international knowledge and technology (Cango, Ramos-Martin, & Falconí, 2018) and results in knowledge being unevenly distributed worldwide (UNDP, 2019).

4.1. Internal drivers of knowledge gaps

In the absence of indigenous innovation efforts, the income gap between developed and developing countries will never be closed (Fu et al., 2011; Nell, 2020). However, there is a cost and there are conditions for technology diffusion and its adoption, where local requirements are absorptive capacity and complementary assets (Howell, 2016); in the absence of such conditions, the greater use of external knowledge is often accompanied by an equivalent decrease in the internal capacity of indigenous science and technology development (Fu et al., 2011).

Given an adequate allocation of human talent in the productive sectors (Yao, 2019), education and technical skills contribute to explain the evolution of labor productivity (Chansarn, 2010; Manuelli & Seshadri, 2014). LCR increased public spending on education from 3.4% to 4.9% of GDP between 1998 and 2015 (World Bank, 2020); this ameliorated the growth in the gap in public spending on education with most regions of the world. In 1998 per capita public spending on education in LCR was 10.6 times lower than that of the United States, 8.9 times lower than that of Canada, and 5.2 times lower than that of the European Union. By the year 2015, LCR had narrowed the gap, nearly halving it with the United States (5.4 times) and Canada (5.5 times) (World Bank, 2020). However, significant gaps remain, as the historical accumulated gap in the growth trajectory estimated in our study was 92%. Education remains a considerable challenge for the region since large fractions of its population remain without access to education of quality (Fischman & Ott, 2018), and the population is still growing faster than in NA or ECA (World Bank, 2020).

Investment in research and development (as a percentage of GDP) has been steady in the world, at 2.1% of GDP between 2000 and 2017 (World Bank, 2020). In the case of LCR, it increased meagerly, from 0.6% of GDP in the year 2000 to 0.7% in 2017 (World Bank, 2020). When compared to the rest of the world, per capita spending on research and development in LCR is considerably low. By the year 2000, this indicator of knowledge for LCR was 27.7 times lower than that of the United States, 19.1 times lower than that of Canada, and 12.2 times lower than that of the European Union. Investment per person is still insufficient in LCR, which for 2015 was 18.8 times lower than that of the United States (World Bank, 2020).

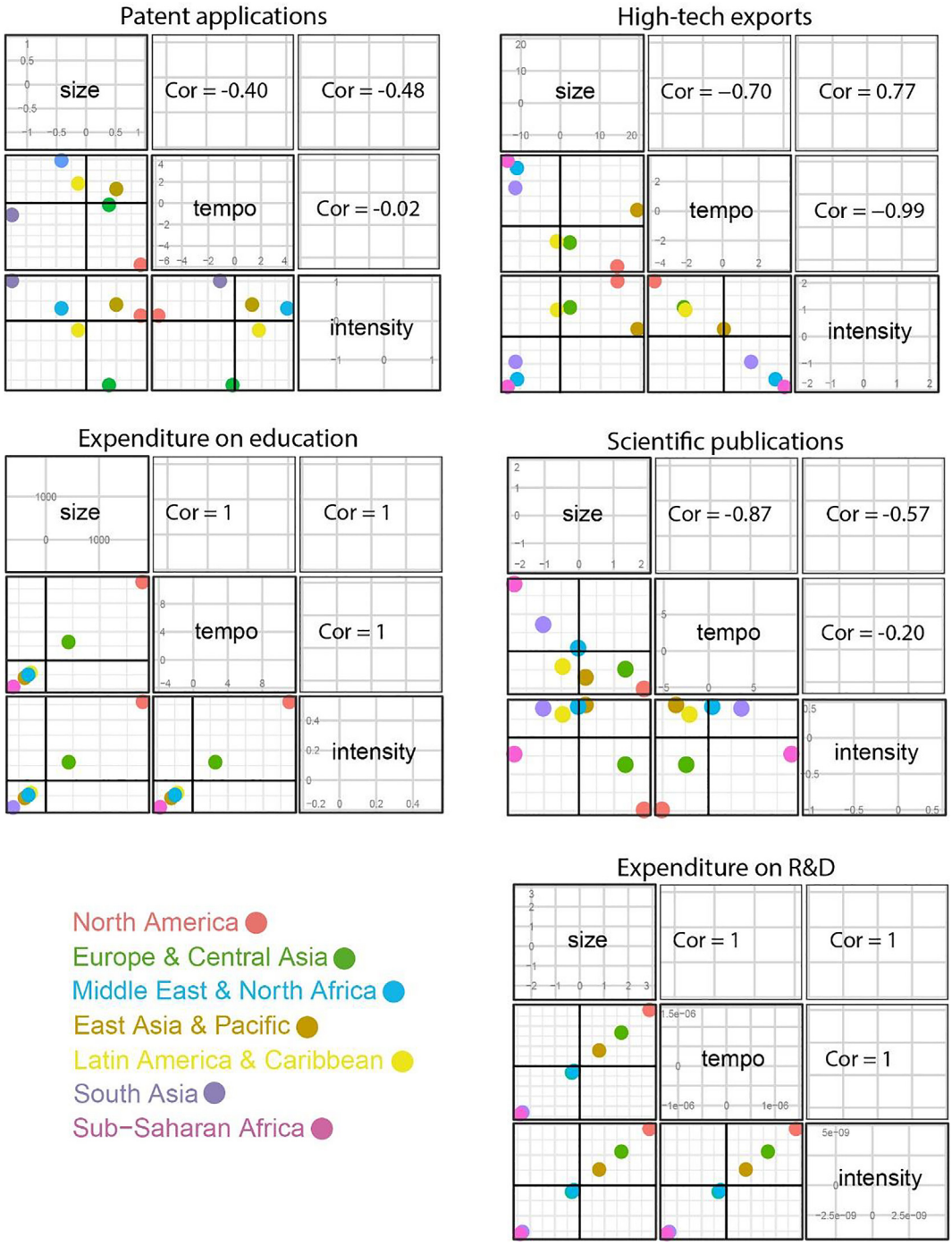

Fig. 4. A lattice of the components of growth for the indicators of knowledge. The paucity of data or the lack of resolution for expenditure on education and expenditure on R&D precluded detailed analysis of tempo and intensity for these indicators.

The lesser levels that LCR maintains with the rest of the world in terms of income per capita, public expenditure in education and R&D per capita result in a reduced generation of knowledge. Replicating knowledge requires low marginal costs; however, generating knowledge requires significant investments in infrastructure and human capital. Both conditions are capable of articulating education and training from the initial levels to advanced stages that result in applied research and technological developments (Ciocca & Delgado, 2017).

Structural change towards the modern productive sector and technological catch-up (i.e., absorption of technology) are two essential conditions on which the development of countries depends (Lavopa & Szirmai, 2018). Even if there is an expanding modern sector, there may be insufficient technological catch-up. A region such as LCR, with a notably expanding modern sector in the 1990s, remained caught in a development trap and in contrast to a growing Asia where technological improvement was possible (Lavopa & Szirmai, 2018). Thus, technological catch-up requires a properly educated and capable population, without which this necessary component for development will not be possible.

The number of patent applications of LCR is markedly low (World Bank, 2020). In 1995, the share of patents from residents

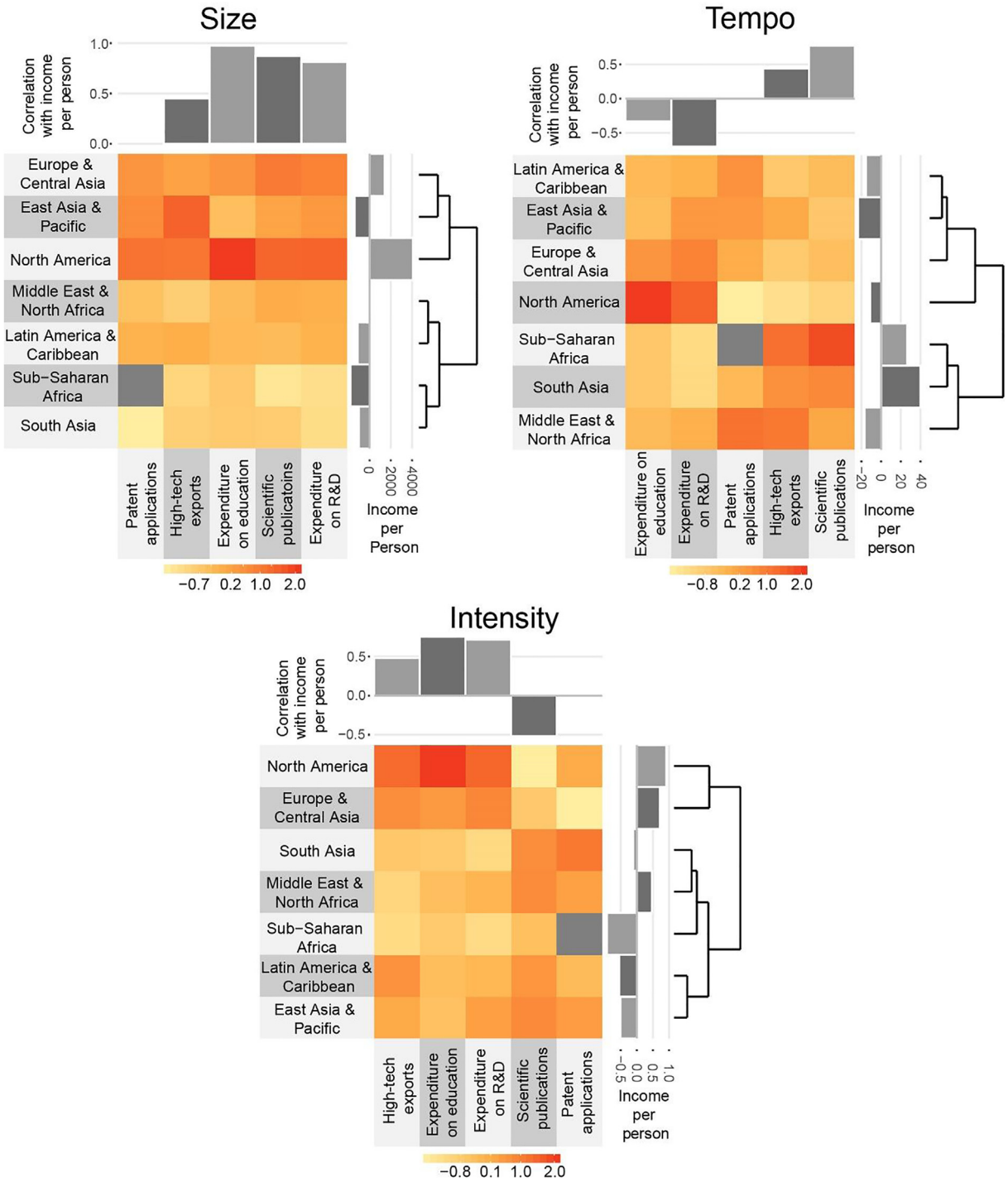

Fig. 5. Heatmaps of the three components of growth for the indicators of knowledge across the World Bank regions, correlations of each component to income per person, and a classification based on the latter variable. The negative income per person is relative to the normalization of this variable. Normalization of each component of growth indicates a trend towards the left or right of a mean centered on zero in terms of standard deviations, and specific to each component of growth.

in the region barely reached 0.7% of the world total. By the year 2018, patent applications by residents had reduced to 0.4% of the world total. This reduction in the world share of patents has widened the knowledge gap. Measured by the number of patents per million inhabitants, the gap between the United States and LCR went from 51.2 times the number of patents filed by LCR in 1995 to 68.6 times in the year 2018 (World Bank, 2020). To ameliorate this increasing gap in technological capability, assimilation and mastering of new technologies through investment in education would allow the modern sector to increase capital and labor output (Lavopa & Szirmai, 2018).

A similar gap to that obtained for patents is also present for scientific publications. Technical and scientific publications in LCR accounted for 2.9% of the world publications in 2003, a number that increased to 4.2% by 2018. In general, LCR has reduced the gaps in publications (per million inhabitants) by 2020, halving them with NA and ECA; however, the gap widened with EAP, which is mostly due to the impressive growth of South Korea and China

(World Bank, 2020). The number of scientific publications has a close relationship with the number of researchers dedicated to R&D (Rosenbloom et al., 2015). In 2014, South Korea had 1.9 times the number of researchers per million inhabitants than LCR. China had 11.4 times as many researchers as LCR per million inhabitants (World Bank, 2020). The larger population allocated to the scientific and research sector may explain the widening gap in scientific publications. Countries trapped in middle-income ranges require moving human resources from low-wage activities and routinized tasks to knowledge-based production and the use of cutting-edge technological innovations (Lavopa & Szirmai, 2018).

Given the assessment of growth trajectories presented in this study, any observed reduction of the present gaps between LCR and more developed regions of the world has been meager and insignificant. Overall, the trends for LCR are essentially flat lines with unremarkable size (as the specific growth component measured in the present study); intensity, however, is relatively large for patent applications, high-tech exports, and scientific publications. The former mirrors the slight reduction in the proportions of gaps that we have mentioned earlier and an intensive rate of R&D investment that has been previously reported by other authors (Gonzalez-Brambila et al., 2016). Caution is however necessary at interpreting these results, as our analysis is unable to discriminate on the differential quality of the measured indicators of knowledge. As we have mentioned in the results section, high-tech exports was the only indicator of knowledge in which the component of size remained close to the mean of the world regions. Yet, our measurement is coarse as it does not distinguish between maquila-type industries—that maintain low intellectual value or absorption of technological knowledge— and high-tech native industries in which knowledge and technology have been properly assimilated (Lavopa & Szirmai, 2018).

Internal factors that preclude catch-up derive from the lack of investment dedicated to research and development, limited productive diversification, the weak articulation between education and the job market, and lack of innovation. A weak State, lack of affordable funding, and a large proportion of the population with unfulfilled basic needs (e.g., access to drinkable water, sanitation, electricity, transport infrastructure) pose countries in the region with a dilemma on how to properly use the available budget. The political cycle, however, tends to favor short-term policies with an eye on the next elections, instead of implementing long-term plans for the development of science and industrialization. The investment dedicated to R&D and its distribution with a focus on expenditure efficiency and quality may reduce knowledge gaps. However, to be successful, R&D processes need to be sustained over time, considered as a state policy, and not just as a transitory measure.

4.2. External drivers of knowledge gaps and the international trade insertion

Another driver of knowledge gaps is the international trade insertion of the region. LCR has asymmetrical trade relations that undervalue (in monetary terms) the exported goods. The latter are usually without added value and result in expensive imported goods and services, especially those with a high degree of added technology. The dependence on natural resources is the most vulnerable form that an economy can assume; given that, due to the existence of unequal exchange, maintaining or increasing domestic consumption and investment levels implies having to export increasing amounts of natural resources, with associated environmental impacts that are not reflected in the prices of such exported goods (Hornborg, 1998; Hornborg & Martinez-Alier, 2016).

Indeed, this sort of unequal exchange (Ciplet & Roberts, 2017; Prebisch, 1950, 1959; Ricci, 2019; Singer, 1950) is complemented by the existence of ecologically unequal exchange. As there are more exports than imports, measured in physical units, there are also more local environmental impacts and socio-environmental conflicts (Bunker, 1984, 1985; Samaniego et al., 2017). Besides, there is also a calorically unequal exchange (Falconí, Ramos-Martin, & Cango, 2017; Ramos-Martin, Falconí, & Cango, 2017); that is, food exports, as measured in calories, with lower unit prices than imported calories.

LCR exports raw materials and food and imports technology. In both cases, the region is unable to set prices on international markets. Regardless of the changes in international prices, the export structure shows little diversification over time (Fig. 6). During the entire analyzed period in this study, more than half of the region's exports have been raw materials, low-tech products based on natural resources, or low technology, without perceiving significant changes that may indicate a shift in the current trend for exports, technological capability, and modern sector. This dependency on commodities has been the result of the lack of investment in education and research, which, as we have discussed, are necessary engines for labor productivity and economic growth.

4.3. Intellectual property asymmetries

Current knowledge gaps are also aggravated by the international system of patents and intellectual property, which hinders the acquisition of knowledge and technology by poor countries (Cango, Ramos-Martin, & Falconí, 2018). It is a vicious cycle in which poor countries cannot devote the same resources in terms of research, innovation, and technological development, which in turn results in a lower number of patents that compel these countries to continue depending on technological developments that occur in other parts of the world. The problem is further aggravated by the impossibility of the population to properly access and use those patents, either due to the absence of absorptive capacity or the lack of complementary assets that are capable of assimilating and mastering these patents (Howell, 2016).

4.4. The weakening of the process of regional integration

LCR is a region that includes low and middle-income countries that share shortcomings in their scientific and technological policies (Gonzalez-Brambila et al., 2016). In this context, the actions of individual countries may have a marginal impact, so in recent years, initiatives to improve regional integration were looked forward to (e.g., CELAC). Multilateral forums were created in which a certain harmonization of educational, research, and industrial policies was sought. LCR countries looked at European integration and the leap that it meant not only for its already developed scientific and technological sectors but for its articulation with the processes of industrialization and public policies (Hayward, 1995).

In recent years, the change in the political cycle in the region, from leftist-progressive to right-wing neoliberal governments has implied a weakening of the regional integration process (Reid, 2017). There is no longer the political will in many countries to seek collective solutions to common problems; thus, returning to the weakness of individual action in each country. This weakening implies an obstacle to coordinate science and technology policies, the generation of research networks, as well as the common use of resources toward development (Albornoz, 2020). The worrying outcome is that the region offers no alternatives to the current reprimarization observed in international trade (Cooney, 2016). As reiterated in the recent study by the United Nations International Resource Panel, the region maintains the historical role of being a supplier of raw materials for industrialized economies (IRP, 2019).

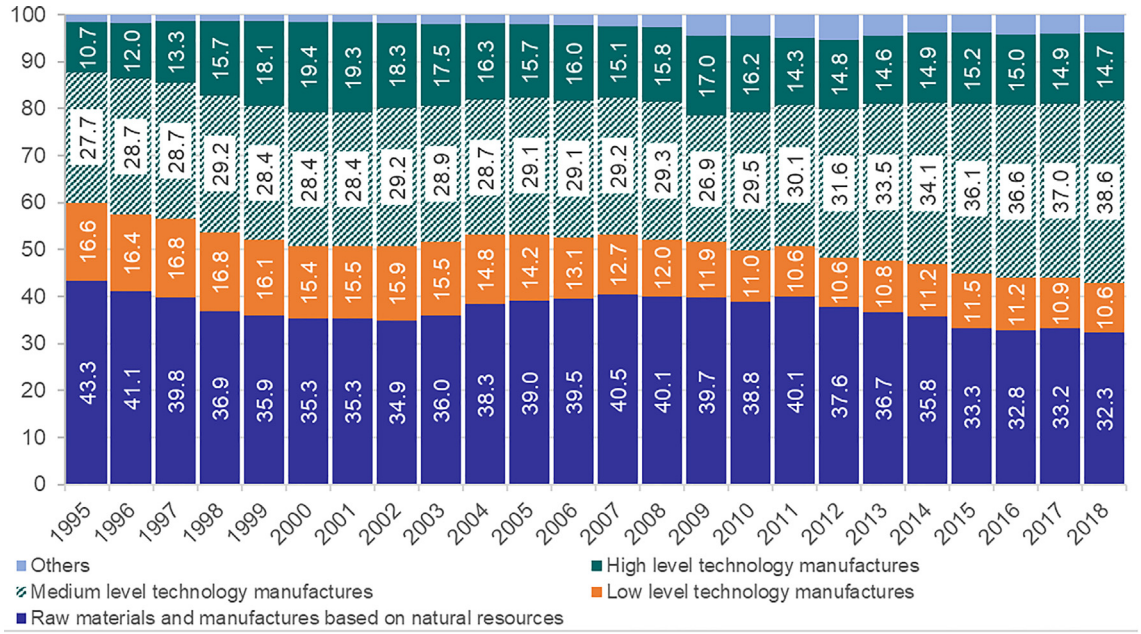

Fig. 6. Latin America and the Caribbean: Structure of exports by technological intensity between 1995 and 2018 (Unctad, 2019).

5. Conclusions and policy recommendations

Our analysis is unique in the sense that we assessed gaps of development in knowledge by decomposing growth in its three essential parameters, which are size, tempo, and intensity. According to our analysis, LCR maintains a historical gap of 70% with NA in income per person growth over the last two centuries. SAR and SSA are close to a 90% gap, which will require special conditions and considerable efforts for a catch-up. Four regions remain on or below the mean trend in economic growth (i. e. SSA, SAR, LCR, and EAP), and three regions above (NA, ECA, and MNA). Catch-up processes should necessarily consist of policies and mechanisms that secure sustainability and equitable development but also achieve economic growth, and that incorporate the complexities and peculiarities of native cultures, geographies, and natural endowments (Demeterova et al., 2020; Li & Lin, 2019).

A contrast of size and intensity shows a strong correlation, where the largest economies, NA and ECA, are also the largest in growth rate. This pattern is also evident for the indicators of knowledge, with regions such as LCR, SSA, and SA having a small size component of growth. Labor productivity helps to explain the result of economic growth. Labor productivity in LCR in 1991 was above the world average, whereas in the year 2018, LCR had a value 12.6% lower than the world average, showing a decline over time and an incapability to keep up with the development in other regions, particularly with EAP. Concerning NA, despite the widening gap in income per capita for LCR, the region has slightly reduced the gap in education expenditure per capita, which reflects both the low starting point of the region, but also efforts deployed in the last decades (i.e., measured as intensity in our study).

In relation to NA, our study showed that the gap for LCR is over 90% for all indicators of knowledge. In terms of the number of patents, LCR remains in the quadrants of low size, late tempo, and low intensity. Despite the growth in patent filing in the region, LCR represented only 4.2% of world-filed patents in 2018. The United States had 68.6 times more patent applications per million inhabitants than LCR in 2018, making it difficult for the region to close the gap. For high-tech exports, LCR remains close to the mean in terms of size and has an early tempo and high intensity. This is the only indicator of knowledge in which LCR remains close to ECA.

For the number of publications, LCR has been classified by our study as a region with low size, early tempo, and large intensity; however, these values were not significant. The slight reduction in the gap for this indicator seems related to NA as being the lowest region in terms of intensity, but the largest in size and with the earliest tempo. In 2018, LCR represented 4.2% of the world's scientific publications, and has slightly reduced the gap with all regions, except for EAP; the latter is heavily pulled up by China's performance. We observed a decline in growth for scientific publications, in the curves for NA and EAP during the last years, which could be associated with the inverse correlation found between intensity for the number of scientific publications and intensity for income per person. The latter relationship opens room for future research at investigating the causes of the plateau reached by NA in terms of publications and to analyze why growth in income per capita seems to be slowing the rate of growth in publications.

Saturation is a concept that we propose for explaining how historical gaps, as the integration of accumulated differences in growth curves through time, will eventually reach a value close to 100% (they will approach the limit as an asymptote) with NA as the reference. Large gaps, above 90%, are present for regions such as LCR, SSA, and SAR in indicators of knowledge, such as expenditure on R&D or scientific publications. The latter represents a trend towards saturation, in which added intensity and size—as components of growth—by more developed regions will no longer represent significant increases in the magnitude of the historical gap, as this will remain a fraction close to 100%. This is a concept that integrates the historical trajectory of World Bank regions and which meaning can be applied to the study of long-term trends, and long-term strategies of development. Avoiding the state of long-term saturation by regions such as LCR should include sound strategies for development.

Access to knowledge, as an essential component for economic development, is not only about strengthening basic and applied research; but also, about down-to-earth knowledge and research, that enhances adaptability to cope with changing future scenarios. This implies turning knowledge into useful realities to solve the

problems demanded by today's society. Income, productivity, and knowledge gaps between LCR and several countries, regions, and the world average are widening. Investment in education, research, and development (as a share of GDP) is necessary, but not sufficient, to reduce knowledge gaps.

With this in mind, we propose several measures for debate (Kesidou & Romijn, 2008): 1) a new productive specialization focused on knowledge and not only on resources endowment, particularly on viable and affordable sectors such as software development; 2) prioritization of innovation activities focused on unsatisfied basic needs, with the intervention of strong developmental states that can negotiate with international capitalists, capture investment and drive such investment towards promissory technology-intensive sectors; 3) sustained investment in education quality, which requires reversing the structural weakness of the State. This third measure is based on the fact that local knowledge spillovers in developed economies are possible due to government subsidies toward universities and firms that conduct substantial R&D; 4) strengthening professional education, for the formation of highly-skilled employees, that should be linked to local industry; 5) deepening processes of regional integration and South-South cooperation, with long-term multilateral agreements between countries from the region, to foster mobility, informal interaction and knowledge transmission by relaxing labor laws, and that avoid parallel efforts in a region that is characterized by budget constraints, with synergies and economies of scale.

LCR and the countries in the region must learn from past experiences of success and development. China's achievements in economic and technological development were accomplished by a national ideology centered on technocratic rationality and technology-driven modernization. Leaders of this nation emphasized science and technology as the key factors for reaching economic productivity. China's empowerment in the global economy was based on state-backed science, technology, and innovation to enhance its production systems and stimulate economic growth (Xu et al., 2016).

Resource constraints and high investment costs for establishing sound R&D processes are real and present challenges facing the development of LCR (Fu et al., 2011). However, cultural traditions and practices that are corrosive to the installation of national R&D also challenge development (e.g., corruption) (Goldstein & Drybread, 2018; Rotberg, 2019). National and regional proposals are needed to lay the foundations of a proactive and innovative region, solidly based on science and technology. But above all, strong and sustained policies over time are urged in support of the generation of knowledge and to create long-sought innovation ecosystems. The future is not about emulating the path set by rich countries; but rather, about learning from countries that managed to shorten those gaps in the shortest time possible.

Conflict/declaration of interest statement

The authors declare no conflict of interest or personal relationships with other people or organizations that could inappropriately influence (bias) their work.

CRediT authorship contribution statement

Pablo Jarrín-V: Formal analysis, Methodology, Validation, Visualization, Writing - review & editing. **Fander Falconí:** Conceptualization, Writing - review & editing. **Pedro Cango:** Data curation, Formal analysis, Methodology. **Jesus Ramos-Martin:** Investigation, Writing - review & editing, Supervision.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.worlddev.2021.105602.

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CAPÍTULO 4.

“TOWARD FOOD SOVEREIGNTY AND SELF-SUFFICIENCY IN LATIN AMERICA AND THE CARIBBEAN: OPPORTUNITIES FOR AGRICULTURAL COMPLEMENTARITY | HACIA UNA SOBERANÍA Y AUTOSUFICIENCIA ALIMENTARIA EN AMÉRICA LATINA Y EL CARIBE: OPORTUNIDADES DE COMPLEMENTARIEDAD AGRÍCOLA

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Toward food sovereignty and self-sufficiency in Latin America and the Caribbean: opportunities for agricultural complementarity

Hacia una soberanía y autosuficiencia alimentaria en América Latina y el Caribe: oportunidades de complementariedad agrícola

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Abstract: Food self-sufficiency is a relevant political issue in many countries, developed and developing, particularly to satisfy the internal nutritional needs of the population and face situations in which the prices of basic products are unstable or when a country faces an external shock. Improving resilience involves strengthening local rural communities to meet demand with domestic production. The member countries of Latin America and the Caribbean (LCN) produce enough food to sustain their population and to be one of the world's largest food exporters. From the theoretical discussion and using data from FAO, the research shows that there is a potential to improve food sovereignty and to define food and agricultural policies through agricultural complementarity among the LCN countries. Diverting part of the current trade with third parties to intraregional trade, for products in which the region has a comparative advantage, would mean that LCN countries could save up to 2.7 billion dollars per year, that is, 6.8% of total imports of food in 2018, avoiding the outflow of foreign currency and promoting greater economic integration between countries.

Keywords: food sovereignty, self-sufficiency, trade, LCN, complementarity, economic integration.

Resumen: La autosuficiencia alimentaria es un tema político relevante en muchos países, desarrollados y en desarrollo, particularmente para satisfacer las necesidades nutricionales internas de la población y enfrentar situaciones en las que los precios de los productos básicos son inestables o cuando un país enfrenta un shock externo. Mejorar la resiliencia implica fortalecer las comunidades rurales locales para satisfacer la demanda con producción interna. Los países miembros de América Latina y el Caribe (LCN) producen suficientes alimentos para sustentar a su población y para ser uno de los mayores exportadores mundiales de alimentos. A partir de la discusión teórica y usando datos de la FAO, la investigación muestra que, existe un potencial para mejorar la soberanía alimentaria y para definir las políticas alimentarias y agrícolas a través de la complementariedad agrícola entre los países de LCN. Desviar parte del comercio actual con terceros al comercio intrarregional, para productos en los que la región tiene una ventaja comparativa, representaría que los países de LCN podrían ahorrar hasta 2.700 millones de dólares al año, es decir, 6.8% del total de las importaciones de alimentos en 2018, evitando la salida de divisas y promoviendo una mayor integración económica entre los países.

Palabras clave: soberanía alimentaria, autosuficiencia, comercio, LCN, complementariedad, integración económica.

1. Introduction

Human beings have several needs that need to be satisfied to live in full, understanding this as the state in which individuals can develop and pursue effectively their capabilities (Malinowski, 1939, 1970). In this sense, food plays an important role as it acts as the satisfier of a basic need, nourishment (Maslow, 1943). This implies that an inadequate supply of food not only threatens the integrity of the individual, but also the sustainability of societies.

For this reason, societies articulate as an entity made up of institutions that work to satisfy their own needs (Malinowski, 1939, 1970). At the international level, common political, legal, economic, or social institutions are created through regional integration processes between countries (Hix, 2001).

From the perspective of nourishment, regional integration may become an opportunity to build common strategies that encourage, through agricultural complementarity, food self-sufficiency. That is, the situation in which food needs are covered with domestic production (Food and Agriculture Organization of the United Nations, 2002), something the world is far from attaining nowadays (Kinnunen et al., 2020). In this case, achieving political influence is only possible if there are studies like ours that show the potentiality of regional cooperation and integration towards regional self-sufficiency.

This move implies a change in the food production system of Latin American and Caribbean countries (LCN), which until now have prioritized production for exports instead of that of internal supply (Pengue, 2009). This trend has implied a gradual loss in food self-sufficiency and an increase in vulnerability to external factors, for instance, to international prices.

Therefore, agricultural complementarity, defined as the contribution each member country has in the production of food that is needed to achieve self-sufficiency of the bloc, becomes an instrument of cooperation and integration. Among the benefits of this cooperation one can list: a) improvement in transport and communications through regional investment in infrastructure; b) mutual assistance in the case of production problems – for example draughts, plagues, etc.; c) promotion of regional economies of scale and d) improvements in food security (Hubbard et al., 1992). Another benefit, although modest, is the reduction in the currency outflow that escapes the region.

Currently, many successful experiences of common strategies exist, promoted by supranational entities, and oriented to food self-sufficiency. This is the case of the European Union, which has achieved that goal through the Common Agricultural Policy (Guinea, 2013). The EU produces more food than it consumes, avoiding in this way a supply-side problem in recent decades (Candel et al., 2014).

For these reasons, similar strategies for the region would strengthen its food sovereignty, improve the efficiency in the use of natural resources, and would increase economic profitability. This would also help to avoid developed countries' food policy affecting developing ones'. Something that is far too familiar nowadays (Brooks, 2014).

However, the design of these strategies requires reliable information regarding agricultural products trade, between LCN countries, and with the rest of the world. This information needs to be available not only in monetary terms but also in nutritional terms. Only in this way, one can get a wider vision of the role international trade plays on the nutritional security of countries (D'Odorico et al., 2014).

Following that, the main objective of this article is to examine the opportunity for agricultural complementarity that LCN has, to achieve food self-sufficiency as a bloc. To do this, after the introduction, section 2 presents a discussion of the relevant literature related to self-sufficiency and food security. Later, in section 3, a description of materials and methods is presented. In the

fourth section, the results are analyzed according to the methodology presented for challenges in the region, food self-sufficiency and opportunities for agricultural complementarity. Then in section 5, the policy implications are discussed and finally, in section 6, the conclusions are presented.

2. Literature review

Pastorino (2020) points out that the term "food security" is not recent. It can be considered an objective (i.e., to solve the problem of hunger and nutrition in the world), an end or goal (for agrarian law it could mean a search for safe food) or a paradigm or a new way of thinking about food from the political, economic, social, and cultural perspectives.

The Rome Declaration on World Food Security, during the 1996 World Food Summit, defined the concept by saying that there is "food and nutritional security" when all people have physical, social and economic access to safe food at all times, the consumption of which is sufficient in terms of quantity and quality to satisfy their food needs and preferences and is supported by a framework of sanitation, health services and adequate care that allow them to lead an active and healthy life (Food and Agriculture Organization of the United Nations, 1996).

At the 1996 World Food Summit, the proposal was to halve the number of undernourished people by 2015. In 2015, the UN approved the 2030 Agenda for Sustainable Development with 17 goals (SDGs). One of them calls for ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture by 2030.

However, hunger levels remain stable. With data from 2017 at the global level, there were 821 million undernourished people. By the end of 2020, it is estimated that the Covid-19 pandemic could have caused an increase of 130 million in the number of people affected by chronic hunger worldwide (Hidalgo & Sorondo, 2020).

In 2018, LCN recorded that the number of undernourished people increased for the third consecutive year, reaching 39.3 million, that is, 6.1% of the population. In ten countries, 20% of the poorest children suffer three times more from chronic malnutrition. Indigenous populations are more food insecure than non-indigenous and rural populations more than urban (Food and Agriculture Organization of the United Nations, 2018b).

Hochedez (2021) reviews the term "food justice" and points out that it is not the traditional framework for analyzing food problems in Latin America, since it is preferred to speak of food insecurity and food sovereignty or sustainable development. He argues that the term food justice implies a real change in the way food inequalities are resolved. However, the Latin American approach highlights two different ways of looking at food justice: accessibility and the right to food.

Accessibility is a classic first way of looking at food justice as good access to safe and quality food. This is traditionally analyzed from the point of view of consumers. It also leads to consider access to resources to produce food as part of accessibility to food. This approach also highlights the processes of connection and disconnection between consumers and producers, between rural and urban areas.

The second approach analyzes food justice in terms of the law. This approach brings food to the context of democracies, including the State's responsibility for food. In addition, food is part of citizenship and a way of exercising our citizenship. At the individual level, the approach of "right to" food justice faces several challenges in Latin America, such as the right to land and access to land, the right to access to food, the right to the city (through urban agriculture initiatives, for example), labor rights in agriculture, in agri-food systems, or the distribution sector.

However, Clendenning et al. (2016) argue that food sovereignty is based more on human rights than similar concepts of food security and, to a lesser extent, food justice. Food sovereignty emphasizes the recovery of the land, food, livelihoods, and identities of people with a lack of food security through their direct participation in the design and implementation of food systems. Food security is a social condition that emphasizes knowing where the next meal will come from and does not address the production, distribution, or control of access to food (Hossfeld et al., 2018). Food justice is a progressive social movement that seeks to address injustices based on race and class (Hossfeld et al., 2018). The food justice movement also develops strategies to "work around and outside" the broader food system to provide access to food for marginalized groups (Clendenning et al., 2016).

The distinctions between these concepts influence who participates in which area and who benefits. For example, in urban areas, food sovereignty can be seen in urban agriculture, home and community gardens, and direct-to-consumer markets such as farmers markets and community-supported agriculture (Clendenning et al., 2016).

Ferranti et al. (2019) make a compendium of a collection of articles in a book on food security and sustainability, which allows an adequate understanding of this relationship. The different approaches and methods used make it possible to understand the different dimensions of the concept of food security.

The global food system is key to sustaining humanity (Rockström et al., 2020). In addition, it is the main emitter of greenhouse gases and is the central cause of loss of biodiversity, destruction of terrestrial ecosystems, consumption of fresh water and pollution of waterways due to the excessive use of nitrogen and phosphorus. Faced with this, they propose safe limits for the development of the world food system, and three essential actions: 1) a change towards healthy diets, 2) an increase in agricultural productivity and a transition towards regenerative production, and 3) reduce the food waste.

Work on food security, sovereignty, or self-sufficiency has adopted usually a national and single product point of view. Amid (2007), for instance, analyzes the case of wheat in Iran from a market and price perspective; Anderson & Strutt (2014) analyze how economic growth and demographic transition in China is making the country more dependent on food imports, modeling its evolution until 2030. Cuesta et al. (2013) argue that public expenditure in Bolivia is not effective in reducing food insecurity. Farrow et al. (2005), on the other hand, show how spatial heterogeneity may play an important role as a determinant of the lack of access to food products in Ecuador, a problem particularly important in the central mountain range. Hassan et al. (2000), adopting a food security-like perspective, analyze the case of wheat and cotton in Sudan, reaching the conclusion that is the interest of Sudan to encourage cotton so that currency is obtained that can be used to import wheat. Giampietro et al. (2014), applying an innovative biophysical approach in the line of that presented in this study, analyze two national case studies, self-sufficiency of wheat in India and total food self-sufficiency in Mauritius islands.

Only a few studies analyze the productive possibilities and availability of food at the regional level. Since the work of O'Hagan (1976), according to which most of the countries had food self-sufficiency, things have changed drastically and many countries and regions have worsened in this respect. Despite this fact, there is a lack of studies with a regional scope.

Among those few studies, one could highlight that of Blackie (1990), where self-sufficiency of corn in Eastern and Southern Africa is analyzed. This is one of the first studies making explicit the potential of trade diversion for one product, complementing in this way the previous work of Koester (1986).

Using both available surveys and FAO food balances, Asfaw (2008) checks the availability of fruits and vegetables for human consumption in Latin America and the Caribbean. The conclusion is reached that the region shows low levels of consumption despite the availability of the products in the region is high.

The focus of the region as a food exporter comes with impacts attached. Ceddia et al. (2013) analyze the intensification of agriculture in South America, concluding that the region would face a "Jevons´ Paradox" like situation; that is, efficiency improvements would not lead to lowering the use of the resource (land) but the opposite would be true. More efficient techniques of production will use more land to export more. In the case of intensification of agriculture, at the expense of more deforestation occurring.

A group of authors takes on the effects of trade and trade policies of regional blocs upon access to food products in developing countries. Brooks (2014) shows how policies implemented by OECD countries have harmed developing countries, especially through import tariffs and production subsidies at home, which lead to surplus exports, generating their example of trade diversion. Candel et al. (2014) use a similar approach to analyze the EU's Common Agricultural Policy. They stress that food security is at the roots of the very existence of the EU, having as a result, an increase in the food surplus. On the other hand, Rask & Rask (2011) show how development at the world level is changing the diet everywhere, towards more meat products that imply a double energy conversion, increasing in this way cereal and oilseeds demand more than proportionally. This fact imposes further pressure upon natural resources and increases the risk of future food provision.

Having in mind all these precedents, our focus here is the situation of Latin America and the Caribbean. Altieri (1992) pointed out that the agricultural model found in Latin America is not based on distributed land. Land reform is still a pending issue in most countries. As a consequence, heterogeneity of levels of productivity is one of the characteristics of the model and this implies environmental impacts attached. The region is rich not only in terms of biodiversity but also in terms of cultural diversity, with important ethnoecological knowledge.

Other authors have a more positive view of the model of agro-exports in southern countries. Bindraban & Rabbinge (2012) say, based on Food and Agriculture Organization of the United Nations (2011), that there are no problems to feed the population at the world level in the next four or five decades. They base their optimism on productivity gains obtained through the introduction of multiple crops and land use systems, agroecological practices, changes in the diet, and the use of new inputs from biological origin.

Siegel & Bastos (2020) carry out a critical evaluation of the incorporation of the Sustainable Development Goals in the national agendas of agri-food governance in three countries: Brazil, Paraguay and Uruguay. The nominal incorporation of the SDG agenda does not imply implementation, since it involves more complex institutional changes that depend on the power relations of the actors, resources, capacities and previous experiences of civil society and governments.

The current paper goes beyond the concept of food security defined at the World Food Summit organized by Food and Agriculture Organization of the United Nations (1996), which included economic access to food (through purchasing power and markets). We rather fall into the concept of food sufficiency that analyzes the relation between local availability of resources and its domestic demand, more oriented to the concept of food sovereignty (Altieri, 2009). The paper does not pretend to make a thorough review of the topic; the interested reader can refer to Chaifetz & Jagger (2014), where the authors conduct a full revision of the concept of food sovereignty for the last 40 years.

The idea of improving food sufficiency in a region that has huge potential if economic integration was promoted, makes even more sense in the current context of the high volatility of prices, and unequal exchange relations in all its dimensions. In this context, the region faces the great challenge imposed by deteriorating terms of trade (Prebish, 1950, 1959; Singer, 1950), unequal ecological exchange (Samaniego et al., 2017; Vallejo, 2010), and caloric unequal exchange (Falconí et al., 2017; Ramos-Martín et al., 2017).

The international insertion of Latin America and the Caribbean in international trade has been limited to play as a supplier of food and raw materials. This only perpetuates international dependency and asymmetries in international trade. This is coherent with modern interpretations of comparative advantages (Krugman & Obstfeld, 2003), which state that countries would import those goods that are either difficult or expensive to produce internally and export products in which they have an advantage in terms of costs.

These trends, far from benefiting countries exporting commodities, deepen an unjust international division of labor. Countries producing commodities compete with each other to sell their products in the same market, by lowering costs and prices in a so-called "race-to-the-bottom". As all of them follow this path, the consequence is an intensification of the exploitation of natural resources, a worsening of current unequal exchange, and a better-off situation for central economies that get the resources they need at ever-lower prices (Schaffartzik et al., 2014).

Traditionally, the extraction of natural resources has been one of the ways to express this unequal economic exchange: selling cheap commodities and buying expensive capital goods. Along with it, there is a sub valuation of social and environmental impacts (Bunker, 1984; Alier, 1992).

3. Material and Methods

The research seeks to examine the opportunities for agricultural complementarity for the countries of Latin America and the Caribbean. The methodology used is subdivided into three parts: main challenges for the region in terms of food production, food self-sufficiency, and opportunities for agricultural complementarity.

3.1. Main challenges for the region in terms of food production

Using data from FAO (Food and Agriculture Organization of the United Nations, 2020e), we analyze the growth of the agricultural frontier between 1961 and 2018 and the deterioration of forests between 1991 and 2018. This is a comparison made between LCN, the world average, and the rest of the regions of the world, using the World Bank classification: East Asia & Pacific (EAS), Europe & Central Asia (ECS), Middle East & North Africa (MEA), North America (NAC), South Asia (SAS), Sub-Saharan Africa (SSF), and World (WLD). To test the statistical significance in the average growth in the period for both indicators for *i* regions and LCN, the Kruskall-Wallis test was used. However, when the test showed significant differences in the distributions and was rejected the null hypothesis, we used Dunn's nonparametric pairwise multiple-comparison test (Dinno, 2015).

Then, using data from FAO (Food and Agriculture Organization of the United Nations, 2020a), differences in yields are analyzed for nine groups of products for LCN, according to the groups found at the food balances published by FAO. Grouping of the nine groups of products was done relying on the availability of data, according to FAO classification (Food and Agriculture Organization of the United Nations, 2020b). For this indicator, as in the previous analysis, we

have compared the average productivity in the period 1961-2019 between the i region and LCN, according to the product group.

Furthermore, using data from UNCTAD (2019) we have calculated exports by technology intensity for the countries of Latin America and the Caribbean. For this purpose, detailed classification by technology was used (Lall, 2000).

3.2. Food self-sufficiency

To calculate food self-sufficiency, we have used detailed trade matrices from 1986 through 2018 (Food and Agriculture Organization of the United Nations, 2020d), as well as national food balances (old methodology for series between 1961 and 2013, and new food balances for series between 2014 and 2018) available in FAOSTAT (Food and Agriculture Organization of the United Nations, 2017, 2021). In this case, FAO data allows using 19 product groups instead of 9, as we did for agricultural land. LCN countries are considered as a region, as we are only interested in the region as a bloc and the relationship with the rest of the world.

We have used 19 product groups corresponding to vegetal and animal products, as classified by FAO. These products are cereals - excluding beer; starchy roots; sugar crops; sugar & sweeteners; pulses; tree nuts; oil crops; vegetable oils; vegetables; fruits - excluding wine; stimulants; spices; alcoholic beverages; miscellaneous; meat; offals; animal fats; milk - excluding butter, and eggs; aquatic products, other; and fish, seafood. However, when analyzing intra-regional trade, we excluded: a) aquatic products, other; and b) fish, seafood, because there is no data available. For these 19 product groups, we analyze food self-sufficiency as shown in the following lines.

To obtain the trade flow from LCN countries with the rest of the world, we calculated, for each country member, the volume consumed by country (LCN) and the volume imported by country of origin (rest of the world). The following indicator shows self-sufficiency (SS) (Falconí et al., 2017; Ramos-Martín et al., 2017).

$$SS_{rt} = \left(1 - \frac{\sum M_{rkjt}}{\sum C_{rkt}}\right) * 100$$

Where:

M = Total imports; r = product group; k = country of the LCN; t = year; j = no LCN countries. In this case, the imports (product group r) of the country k from country j in year t (M); consumption (product group r) of the country k in year t (C); $\forall k \in LCN$ and $\forall j \notin LCN$.

A value of self-sufficiency equal or greater to 100 for this indicator shows whether the region is self-sufficient for that product group or not. On the other hand, values below 100 indicate the region only partially supplies its domestic consumption with domestic production and therefore is not one hundred per cent self-sufficient. In the case there is domestic consumption but not domestic production, the indicator gets a value of zero.

Likewise, we analyze the relationship between self-sufficiency and nutrition. In this analysis, we consider the indicator food supply (kcal/person/day) provided by (Food and Agriculture Organization of the United Nations, 2017, 2021).

3.3. Complementarity opportunities

Using FAO's detailed trade matrix (Food and Agriculture Organization of the United Nations, 2020d), we analyze the opportunities for agricultural complementarity of the 19 product groups (described in the previous section) between LCN countries. To avoid heterogeneity between

the groups of products in the food balance used in this study, we have disaggregated all 296 products, whose definitions can be found in FAO's definitions and standards (Food and Agriculture Organization of the United Nations, 2020b).

$$OC_{rt} = \sum X\left(Ton\right)_{ikjt} - \sum M\left(Ton\right)_{ikjt} \quad if \begin{cases} X \geq M, OC\ strong \\ X < M, OC\ weak \\ X = 0, OC\ null \end{cases}$$

Where:

OC_{rt} represents the opportunities for agricultural complementarity of the product group *r* in year *t*; $X\left(Ton\right)_{ikjt}$ represents the exports, measured in tons, of product *i,* by country *k* to country *j* in year *t*; $M\left(Ton\right)_{ikjt}$ represents the imports, measured in tons, of product *i,* by country *k* to country *j* in year *t*. $\forall k \in LCN$ and $\forall j \notin LCN$.

In the case of products that show opportunities for agricultural complementarity, we assume that the countries in the region substitute imports from the rest of the world with imports from other countries within the region that would, otherwise, be exported to the rest of the world. With this assumption, we can compute the approximate monetary value (constant 2015 USD) of food imports and exports. To estimate exports and imports in monetary terms (constant prices 2015), we adjusted to value-added deflator by country for agriculture, silviculture, and fishing, available in FAOSTAT (Food and Agriculture Organization of the United Nations, 2020c).

Then, the regional value is obtained, as follows:

$$XC_t = \begin{cases} \sum X\left(US\$\right)_{ikjt} - \sum M\left(Ton\right)_{ikjt} * \overline{p}x_{ikjt} + \sum M\left(Ton\right)_{ikjt} * \overline{p}x_{ikkt}; \ \ If\ X \geq M \\ \sum X\left(US\$\right)_{ikjt} - \sum X\left(Ton\right)_{ikjt} * \overline{p}x_{ikjt} + \sum X\left(Ton\right)_{ikjt} * \overline{p}x_{ikkt}; \ \ If\ X < M \end{cases}$$

Where:

MC_t total imports of LCN with complementarity (constant 2015 US$) in year t; XC_t total exports of LCN with complementarity (constant 2015 US$) in year t; $\overline{p}m_{ikkt}$ is the average import price for product i, country k, from LCN $(country\,k)$ in year t; $\overline{p}m_{ikjt}$ is the average import price for product i, country k, from country j in year t; $\overline{p}x_{ikjt}$ is the average export price for product i, country k, to country j in year t; $\forall k \in LCN$ y $\forall j \notin LCN$.

In the case of imports of product *i* for which the region has a surplus, we consider that the region reduces its exports to the rest of the world by the total of imports from the rest of the world. The assumption is made that country *k* (member of LCN) covers its deficit in product *i* at the average price of its imports from the region (country *k*) in year *t*. Likewise, for product *i* for which the region has a deficit, we assume that the region promotes complementarity in total exports to the rest of the world, at the average price of product *i* that country *k* imports from the region (country *k*) in year *t*. Whereas, the remaining deficit of each product *i* in country *k* would be covered by maintaining imports from the rest of the world at the average price of its imports from the rest of the world (country *j*) in year *t*.

On the other hand, the value of exports with complementarity (*XC*) is estimated considering that this policy reduces food exports to the rest of the world and increases at the regional level. For product *i* with a regional surplus, we find the difference between the value of exports to the rest of the world in constant dollars of 2015 and the monetary difference that results from replacing the imports from the rest of the world at the average price of product *i* that country *k* exports to the rest of the world in year *t* for the average price of the same product that country *k* exports intra-regionally. Similarly, for products with a food deficit, the difference

between the value of exports (constant dollars of 2015) and the monetary difference resulting from replacing the exports to the rest of the world at the average price of product *i* exported by country *k* by the average price of the same country and product exported within the region.

However, the missing prices of country *k* and product *i* (imports as intra- or extra-regional exports) were imputed with the average value (regional or rest of the world) in year *t*. It should be noted that the use of averages corresponds to one of the univariate imputation techniques (van Buuren & Groothuis-Oudshoorn, 2011).

4. Results

4.1. Main challenges of the region

Three main challenges for food production in the region are discussed in this section: arable land availability, low production yields, and global insertion in food trade.

According to Food and Agriculture Organization of the United Nations (2018a), between 2012 and 2050, on a global scale, crop areas could increase by 23% and the size of the herd of animals by 46%. This increase in land use is worrying when it comes to walking towards the sustainability of the planet. However, not all regions have the same degree of vulnerability.

Data from Food and Agriculture Organization of the United Nations (2020a), show that between 1962 and 2018 Europe & Central Asia and North America had a negative average annual growth in agricultural land. On the other hand, in South Asia, Sub-Saharan Africa, and the World, agricultural land increased about 0.1%; this yearly increase was 0.3% in East Asia & the Pacific, 0.4% in Latin America and the Caribbean, and 0.5% in the Middle East & North Africa. Using Dunn's z-test we can see that only East Asia & Pacific and the Middle East & North Africa have average annual growth rates statistically equal to LCN (see Figure 1).

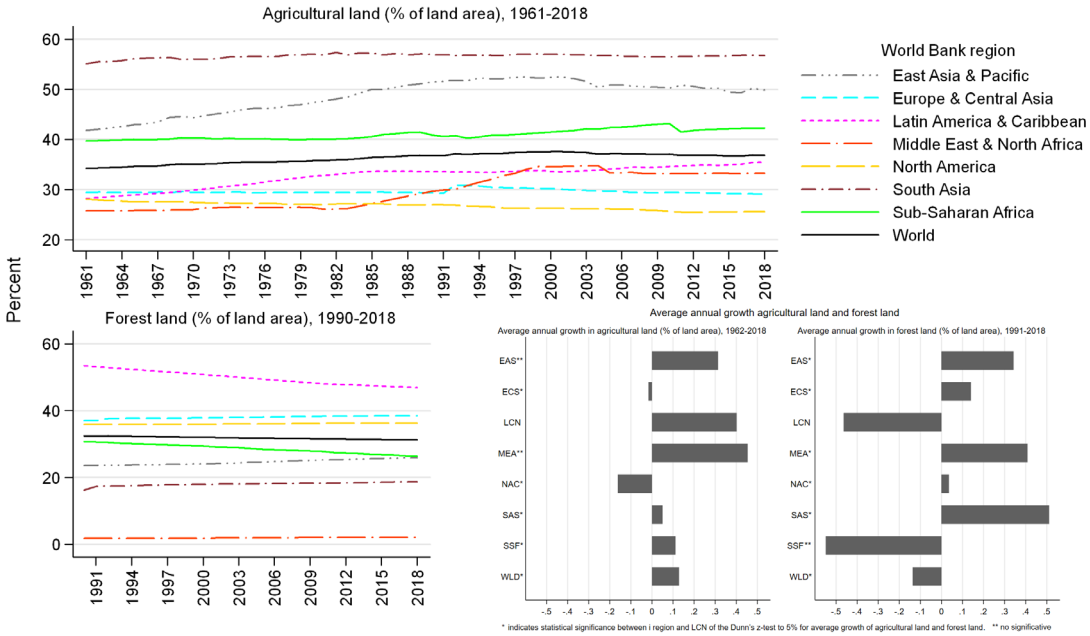

Figure 1. Agricultural land and forest land by region, 1961-2018. Source: (Food and Agriculture Organization of the United Nations, 2020e).

This increase in agricultural land in LCN, as in SSF and the World, was at the expense of forest area, which diminished (as a % of the land area). Forest land (as % of land area) decreased between 1991 and 2018 in LCN and SSF. The rate of annual decrease in forest land was 0.46% for LCN and 0.56% for SSF. This decrease, using Dunn's test, turned out to be statistically the same. This dichotomy is statistically different from the average annual reduction of the world (0.1%) and the other regions such as North America, which increased on average by 0.04%, Europe & Central Asia by 0.1%, East Asia & Pacific by 0.3%, Middle East & North Africa 0.4% and South Asia 0.5%.

According to Ferreira et al. (2016) between 1961 and 2010, 19 Latin American countries presented a positive variation in total factor productivity (TFP) in agriculture, which has contributed to a growth in production and technical development. Likewise, Reis et al. (2020) show that between 1991 and 2012, the area and labor presented positive effects on the production of 18 LCN countries. In this context between 1962 and 2018, food production increased in the region. Vegetables grew by 2.9% per year, and animal products grew by 2.8% per year (Food and Agriculture Organization of the United Nations, 2017, 2021). That is, agricultural production kept the path of population growth. Currently, LCN represents 14% of the world's agricultural production and 23% of agricultural and fish commodities exports (Organisation for Economic Co-operation and Development, 2019).

This increase in production and in agricultural land, which helps to explain how the agricultural frontier is still expanding in the region threatening particular ecosystems like the Amazon basin, is coupled with low productivity. According to the World Bank (2021), the labor productivity of workers in the agriculture, forestry, and fishing sector in LCN was 7,347 USD (constant 2010) in 2018. This represents just 47.8% of the productivity of an agricultural worker from Europe & Central Asia and a mere 8.5% of the productivity of a North American farmer.

According to the FAOSTAT database (Food and Agriculture Organization of the United Nations, 2020a), yields of the different product groups were, in the region, as follows: cereals (excluding beer) 1.3 t/ha, starchy roots 9.8 t/ha, sugar crops 49.3 t/ha, pulses 0.6 t/ha , tree nuts 14.8 t/ha, vegetables 6.6t t/ha, fruits (excluding wine) 13.0 t/ha, and stimulants 0.5 t/ha (see Figure 2a-i). Productivity of LCN in 1961 was higher than the average for the world and regions such as EAS, MEA, SAS, and SSF, in at least 6 of the 9 product groups. However, in that same year, the productivity of product groups in the region was lower than the results obtained in NAC, except for tree nuts. Concerning ECS, LCN only exceeded productivity for sugar crops, tree nuts, and fruits (excluding wine). The productivity for oil crops was the same in the three regions.

On the other hand, using Dunn's test, the average productivity by product group for the period 1961 and 2019 of the *i* regions and Latin America and the Caribbean is compared (see Figure 2j). We can observe that North America and East Asia & Pacific had significantly higher productivity than LCN in cereals (excluding beer) and oil crops, while it was the same when comparing with Europe & Central Asia, except for oil crops, where LCN has higher productivity. The productivity of starchy roots, pulses, and vegetables was also higher in EAS, ECS, MEA, and NAC than in LCN.

LCN had higher average productivity than the other regions in sugar crops, tree nuts, and fruits (excluding wine), except for sugar crops, where it turned out to be statistically equal to that of NAC and SSF. In the case of fruits (excluding wine), Dunn's test shows that NAC has higher productivity. In the case of stimulants, ECS, MEA, NAC, and SAS have higher productivity than LCN and are equal to EAS. At the same time, LCN outperforms SSF in all product groups, except for sugar crops, as already mentioned above.

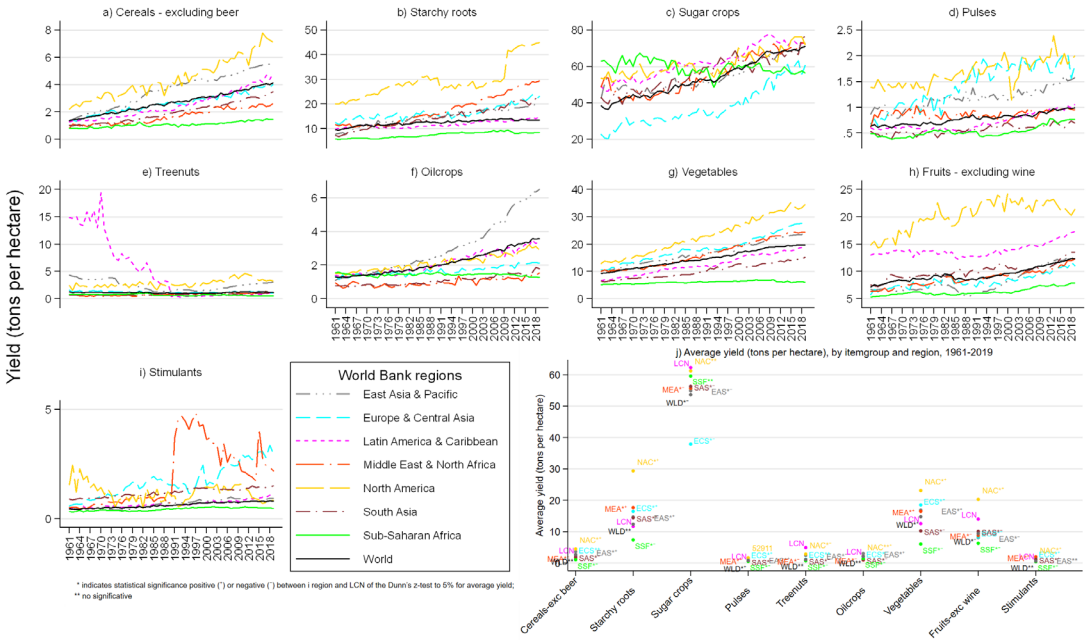

Figure 2. Yields (tons per hectare) by region and product groups, 1961-2019.Source: (Food and Agriculture Organization of the United Nations, 2020a).

In addition to low productivity, the economy of LCN countries indeed has a great dependence on exports of raw materials and food products. Primary exports of commodities represented 43.3% of total exports in monetary terms in the year 1995, and they went down to 32.3% in 2018 (UNCTAD, 2019).

4.2. Food self-sufficiency and nutrition in LCN countries

Using the indicator of self-sufficiency presented in Section 3 we see that LCN is self-sufficient as a bloc. Between 1986 and 2018, it maintained a level of 80% self-sufficiency in all product groups but spices and animal fats (See Table 1). However, the level of self-sufficiency has been reducing over time for all product groups, but sugar crops, vegetal oils, Alcoholic beverages, miscellaneous, and milk - excluding butter. This is an alarming outcome, especially if we consider that many regions in the world will face soon diminishing rates for food self-sufficiency (Beltran-Peña et al., 2020).

This aggregate result of self-sufficiency at the continental level does not hold when we go down to the level of nations, where there is heterogeneity within countries, although a common trend is that all countries of LCN have insufficiency of some products. This result opens the door to gains from agricultural complementarity between countries, which is crucial because, as Clapp (2017) mentioned, self-sufficiency in just a few products is not enough to eradicate hunger and malnutrition. Conventional economics tells us that if a product is cheaper in international markets than it is domestically, a country should import that product. Under this reductionist logic, based exclusively on monetary variables, we can omit fundamental aspects of the issue. One of them is the existing link between food self-sufficiency and nutrition, due to the cultural diversity (genetic and gastronomic) of a country. In this way, importing food products may have direct impacts in terms of losing genetic diversity and the local food culture, which could lead to changes in the traditional diet, associated with the spread of malnutrition or overweight.

Apparent consumption, measured as calorie intake per person per day, increased in almost all LCN countries in the period 1961-2018. The only exception being Venezuela, where calorie intake went from 2,147 kcal/person/day in 1961 to 2,121 kcal/person/day in 2018 (Food and Agriculture Organization of the United Nations, 2017, 2021).

Along with the increase in calorie intake, one can see a change in the diet of the population (see Figure 3), which would follow the so-called Bennet's Law (Bennet, 1941). According to Bennet, carbohydrate intake would be reduced as income per capita grows, and protein-rich products such as meat would increase its consumption.

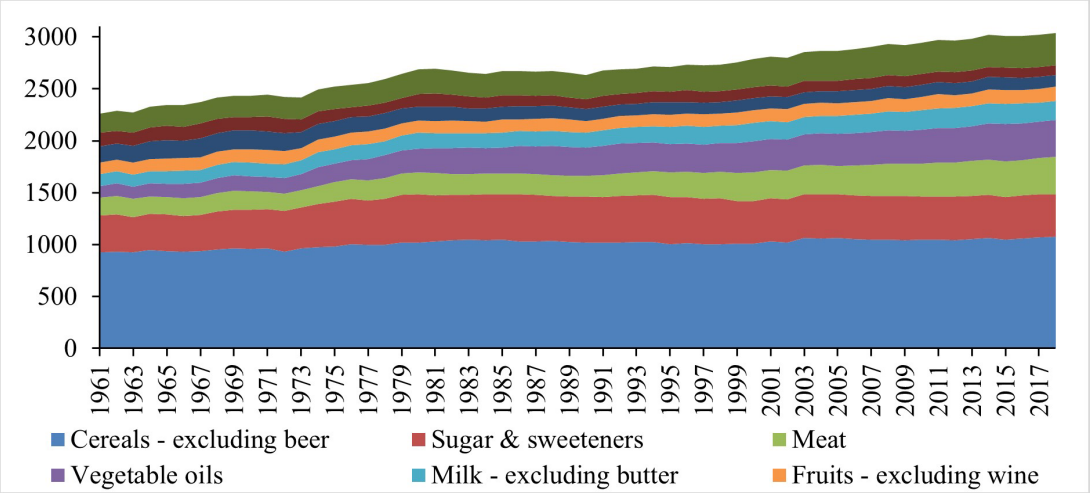

Figure 3: Origin of the energy (kcal) of apparent consumption, LCN (1961-2018). *Includes Sugar Crops, tree nuts, oil crops, vegetables, stimulants, spices, alcoholic beverages, and miscellaneous, offals, animal fats, eggs, fish seafood.Source: (Food and Agriculture Organization of the United Nations, 2017, 2021).

Meat calorie intake went up at a yearly growth rate of 1.3%, vegetal oils at 2.1%, milk (excluding butter) at 0.9%, fruits at 0.4%, while cereals (excluding beer) and starchy roots grew at 0.3% and -0.5% respectively, in the period analyzed.

4.3. Opportunities for complementarity

To look at the opportunities for complementarity between LCN countries, we need to see imports and exports from and to the rest of the world. This is what is presented in Table 2 with data for 2018. The bloc imported 74.3 million tons from the rest of the world. Only four product groups accounted for 86.9% (cereals excluding beer, with 65.5%; oil crops, 13.2%; sugar and sweeteners, 4.1%; and meat, 4.0%). On the other hand, the bloc exported 235.5 million tons of food to the rest of the world. Again, four product groups represent 84.5% (oil crops, 38.2%; cereals excluding beer, 22.3%; fruits, excluding wine, 12.8%; and sugar and sweeteners, 11.2%).

Table 3 shows the opportunities for complementarity between LCN countries. The cells in grey, show surplus exports for each member country and by product group, to third countries in 2018. The cells in white show the deficit. In that year, Antigua and Barbuda, Bahamas and Saint Kitts and Nevis showed a deficit in all product groups. While, Barbados, Saint Lucia, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago showed surplus only in one product group. Similarly, Cuba, El Salvador, and Guyana showed a surplus to two product groups. The countries with fewer product groups with the deficit are Argentina and Brazil.

Table 1. Food self-sufficiency in LCN by product groups, 1986-2018

Item groups products	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Cereals - excluding beer	87	87	93	89	87	86	87	87	84	86	90	86	83	80	80	80	79	80	81	81	81	79	83	83	84	84	85	85	81	82	78	81	80
Starchy roots	100	100	100	100	100	100	100	99	100	100	100	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	98	98	98	98	98
Sugar crops	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Sugar & sweeteners	99	99	99	97	94	96	98	98	97	98	100	97	98	98	97	97	98	98	98	97	96	94	95	95	93	92	92	93	93	92	91	91	91
Pulses	94	96	97	96	91	96	96	97	94	95	96	93	90	89	91	88	91	91	90	89	92	89	91	91	91	91	88	89	89	92	88	88	89
Treenuts	91	94	97	93	93	90	90	85	81	87	95	88	87	81	81	83	83	83	80	84	80	82	80	84	83	80	72	76	80	78	79	83	82
Oilcrops	95	92	98	95	96	94	93	92	91	93	98	88	91	91	91	91	91	93	94	93	93	94	94	94	94	95	94	95	95	95	95	95	93
Vegetable oils	87	90	96	90	90	91	91	89	89	88	96	88	87	89	88	89	89	89	90	90	91	91	90	90	90	90	91	91	91	90	91	92	91
Vegetables	100	100	100	100	99	99	99	99	99	99	99	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	97	98	98	98
Fruits - excluding wine	100	100	100	100	100	100	100	99	99	99	100	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
Stimulants	99	100	100	98	97	97	97	97	96	96	98	95	95	93	93	94	93	93	93	91	91	89	91	90	91	90	90	91	86	87	88	83	89
Spices	81	83	89	91	86	83	84	82	76	81	83	77	65	80	79	76	75	79	76	80	84	83	78	79	82	82	81	83	70	69	65	64	62
Alcoholic beverages	99	100	100	98	97	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	98	97	97	97	97
Miscellaneous	28	17	82	82	74	68	53	18	31	50	48	22	9	-51	-42	-2	20	1	-173	-85	-89	-227	-11	27	-19	-4	-59	-97	92	93	91	94	94
Meat	97	98	100	99	99	98	98	98	98	98	100	98	97	97	96	96	96	96	96	96	96	95	96	96	96	96	96	95	95	95	94	94	94
Offals	97	96	99	93	87	92	91	91	91	93	99	92	91	91	90	90	90	91	91	91	91	90	90	89	89	89	89	90	91	91	92	91	91
Animal fats	80	79	92	87	85	79	81	79	81	81	92	81	77	78	82	80	78	79	78	79	80	79	80	79	80	83	83	86	74	74	78	78	78
Milk - excluding butter	98	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
Eggs	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	100	100	100	100	100	100	100	100	99	99	99	99	99	99	99

Source: (Food and Agriculture Organization of the United Nations, 2017, 2020d, 2021)

On the other hand, the aggregate surplus exceeded 161.2 million tons. The region shows commercial surplus for all product groups but starchy roots, pulses, miscellaneous, animal fats, milk - excluding butter, and eggs, where the proportion of the exports to imports were, respectively, 20.9%, 78.8%, 66.5%, 29.8%, 35.0%, and 27.2%. Replacing imports from outside the bloc with current exports to outside the bloc would imply reducing exports amounting to 72.2 million tons in 2018. In other words, to satisfy the consumption level of the LCN countries due to the deficit of some products, the region will have to keep importing 2.8% of the food imported in 2018 from the rest of the world, which means that exports towards the rest of the world would decrease by 30.7%.

Table 2. Volume of imports and exports of LCN from and to the rest of the world, in thousands of tons, 2018

Item groups	Imports	Exports
Cereals - Excluding Beer	48,640.7	52,529.4
Starchy Roots	1,074.7	224.4
Sugar Crops	0.03	0.1
Sugar & Sweeteners	3,074.2	26,379.9
Pulses	828.7	653.1
Treenuts	101.8	252.8
Oilcrops	9,840.8	89,890.2
Vegetable Oils	1,982.6	7,557.4
Vegetables	1,030.4	9,848.1
Fruits - Excluding Wine	1,123.2	30,188.3
Stimulants	373.4	4,398.3
Spices	91.2	222.0
Alcoholic Beverages	1,213.3	4,971.6
Miscellaneous	29.1	19.4
Meat	2,995.4	7,355.4
Offals	292.8	469.6
Animal fats	523.7	155.9
Milk - Excluding Butter	995.2	348.7
Eggs	67.6	18.4

Source: (Food and Agriculture Organization of the United Nations, 2020d).

Supplementary material shows the opportunities for agricultural complementarity between LCN member countries in 2018, broken down by all the 296 products included in the 19 product groups presented in Table 3. In this annex, LCN showed a surplus for 161 out of 296 products. The five countries with the highest number of surplus products are Brazil (126), Mexico (106), Peru (89), Argentina (82), and Chile (80). Size matters and Brazil had a surplus of 137.6 million tons, followed by Argentina with 34.6 million tons, Guyana 14.8 million tons, Ecuador 5.9 million tons, and Costa Rica 4.0 million tons. Similarly, the five products with the highest regional surplus were soybeans, with 81.0 million tons, followed by sugar raw centrifugal, with 20.2 million tons, bananas 14.6 million tons, maize 12.5 million tons, and wheat 8.4 million tons.

A policy of regional complementarity among the LCN countries would result in a modest monetary surplus. For example, in 2018, net exports in constant 2015 dollars reached 106.6 billion dollars, while this balance would be 99.5 billion dollars with the integration proposal. However, by replacing imports from the rest of the world with products that would otherwise be exported to the rest of the world, food imports would cost the region 8.1 billion dollars more (constant 2015 US $).

These results show that, despite the proximity between countries in the region, given the historical trade prices, it is cheaper to import from the rest of the world than to import from

the same region. This is the result of the challenges the region experiences mentioned above: low labor productivity, low yields, and lack of proper policies, such as subsidies found in the US, Canada, or the EU. As an example, in the case of Mexico, 12 out of 19 product groups have lower international prices than those offered, as average, by the region. Meanwhile, the inflow of currency for exporting countries would increase by 1.0 billion dollars. This is in response to the fact that exports to the rest of the world have a higher price than exports to LCN member countries.

On the other hand, under the hypothesis that the region could prioritize complementarity for products that are cheaper to acquire within the region than from the rest of the world, the savings would be approximately 2.7 billion dollars, that is, 6.8% of the total of imports from the rest of the world. Meanwhile, the monetary value of exports would decrease by approximately 1.3 billion. Using the Kruskall Wallis test we can also see that the average food balances with and without complementarity between 1986 and 2018 are statistically equal.

The apparent low economic benefits that a policy of complementarity would imply are offset by the decrease in environmental impacts that are favored by the reduction in food transport between regions and the outflows of foreign currency. Likewise, as pointed out by Krapohl (2019), regional integration would produce effects of size and stability that would help attract investment flows from the rest of the world. It would even be a policy that fosters higher levels of competitiveness for the region in the global market.

5. Policy implications

The results presented above indicate that, despite the challenges LCN countries face, there exists a potential gain from food production and trade complementarity between them. The countries, as a bloc, produce enough food to feed their population and be net exporters to the rest of the world.

To exploit the advantages provided by available arable land and soil, and climatic conditions without compromising their natural resources base, LCN countries need to confront some of the challenges mentioned. This is of special relevance as the region shows a pattern of de-industrialization in recent years (Cango et al., 2018).

They need to increase yields, which are much lower than those of third-country partners. They also need to implement sound agricultural policies that strengthen the sector. This can be achieved with the implementation of national-scale technical assistance programs, which are too project-based these days. Given the lack of financial strength that prevents countries to implement subsidies policies like in the USA or the EU, governments could work also on price guarantees to producers, at least for staples. But a better alternative would be to involve public procurement systems that exist in most of the countries for other kinds of goods. Many of the countries have implemented school food plans, where children are given breakfast and sometimes also lunch at the school. This is a good opportunity for establishing price guarantees to producers, instead of relying on big corporations. The extra income could be used by peasants to improve their technology and inputs, raising yields.

These interventions would have a larger impact if coordinated between LCN countries. Most of the countries face the same challenges, including lack of access to cheap credit, another reason to ask for the integration of policies. This integration could not only include productivity-oriented measures but could address the whole production cycle: from the technification of production and post-harvest processing to infrastructure and logistics and the coordination of trade policies. These measures would help climbing the value-added ladder, bringing more currency to the region.

Table 3. Trade complementarity within LCN by product groups (thousands of tons) and country, 2018

Products groups	Antigua and Barbuda	Argentina	Bahamas	Barbados	Belize	Bolivia	Brazil	Chile	Colombia	Costa Rica	Cuba	Dominica	Ecuador	El Salvador	Grenada	Guatemala	Guyana	Honduras	Jamaica	Mexico	Nicaragua	Panama	Paraguay	Peru	Saint Kitts and Nevis	Saint Lucia	Saint Vincent and the Grenadines	Suriname	Trinidad and Tobago	Uruguay	Venezuela	Rest of the world
Cereals - Excluding Beer	3.3	26,119	30.8	53.7	30.1	29.7	22,951	854	7,261	1,264	881	1.5	984	1,004	19.1	1,882	41.1	1,173	492	22,907	399	714	487	4,960	2.2	11.1	29.4	20.9	262	427	845	3,889
Starchy Roots	2.0	9.5	8.8	13.2	5.3	1.3	184	115	49.8	102	17.2	1.0	7.7	11.9	1.7	28.3	11.9	13.3	21.3	302	4.8	26.9	1.6	27.8	0.99	3.0	0.59	11.0	47.4	22.1	0.50	850
Sugar Crops							0.001			0.02										0.07						0.03						0.05
Sugar & Sweeteners	5.1	118	16.7	12.2	178	6.8	20,560	72.7	380	188	1.1	0.58	7.1	661	0.14	422	86.7	217	29.1	676	589	37.0	77.3	14.4	0.12	0.09	0.59	8.2	4.7	3.4	1.9	23,306
Pulses	0.41	338	0.04	0.67	1.0	0.51	85.9	29.5	115	15.2	93.0	0.10	26.4	3.3	0.12	7.2	3.0	1.5	5.3	181	11.7	17.4	0.09	86.1	0.08	0.51	0.27	1.8	9.0	3.6	14.6	176
Treenuts	0.18	2.8	0.20	0.65	0.18	23.9	1.1	94.1	2.9	2.4	0.06	0.004	0.12	0.46	0.01	3.3	0.74	0.73	0.02	32.6	0.29	1.7	0.01	5.7	0.02	0.05	0.06	0.05	1.6	0.09	0.03	151
Oilcrops	0.20	2,437	0.56	29.0	0.33	10.1	82,638	20.1	662	314	109	0.01	2.8	1.3	0.01	13.5	0.07	0.12	1.4	6,576	50.6	42.3	1,737	262	0.05	0.06	1.7	1.8	2.7	1,322	129	80,049
Vegetable Oils	0.71	3,738	5.2	3.7	8.9	0.59	1,099	119	364	68.5	86.6	2.5	45.8	22.1	0.90	367	5.2	461	42.7	453	10.3	15.8	607	92.5	0.39	1.2	0.86	7.0	27.2	23.0	131	5,575
Vegetables	4.9	11.0	11.7	9.3	3.0	1.2	57.4	17.8	54.6	162	12.7	0.50	80.1	2.4	0.9	639	11.2	376	18.2	7,231	3.9	30.1	7.2	498	0.72	2.8	1.7	10.5	26.2	17.7	1.4	8,818
Fruits - Excluding Wine	3.4	803	18.0	10.2	111	1.1	2,920	2,740	1,918	5,206	6.5	3.7	6,483	12.2	0.13	2,711	0.25	667	1.9	3,572	128	266	2.1	1,485	0.99	9.1	0.53	39.1	11.8	65.6	5.0	29,065
Stimulants	0.41	89.0	1.1	1.5	1.0	1.4	1,709	35.0	735	70.7	0.89	0.02	282	32.9	0.89	208	1.0	344	0.79	184	135	3.4	0.20	286	0.05	0.09	0.08	0.79	2.5	4.2	0.38	4,025
Spices	0.25	2.4	0.35	0.41	0.18	0.85	67.1	3.0	2.1	1.8	1.2	0.05	1.3	0.62	0.79	28.3	0.56	0.99	0.43	2.2	0.15	0.58	0.94	35.2	0.06	0.06	0.05	0.58	1.7	0.32	0.09	131
Alcoholic Beverages	2.8	196	7.9	9.8	2.8	0.81	106	561	58.6	23.4	15.7	0.20	11.1	0.82	0.43	8.9	16.9	26.5	29.9	3,433	4.0	175	47.3	8.5	0.26	1.7	0.27	7.2	8.3	5.9	1.4	3,758
Miscellaneous	0.01	0.15	0.18	0.14	0.12	0.28	1.7	3.8	3.7	0.26	0.31	0.002	1.0	0.41	0.01	0.83	0.24	0.14	0.47	0.39	1.1	0.88	0.09	3.3	0.001	0.01	0.01	1.4	0.44	0.06	0.02	9.8
Meat	7.6	517	26.2	6.2	7.1	0.001	5,578	132	151	10.1	212	3.2	0.76	20.8	4.0	150	0.66	45.5	38.3	1,577	46.4	43.7	182	33.8	3.2	11.6	9.7	20.5	33.6	327	5.7	4,360
Offals	0.30	95.5	0.69	0.39	0.02	0.17	209	29.9	5.2	1.8	4.8	0.11	0.37	1.0	0.07	2.2	0.04	2.2	6.6	229	5.0	2.9	27.7	6.8	0.07	0.60	0.15	0.05	2.6	73.1	0.30	177
Animal fats	1.0	24.8	1.0	0.59	5.9	0.54	6.1	1.5	8.8	5.8	4.5	0.07	0.55	1.6	0.15	19.7	0.89	10.3	5.3	364	1.2	3.4	4.2	2.8	0.07	0.31	0.09	1.0	4.5	54.0	0.14	368
Milk - Excluding Butter	3.5	122	7.6	6.3	6.0	1.2	5.2	37.8	27.5	7.6	20.0	0.64	0.54	13.5	2.4	20.6	8.8	15.5	11.9	608	0.65	23.3	0.37	33.6	0.80	2.6	2.2	4.4	26.1	130	2.9	647
Eggs	0.06	0.17	2.1	1.2	0.12		17.7	0.49	0.08	1.3	0.001	0.02	0.04	0.33		0.07	3.1	0.31	5.6	46.9	0.48	0.26		0.04	0.03	0.10	0.03	0.29	4.2	0.01	0.01	49.2
Total surplus or deficit	36.2	34,582	139	139	219	49.6	137,593	2,291	5,761	4,018	1,463	5.5	5,852	403	28.3	2,272	14.8	780	591	18,114	570	798	3,064	3,223	10.1	27.0	48.2	58.3	460	2,330	1,127	161,204

Source: (Food and Agriculture Organization of the United Nations, 2020d).*Grey cells correspond to countries and product groups with a surplus. While white cells correspond to countries and product groups with a deficit that needs complementary intra-regionCurrent production and trade patterns are changing the nutritional status of the inhabitants of the region. We have seen there is an increase in calorie intake, which is a good outcome in itself, although there is also a change in the composition of those calories, with carbohydrates and vegetal proteins reducing and meat and vegetable oils increasing, worsening the quality of the diet. Monitoring changes in nutrition needs public policies oriented to establishing national institutes of nutrition that can issue food guides. This is of special relevance in a region with a young and growing population that anticipates the need for more (and better) production to feed it in the future.

Coordination, integration, and joint policies are needed to overcome challenges that are too difficult or too expensive when tackled individually, it is a question of economies of scale, as the EU exemplifies. Common policies, although slower in their implementation, tend to result in more stable economies, as a large fraction of trade would be intra-regional trade. This is of particular importance for a region of currency-hungry countries which tend to overexploit their natural resources to obtain the hard currency they need for their imports.

We know that the savings presented in this research are modest, but would imply a step forward towards economic integration, which could lead, as it did in the EU, to future common policies in other related areas such as product certification and quality standards, supra-national logistic and transport projects and hopefully some kind of integration also of commercialization and trade policies.

Finally, as shown in the article, to re-direct trade to the region, we believe that the region should initially promote a policy of agricultural complementarity for products whose domestic prices are lower than those of the rest of the world. At the same time, agricultural complementarity agreements should be promoted between the countries, with synchronization of regional macroeconomic and agricultural policy, and strong support from governments to local producers to strengthen value chains.

6. Conclusions

This research has contributed to the debate on food self-sufficiency in LCN countries and has shown there is room to advance food and agricultural complementarity. Regional self-sufficiency and complementarity are fundamental elements to guarantee that the inhabitants of the region have their caloric needs covered.

The region is self-sufficient, as a bloc, in 17 out of 19 product groups. Trade diversion would reduce the region's vulnerability to exogenous factors such as price volatility, natural hazards, and external trade policies from the rest of the world. In turn, this move would strengthen the agri-food sector in the region, allowing for more robust internal markets and integration, and highlighting the need for common trade policies.

It is true, though, that the challenges of low yields and labor productivity persist, with developed regions such as North America or Europe & Central Asia offering lower prices for certain products (in part thanks to their policy of subsidies). This is why regional integration should go beyond trade diversion, aiming at common policies from production to commercialization.

Despite all the challenges ahead, complementarity would still save 6.8% of total imports from the rest of the world, meaning that 2.7 billion a year would remain in the region, inducing extra economic activity, and therefore profits, wages, and taxes.

Other positive outcomes can come from this policy, such as the reduction in currency outflows, transport needs, and therefore energy use and CO_2 emissions; the strengthening of value chains in the region; an increase in job opportunities; an impulse to rural development; and a reduction in poverty among others.

This is why, in our view, the region can only benefit from harmonizing policies that would allow for exploiting this complementarity between countries for the benefit of the whole region. We are aware, though, that this requires solid integration agreements between nations, which harmonize macroeconomic policies in countries with limited autonomy, countries with restricted access to food and countries with limited agricultural production, generated mainly by the high levels of social inequality in the region. We hope the debate opens up with more research and discussion soon.

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Supplementary Material

Supplementary material accompanies this paper.

Table 5.1. Trade complementarity within Celac by product (thousands of tons) and country, 2018.

This material is available as part of the online article from https://www.scielo.br/j/resr

Comentarios finales

El debate engendrado a lo largo de esta tesis demuestra que los problemas de desarrollo de las economías latinoamericanas no han mejorado con el pasar de los años. Por el contrario, los países latinoamericanos y caribeños, además del intercambio desigual e intercambio ecológicamente desigual ampliamente debatidos en la literatura, se enfrentan a un nuevo intercambio desigual denominado 'intercambio calóricamente desigual', que define el deterioro de los términos de intercambio de alimentos tanto en calorías como en unidades físicas. De este estudio, se observa que ALC contribuye cada vez más a alimentar al mundo, a un costo calórico que ha disminuido en un 200% entre 1986 y 2013. No obstante, contrario a este resultado, una nueva investigación desarrollado por Cango, Falconí, y Ramos-Martín (2025)[1] muestran que la relación de intercambio de China y el mundo, entre 1986 y 2022 mejoró en un 52%. Aunque este resultado simplifica el desarrollo de la economía China, su ampliación y conjetura con la realidad de ALC es motivo de una nueva investigación, sin embargo, de manera simplificada recalca la importancia que los países latinoamericanos tienen con respecto a la adopción de políticas orientadas hacia sector industrial.

De este modo, junto con otros problemas, el deterioro de los términos de intercambio, profundizan las brechas económicas y de conocimiento entre las regiones ricas del mundo y ALC. Es decir, la forma de inserción internacional de Latinoamérica y el Caribe —exportadora de materias primas— genera un círculo virtuoso en materia de desarrollo. Ante ello, en la actualidad, el estructuralismo latinoamericano reivindica su importancia, especialmente por ser el instrumento teórico de impacto significativo en la comprensión y abordaje de los problemas económicos y sociales de la región. El cimiento relacional centro-periferia muestra que el país central influye sobre los países periféricos, incluso, muchas de las decisiones norte - sur son condicionados y ajustados de acuerdo con los intereses del centro, principalmente de instituciones financieras internacionales como el Fondo Monetario Internacional (FMI) o el Banco Mundial que generan mayores condiciones a cambio de financiamiento, que en sí mismo es una muestra de dependencia económica.

Sin embargo, aunque la propuesta de "industrializar las economías" planteado por Prebisch fracasó en Latinoamérica, esta teoría junto con el planteamiento de desarrollo dependiente asociado de Cardoso ha mostrado resultados positivos fuera de la región. Prueba de ello están los países asiáticos —Corea del Sur, Taiwán, Hong-Kong y Singapur—, que, en su etapa inicial de desarrollo, el Estado ha jugado un papel agresivo en la industrialización, sin dejar de mencionar que muchas de sus políticas han sido temporales, en especial, porque luego de su industrialización

[1] Cango, Pedro, Fander Falconí, y Jesús Ramos-Martín. 2025. «Unequal Exchange and Food Terms of Trade for China». *Journal of Environmental & Earth Sciences* 7(3):99-111. doi: 10.30564/jees.v7i3.7951.

también han incorporado políticas neoliberales como el aperturismo, desregulación del sistema financiera o reformas laborales.

Al respecto, un reciente estudio desarrollado por Cherif y Hasanov (2024) estiman que entre 1980 y 2010, cuando se abandonó la industria por sustitución de importaciones en los países en desarrollo, el promedio de crecimiento de la industria decreció, mientras que el valor agregado manufacturero de los tigres asiáticos siguió creciendo a tasas relativamente altas. Ante esta evidencia, la crítica del modelo estructuralista a la visión ortodoxa de desarrollo es coherente, no por su objetivo sino por su medio que insta en el libre comercio y la especialización productiva como mecanismos eficientes de desarrollo. A la inversa, como se mencionó anteriormente, el estructuralismo defiende la importancia del Estado como ente conciliador del desarrollo, a través de políticas públicas encaminados a la inversión, fortalecimiento institucional, protección y asistencia social.

Otro aspecto, no menos importante en materia de desarrollo, son las diferencias en el nivel de aprovechamiento del progreso técnico en el norte rico y el sur pobre. En realidad, por la dependencia de exportaciones de materias primas, se observa que ALC sufre un estancamiento en su desarrollo. Según datos del Banco Mundial (2020) en 1960, el PIB (dólares constantes de 2010) de la región representaba el 7,1% de la economía global, mientras que su participación en 2019 fue solo del 7,3%. No obstante, en términos de brecha económica (PIB per cápita en términos constantes) entre Norte América y ALC aumentó en los últimos 57 años de 4,8 a 5,8 veces (Banco Mundial, 2020). Asociado a esta realidad, la tesis ha permitido evidenciar que las brechas económicas y de conocimiento de ALC con las regiones ricas del mundo, divergen del planteamiento teórico neoclásico que establece que los países pobres y ricos convergen.

En efecto, tanto el deterioro de los términos de intercambio como la divergencia económica muestran que la forma de participación en la división internacional del trabajo, así como la ausencia de una política interna centrada en la diversificación productiva y productividad mantienen a la región en el subdesarrollo. Es más, la ausencia de convergencia en la dinámica del conocimiento está ralentizando aún más el desarrollo latinoamericano y caribeño debido a la ausencia de progreso técnico e innovación de la producción.

En línea con los problemas señalados, el conocimiento resulta ser clave para fortalecer las ventajas competitivas de la región. Se requiere de soluciones creativas e inversiones sostenidas para dinamizar la generación de conocimiento e innovación en los países del Sur. Entre otros aspectos, la productividad, la inversión en educación e investigación y desarrollo (I+D) y la generación de conocimiento son cruciales para romper las trampas del subdesarrollo. Bajo este antecedente, además de los problemas estructurales analizados: deterioro de los términos de intercambio, brechas económicas, brechas de conocimiento y pérdida de autosuficiencia alimentaria, la tesis plantea que la región requiere de nuevas formas de inserción

internacional y relacionamiento con otros países. Por ello, se sostiene que en el plano regional existe oportunidades de desarrollo a partir de la complementariedad agrícola, entendida como un acuerdo de integración comercial entre los países de ALC. Incluso, se determina que solo al reemplazar el comercio donde los países latinoamericanos tienen ventaja en términos de precios, la región ahorraría el 6,8% del total de importaciones. Además, a la región le permitiría mantener sus divisas, generar sus propias normas y regulación de las exportaciones, incluso reducir costos de transporte que por sí misma beneficiaría incluso en términos ambientales. Es decir, pese a que el ahorro no es tan elevado, esta opción de desarrollo contribuiría a fortalecer las cadenas de valor en la región, crear nuevas oportunidades laborales, mejorar la productividad, reducir la salida de divisas y los costos de transporte. Aparte de ello, resulta ser una oportunidad para garantizar demanda de productos de los países miembros, atracción de la inversión extranjera e industrialización.

Finalmente, aunque los resultados sobre la complementariedad agrícola son motivadores es fundamental que desde la academia se siga profundizando este debate y rellenando ciertos vacíos que aún hace falta profundizarlas, en especial, los relacionados con la complementariedad agrícola visto de la política macroeconómica.