The Interplay of Services Productivity and the Competitiveness of Colombian Exports

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Abstract

We use the computable general equilibrium model for Colombia (CEER model) to analyze the impact of the productivity increase of KIBS on the competitiveness of Colombian exports. Our simulations show that productivity shocks in the KIBS sectors can propagate through interregional and inter-industry linkages and generate a potential competitiveness gain for Colombian exports. However, the KIBS' low vertical integration with tradable sectors in the Colombian economy weakens the propagation of KIBS productivity shocks in the supply chain. Our results show that KIBS productivity shocks propagate through the input-output trade relationships and are a channel for technical changes in the economic system. The ability of an industry to become more competitive does not only depend on productivity gains in the industry itself but also on shocks that affect its supply chain.

Keywords: CGE model, KIBS, Export competitiveness

Resumo

O estudo analisa o impacto do aumento da produtividade dos KIBS na competitividade das exportações colombianas a partir do modelo de equilíbrio geral computável para a Colômbia (modelo CEER). Nossas simulações mostram que choques de produtividade nos setores KIBS podem se propagar por meio de ligações inter-regionais e interindustriais e gerar um potencial ganho de competitividade para as exportações colombianas. No entanto, a baixa integração vertical dos KIBS com os setores industriais na economia colombiana enfraquece a propagação dos choques de produtividade ao longo da cadeia de suprimentos. Nossos resultados mostram que os choques de produtividade dos KIBS se propagam através das relações comerciais insumo-produto e são um canal para mudanças técnicas no sistema econômico. A capacidade de uma indústria se tornar mais competitiva não depende apenas de ganhos de produtividade na própria indústria, mas também de choques que afetam sua cadeia de suprimentos.

Palavras-chave: Modelo CGE, KIBS, Competitividade das exportações

Classificação JEL: C68, R12

Área de submissão: 6 – Globalização e competitividade regional

1. Introduction

Services are increasingly important worldwide, as their share in global GDP reached 65.0% in 2018, and in Colombia, 57.8%. Services also present a large and increasing share of value added in global and regional value chains, with an overall contribution to the value of manufacturing exports. Therefore, a substantial service value is incorporated into the exports of goods (Haddad and Araujo, 2021).

In this paper, we will focus on service value added in exports from Colombia, a country that shows a historical dependence on natural resource-intensive exports. We situate our analysis in the collapse's context of the boom or 'super-cycle' of commodity prices that has generated significant macroeconomic challenges in recent years in the country. Moreover, we add to the discussion the internal, within-country geography of trade in value added since the locational preferences that help understand the spatial patterns of natural resource-intensive activities differ dramatically from that for services.

We use interregional input-output analysis to measure the services value added embodied in Colombian exports. Our main results show that, when one considers local value chains (within-country) of exports, especially in natural resource-rich commodities, servicification has potential asymmetric locational impacts, benefiting larger urban agglomerations in the more developed regions and reinforcing regional inequality. Servicification refers to the utilization of services in manufacturing production. Services are traded directly and indirectly embodied in the sales of goods (Chun et al., 2021; Pattnayak and Chadha, 2022). While the geography of natural resources may act as a driver to reduce regional inequality, inter-regional and intersectoral linkages are likely to act in the opposite direction. Thus, analyzing (local) services bundled in export goods points to regional inequality in natural resource-rich Latin American countries, such as Colombia.

In summary, the internal geography of services value added in exports *vis-à-vis* the location patterns of natural resources in Colombia may add another source of tension to current trade negotiations in the region. To the extent that there will be mismatches between the sequencing, cadence, and intensity of policies promoting a greater insertion of Colombia and other Latin American countries into regional and global value chains may lead to a novel form of the geography of discontents in the region (Haddad and Araujo, 2021). To increase and sustain its competitiveness in global value chains, Colombia requires policies, capabilities, and infrastructure to promote intermediate services.

The paper adds another layer of analytical material by simulating TFP changes in Knowledge-Intensive Business Services (KIBS). Overall, the competitiveness of firms in open economies is increasingly determined by access to high-quality and low-cost services. In an analysis of the Mexican economy, Haddad et al. (2022) show that changes in services productivity have potential effects on increasing the export competitiveness of goods. Thus, we use the computable general equilibrium model for Colombia (CEER model) to assess the effects of changes in KIBS productivity on the competitiveness of Colombian exports.

Evidence shows that increases in export competitiveness can also be achieved from service productivity shocks (Hoekman and Shepherd, 2015; Kordalska and Olczyk, 2021). Previous studies also show a relationship between KIBS and the manufacturing industry, such as Ciriaci et

al. (2015), Antonioli et al. (2020), Di Berardino and Onesti (2020), Kong et al. (2021), and Herrero and Rial (2022). Productivity shocks in services can propagate throughout the economy due to the inter-industry and interregional interdependence of production chains, which can be identified through input-output linkages, as demonstrated by Hanel (2000), Keller (2002), Hauknes and Knell (2009), Foster et al. (2012), and Gonçalves et al. (2017).

Our results from the CEER model show that the effects of the TFP-growth of KIBS on exports are more relevant for the mining industry, medium-high technology manufacturing industries, and business sectors in Colombia. Factor income effects are more substantial in the long run, generating stronger impacts on domestic absorption *vis-à-vis* foreign exports. In contrast, the effects of the exports are less relevant due to the relatively small share of KIBS sales for exports (direct effect) and to export sectors with relatively inelastic export demand (indirect effect).

The paper is organized into four sections in addition to this introduction. Section two shows the contribution of services, and specifically KIBS, to Colombian exports. Section three describes the simulation of TFP changes in KIBS using the CEER model. This section also describes the main shock transmission mechanisms. Section four presents the CEER model outcomes. Finally, the last section concludes the paper.

2. Do Service Sectors Matter to Exports?

Services have small participation in gross exports in Colombia. However, according to Haddad and Araújo (2021), "there is substantial value-added of services incorporated in goods exports". We replicated Haddad and Araújo (2021) to measure the importance of KIBS value-added embodied in Colombian exports. We used the Interregional Input-Output Matrix for Colombia (IIOM-COL) for 2015, and the same method applied by Haddad and Araújo (2021) to measure the value added embodied in exports. Table 1 shows the share of the sectors in gross exports and the value added in exports. Services correspond to 13% of gross exports, and 32% of the value added incorporated into exports – about a third of this value (11%) comes from KIBS.[1] This result shows the importance of KIBS in the domestic (within-country) supply chain of Colombian exports.

Table 1. Participation of the sectors in gross exports and the value-added in exports

Sectors	Gross Exports (COP billions)	Share in Gross Exports	Value-added in Exports (COP billions)	Share in Value-added in Exports
Non-Services	103,683	87.0%	66,218	67.8%
Services	15,314	13.0%	31,429	32.2%
KIBS	*3,753*	*3.0%*	*10,803*	*11.1%*
Other services	*11,561*	*10.0%*	*20,626*	*21.1%*
Total	118,997	100.0%	97,647	100.0%

Source: Authors' own from the Interregional Input-Output Matrix for Colombia (IIOM-COL), 2015.

[1] Knowledge-Intensive Business Services (KIBS) are identified in the sectoral classification of the Interregional Input-Output Matrix and the CEER model by the services: Information and communications (sector 46), Financial insurance activities (sector 47), and Professional, scientific and technical activities (sector 49). Haddad and Araújo (2022) present the complete sectoral classification.

Although KIBS accounts for only 3% of Colombia's gross exports, 11% of the value added in exports comes from the KIBS sectors. An important portion of this value, 6.8%, is incorporated in exports of goods, compared to 1.1% in exports of services (except KIBS) and 3.1% in exports of KIBS (Table 2). The integration between manufacturing and business services can improve the strategies for the countries to achieve a more upstream position in the global chain value. Kordalska and Olczyk (2021) found that the Baltic countries and the Czech Republic improved their positions and participation in global value chains through the vertical integration of KIBS into manufacturing sectors.

Table 2. Trade in value added: Colombia, 2015

Value added embodied in exports	COP billions	%
Exports of goods		
VA in goods	64,937	66.5%
VA in service sectors (except KIBS)	12,943	13.3%
VA in KIBS	6,669	6.8%
Total VA	**84,550**	**86.6%**
Exports of services (except KIBS)		
VA in goods	1,211	1.2%
VA in service sectors (except KIBS)	7,400	7.6%
VA in KIBS	1,069	1.1%
Total VA	**9,680**	**9.9%**
Exports of KIBS		
VA in goods	69	0.1%
VA in service sectors (except KIBS)	288	0.3%
VA in KIBS	3,060	3.1%
Total VA	**3,417**	**3.5%**
Total exports		
VA in goods	66,218	67.8%
VA in service sectors (except KIBS)	20,631	21.1%
VA in KIBS	10,798	11.1%
Total VA	**97,647**	**100.0%**

Source: Authors' own from the Interregional Input-Output Matrix for Colombia (IIOM-COL), 2015.

Table 3 presents the share of the value added embodied in Colombian exports distributed by nine groups of sectors. The content of value added from KIBS corresponds to 7.9% of exports of goods, 11.1% of exports of services (except KIBS), and 89.5% of exports of KIBS.

Bogotá D.C. (25%), Antioquia (14%), and Valle del Cauca (10%) concentrate a half of Colombian GDP (DANE, 2021). The service sectors follow the pattern of spatial concentration of income. GDP from service sectors is distributed among these three departments at 28%, 14%, and 10%, respectively. GDP from the KIBS sectors in these three departments is even more concentrated – 40%, 17%, and 11%, respectively. KIBS sectors tend to be highly spatially concentrated in core metropolitan regions (Strambach, 2001). The geographical proximity of research and innovation centers where human capital is more abundant, particularly in large and capital cities, explains this pattern (Cuadrado-Roura, 2013).

Gross exports are also spatially concentrated in Colombia. However, the spatial pattern of exports reveals a dichotomous profile of specialization in Colombian regions. According to the IIOM-COL for 2015, Meta (17.4%), Antioquia (13.4%), and Casanare (10%) account for around 40% of exports of goods, mainly concentrated in natural resource-intensive commodities – while Bogotá (31.2%), Antioquia (12.6%) and Valle del Cauca (8.7%) account for 52.5% of service exports. These regions concentrate 37.1%, 16.5%, and 11.3%, respectively, of KIBS exports in Colombia.

Table 3. Sectoral distribution of services value added in total exports: Colombia, 2015

	Classification	Value-added embodied in exports (in COP billions)			Value added embodied in exports (in %)		
		Non-services	Services (except KIBS)	KIBS	Non-services	Services (except KIBS)	KIBS
1	Agriculture	10,530.7	371.5	5.5	12.5	3.8	0.2
2	Mining	36,012.5	155.8	9.3	42.6	1.6	0.3
3	Manufacturing	18,394.2	683.7	54.2	21.8	7.1	1.6
4	Business services	3,474.9	3,429.7	134.7	4.1	35.4	3.9
5	Construction services	260.2	74.9	11.8	0.3	0.8	0.3
6	Distribution services	2,709.7	735.2	49.8	3.2	7.6	1.5
7	Transport services	6,189.8	2,790.9	61.6	7.3	28.8	1.8
8	KIBS	6,669.4	1,073.3	3,059.9	7.9	11.1	89.5
9	Other services	308.3	364.8	30.3	0.4	3.8	0.9
	Total	**84,549.9**	**9,679.8**	**3,417.1**	**100.0**	**100.0**	**100.0**

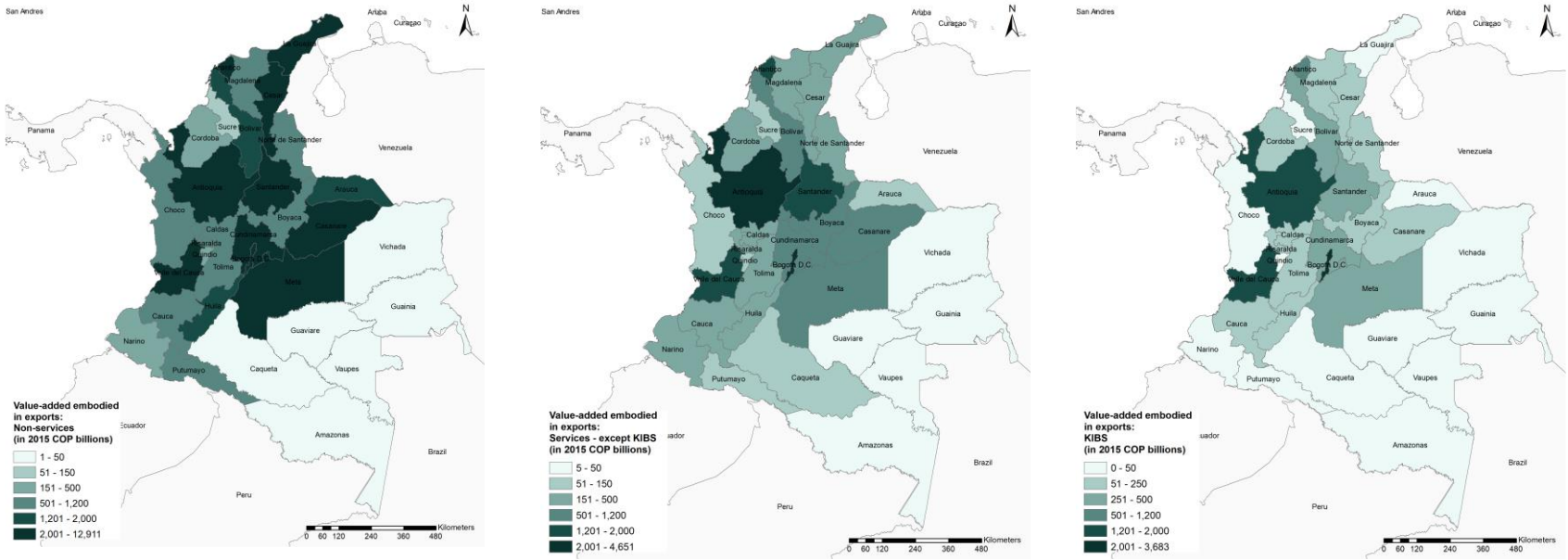
Source: Authors' own from the Interregional Input-Output Matrix for Colombia (IIOM-COL), 2015.

More sophisticated service exports tend to benefit the larger urban agglomerations in the more developed regions, reinforcing regional inequality (Haddad and Araujo, 2021). KIBS also tend to be located in larger urban centers, affecting their regional competitiveness (Ferreira et al., 2016). Figure 1 shows the spatial distribution of value-added embodied in Colombian exports. Meta (19.5%), Antioquia (12.2%), and Casanare (9.3%) concentrate 41.0% of the value-added incorporated in exports. Meanwhile, Bogotá D.C. (34.1%), Antioquia (18.1%), and Valle del Cauca (11.9%) concentrate 64.1% of the value-added incorporated in KIBS exports (see Table A1 in Appendix).

This section analyzed the characteristics of the domestic supply chains of Colombian exports using data from value added embedded in exports. We have seen that KIBS is important in this production chain. Roson and Sartori (2016) show that relatively small sectoral productivity shocks could propagate through the input-output trade relationships and lead to sizable macroeconomic variability. Therefore, given the importance of KIBS value added embodied in exports, the remainder of the paper explores the effects of changes in the productivity of KIBS on Colombian export competitiveness.

Figure 1. Spatial patterns of value added embodied in exports of goods, services, and KIBS: Colombia (in 2015 COP billions)

Goods *Services (except KIBS)* *KIBS*



Note: Table A.1, in the appendix, presents the regional values used to draw the maps.

Source: Authors' own from the Interregional Input-Output Matrix for Colombia (IIOM-COL), 2015.

3 Methodology

We use the computable general equilibrium model for Colombia – CEER model – (Haddad and Araújo, 2022) to analyze the impact of the productivity increase of KIBS on the competitiveness of Colombian exports.

In the CEER model, Equation 1 specifies firms' primary factors use. It is derived under the assumption that industries choose their primary factor inputs to minimize costs subject to obtaining sufficient primary factor inputs to satisfy their technological requirements (nested Leontief/CES specification). The CEER model includes technical change variables to allow for factor-specific productivity shocks.

$$x_{(g+1,s)}^{(1j)r} - a_{(g+1,s)}^{(1j)r} = \alpha_{(g+1,s)}^{(1j)r} x_{(g+1,\bullet)}^{(1j)r} - \sigma 3_{(g+1)}^{(1j)r} \left(p_{(g+1,s)}^{(1j)r} + a_{(g+1,s)}^{(1j)r} - \sum_{l \in F} \left(\frac{V(g+1,l,(1j),r)}{V(g+1,\bullet,(1j),r)} \right) \left(p_{(g+1,l)}^{(1j)r} + a_{(g+1,l)}^{(1j)r} \right) \right) \qquad j \in H;\ s \in F;\ r \in S^{*} \tag{1}$$

where $x_{(g+1,s)}^{(1j)r}$ is the demand by sector *j* in region *r* for each primary factor; $a_{(g+1,s)}^{(1j)r}$ is the exogenous sector-specific variable of (saving) technical change for primary factor *s* in region *r*; $p_{(g+1,s)}^{(1j)r}$ is the price paid by sector *j* in region *r* for primary factor *s*; $\sigma 3_{(g+1)}^{(1j)r}$ is a parameter measuring the sector-specific elasticity of substitution among different primary factors; and $V(g+1, l, (1j), r)$ is an input-output flow coefficient that measures purchasers' value of factor l used by sector *j* in region *r*.

We simulate a change in the productivity of the primary factor ($a_{(g+1,s)}^{(1j)r}$) equivalent to a 1% productivity gain in all regions (*r*) and factors (*s*) for the KIBS (*j*=46, 47, and 49). The transmission mechanisms between the productivity gain and the competitiveness of exports occur through variations in relative prices by the cost change and technical change (Figure 2).

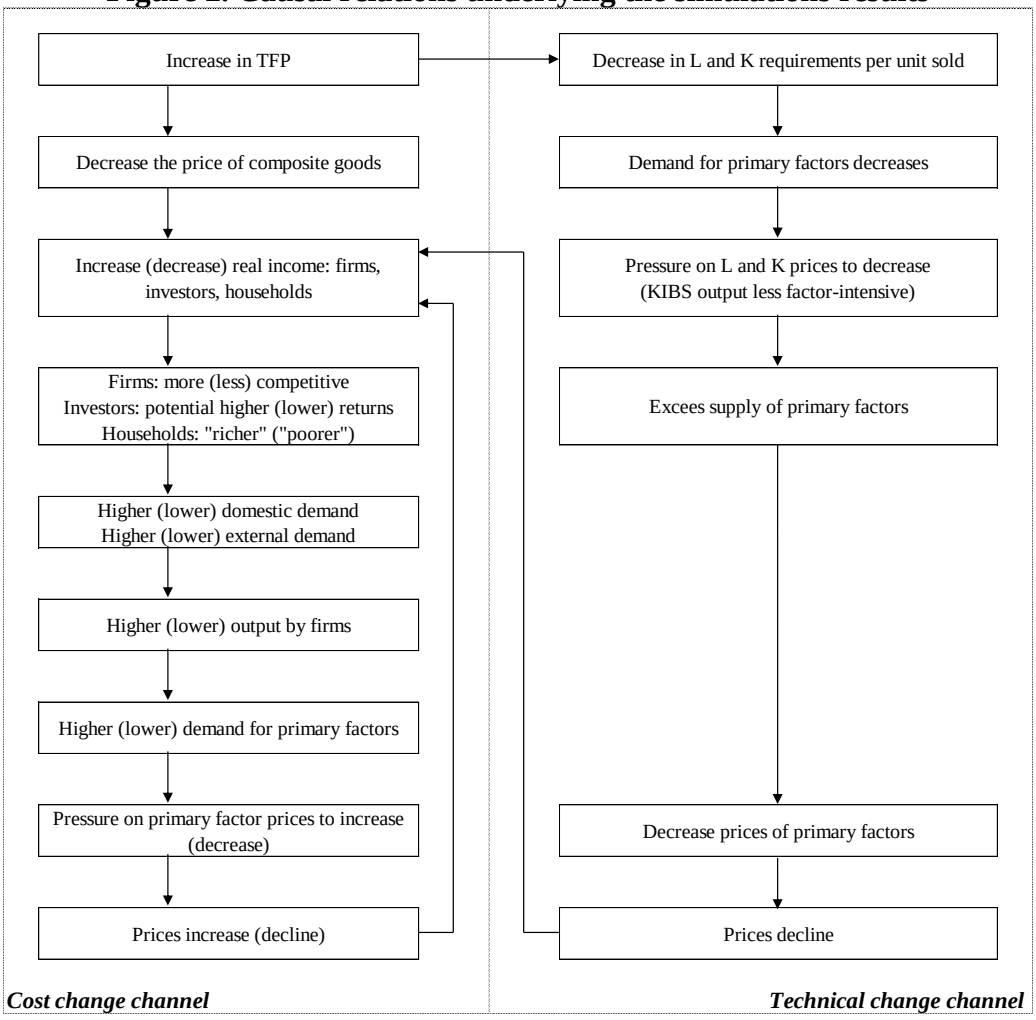
In the cost change channel, the productivity increase of the primary factors used in the KIBS reduces prices in the economy. As a result, there is an increase (decrease) in the real income of firms, investors, and families. It makes the firms more (less) competitive, provides potentially higher (lower) returns on investments, and makes households richer (poorer). This would increase (decrease) domestic and foreign demand for Colombian products, which would increase (decrease) the production of the companies. Therefore, there would be an increase (decrease) in the demand for primary factors, raising (reducing) prices.

Through the technical change channel, the TPF-growth of the KIBS leads to a reduction in the labor and capital requirements for each unit produced, reducing demand for these primary factors of production, which leads to a reduction in their prices.

If the effect of the price reduction observed in the technical change channel overcomes the effect of the price change in the cost change channel, there will be an overall price reduction in the economy. Competitiveness gains in exports occur through a reduction in the price of exports.

We use the long run closure of the CEER model, which allows us to simulate KIBS productivity gains. In the long run, the technological level is exogenous, and the factors might move across sectors and regions. The model assumes that productivity gains influence the economy over a more extended adjustment period. The rate-of-return differentials across sectors, regions, and productivity differentials, in the long run, stimulate the movement of capital in the CEER model.

Figure 2. Causal relations underlying the simulations results



Source: Authors' own.

4. Results

This section presents the CEER model outcome for simulating the productivity increase of the KIBS sectors. Table 4 shows the macroeconomic results and their breakdown (subtotal) for the KIBS sectors (Information and communication; Financial insurance activities; Professional, scientific and technical activities).

Productivity shocks in KIBS propagate across the entire Colombian economy due to inter-industry and interregional linkages along supply chains. GDP growth of 0.266% is mainly driven by

domestic components of final demand. Professional, scientific, and technical activities make the most significant contribution to GDP growth. This sector has strong forward linkages in the Colombian input-output system; as a result, shocks in this sector can propagate strong effects on the domestic supply chain. The average real wage grew 0.363%, and the consumer, exports, and government price indices declined after the shock.

Table 4. Macroeconomics results (%)

	Total	Subtotal		
		Information and communication	Financial insurance activities	Professional, scientific and technical activities
Aggregate primary factor payments	0.179	-0.051	0.018	0.212
Aggregate payments to capital	0.133	-0.058	0.014	0.177
Aggregate payments to labor	0.236	-0.057	0.047	0.245
Real GDP from expenditure side	0.266	0.022	0.075	0.169
Aggregate real investment expenditure	0.208	-0.013	0.054	0.166
Real household consumption	0.329	0.018	0.104	0.206
Aggregate real government demands	0.147	0.008	-0.023	0.162
Export volume	0.060	0.030	0.020	0.010
Import volume	0.171	-0.035	0.038	0.168
Average real wage	0.363	0.024	0.116	0.223
Consumer price index	-0.088	-0.075	-0.056	0.043
Exports price index	-0.104	-0.049	-0.034	-0.021
Government price index	-0.087	-0.082	-0.010	0.004

Source: Authors' own.

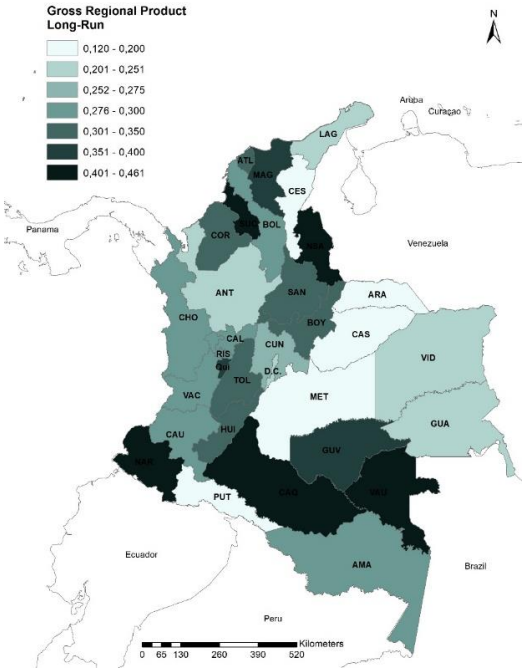
4.1 Regional impacts

Figure 3 shows the impact of the TPF growth in KIBS sectors on the Gross Regional Product (GRP) by Colombian Department. Although the production of the KIBS sectors is strongly spatial concentrated in Colombia, the impacts of increasing the productivity of KIBS sectors are spatially uneven.

Figure 4 shows the correlation between the GRP growth and the GRP at the baseline. The departments with the highest GRP growth are those with the lowest GRP at the baseline. However, Figure 4 shows two patterns of impacts on GRP. The departments specialized in the production of mineral-intensive commodities (Meta, Casanare, Cesar, La Guajira, Arauca, and Putumayo) have the smallest impact on GDP growth. On the other hand, the departments where the main urban centers and the manufacturing industry are located (Bogotá, D.C., Antioquia, Cundinamarca, Valle del Cauca, Santander, Bolivar, and Atlantico) show distinct patterns of GDP growth.

The sectoral composition of the Departmental supply chain determines the impacts on GRP. Departments with a lower content of non-service value-added embodied in their production chain present higher GDP growth (Figure 5).

Figure 3. Gross Regional Product (GRP) changes by departments



Source: Authors' own.

Propagation of the KIBS productivity gains over other sectors is more substantial for those activities with greater inter-industry interdependence with the KIBS sectors. The interdependence with KIBS occurs mainly with the other service sectors in the Colombian input-output system. This pattern reflects the low-technology intensity of the Colombian manufacturing industry, which is poorly integrated with the complex and technology-intensive service sectors.

Productivity shocks propagate to a lower intensity along supply chains due to the weak integration of KIBS into manufacturing and other service sectors in the Colombian economy. Figures A.1 and A.2, in the appendix, show an international comparison of KIBS value added embodied in the non-service and services final demand, respectively. Vertical integration of KIBS into non-services sectors in Colombia (4.0%) ranks 34th in the ranking formed by 38 OECD countries (Figure A.1). Colombia also has the lowest share of KIBS value-added embodied in the non-services final demand among a selected group of Latin American countries (Argentina, Brazil, Chile, Costa Rica, and Peru). Although the integration of KIBS into other service sectors is stronger than with manufacturing sectors, KIBS value-added embodied in the service final demand is small (Figure A.2). Ciriaci and Palma (2016) show that KIBS vertical integration into the final demand of manufacturing has increased over time in the largest European economies.

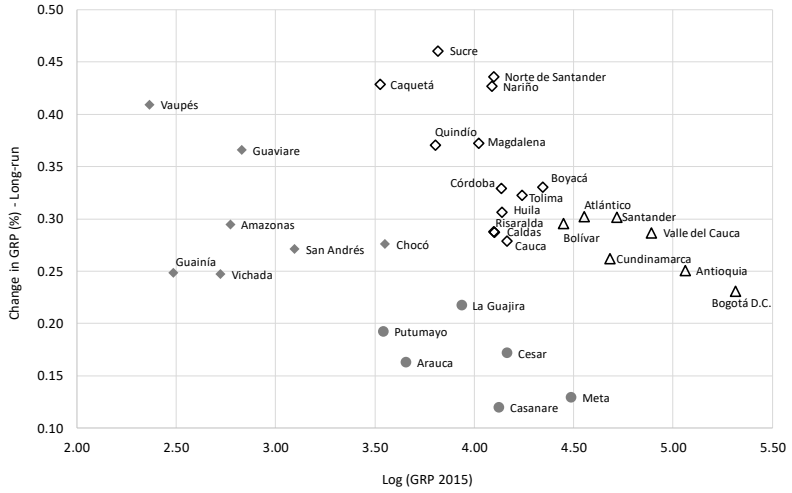
4.2 Interregional linkages and the propagation of KIBS productivity shocks

KIBS value chain is spatially concentrated in urban areas of the wealthiest departments (Bogotá D.C., Antioquia, and Valle del Cauca). Thereby, service has potential asymmetric locational impacts. We test the hypothesis of asymmetric locational impacts by repeating our 1% KIBS productivity gain simulation exercise, applying individual shocks in each Department. Figure 6 shows the results of the 33 simulations on GRP and GDP. TFP-growth of KIBS located in Bogotá

D.C. impacts all other Departments strongly and promotes the most significant increase in the national DGP (0.12%) – although the net effect on Bogotá D.C. of a simultaneous shock across all Departments is only 0.23%.

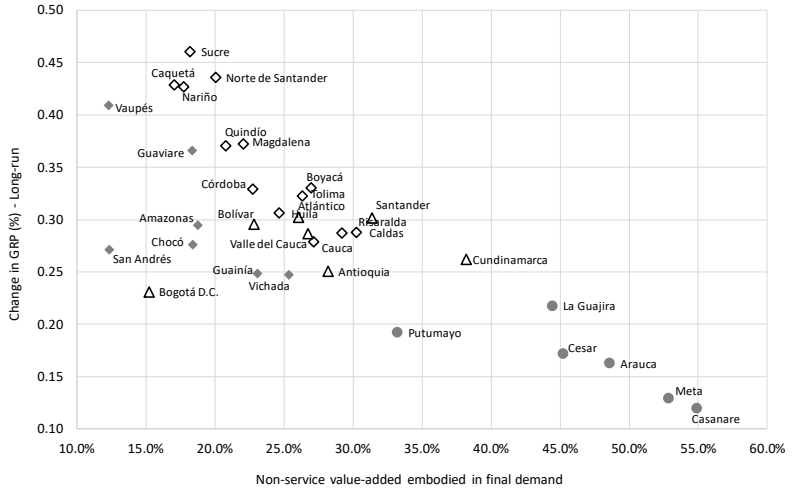
The Colombian departments, except for Bogotá D.C., Antioquia, and Valle del Cauca, have weak interregional linkages. Therefore, KIBS productivity gains mainly impact local production chains and provide little propagation through interregional trade relationships. These local effects are reinforced by the characteristic of the Colombian input-output system, in which KIBS vertical integration into the supply chain is weak and occurs essentially with the service sectors, mainly sold in the departmental internal markets.

Figure 4. Correlation between the GRP change and GRP in baseline



Source: Authors' own.

Figure 5. Correlation between the GRP change and non-service value added embodied in final demand



Note: Non-services sectors: agriculture, mining, and manufacturing. We calculate the non-service value-added embodied in final demand using the Interregional Input-Output Matrix for Colombia (IIOM-COL), 2015.

Source: Authors' own.

Figure 6. Impact of the KIBS productivity shocks by Department on GDP and GRP

Impact on the Gross Regional Product (GRP) — Department	KIBS productivity shocks (individual shock by department)																																All dep.
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26	R27	R28	R29	R30	R31	R32	R33	
R1 Antioquia	0.32	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
R2 Atlántico	0.00	0.27	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
R3 Bogotá D.C.	-0.03	-0.01	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	-0.01	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
R4 Bolívar	0.01	0.01	0.06	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
R5 Boyacá	0.01	0.00	0.14	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
R6 Caldas	0.01	0.00	0.05	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
R7 Caquetá	0.05	0.01	0.14	0.01	0.00	0.00	0.12	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43
R8 Cauca	0.01	0.00	0.08	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
R9 Cesar	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
R10 Córdoba	0.02	0.01	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
R11 Cundinamarca	-0.01	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26
R12 Chocó	0.07	0.01	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28
R13 Huila	0.02	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31
R14 La Guajira	0.03	0.01	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
R15 Magdalena	0.04	0.03	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.15	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37
R16 Meta	0.01	0.00	0.03	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
R17 Nariño	0.05	0.01	0.12	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.15	0.00	0.00	0.00	0.01	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43
R18 Norte de Santander	0.05	0.01	0.13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.17	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
R19 Quindío	0.03	0.01	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.20	0.01	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37
R20 Risaralda	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
R21 Santander	0.02	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
R22 Sucre	0.06	0.02	0.13	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.14	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
R23 Tolima	0.01	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32
R24 Valle del Cauca	-0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
R25 Arauca	0.02	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
R26 Casanare	0.01	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
R27 Putumayo	0.02	0.01	0.04	0.00	-0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.19
R28 San Andrés	-0.02	0.00	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.27
R29 Amazonas	0.06	0.01	0.09	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.29
R30 Guainía	0.04	0.01	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.25
R31 Guaviare	0.06	0.01	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.37
R32 Vaupés	0.09	0.01	0.17	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.41
R33 Vichada	0.05	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.25
National GDP	0.04	0.01	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27

Note: R1-R33 columns show the impacts of KIBS productivity gains with individual shocks in each Department. The last column shows the results of a single simultaneous productivity shock across all departments.

Source: Authors' own.

4.3. Impacts on foreign exports

The productivity gain in the KIBS sectors has the potential to increase Colombian exports by 0.06%, and about half of this increase (0.03%) is driven by the information and communication sector (Table 5). Goods exports increased by 0.04%, and services exports increased by 0.17%. Our results are in line with the findings of Arnold et al. (2016). They show that India's policy reforms in services (banking, telecommunications, and insurance) allowed firms to access better, newer, and more diverse business services. These changes in the service sectors have positive effects on the productivity of manufacturing firms providing greater foreign and domestic competition. Muller and Zenker (2001), Rubalcaba and Kox (2007), and Cusumano et al. (2015) also present evidence that business services and KIBS sectors play a fundamental supporting role in the production and competitiveness of manufacturing enterprises.

Table 5. Export volume results by sectors

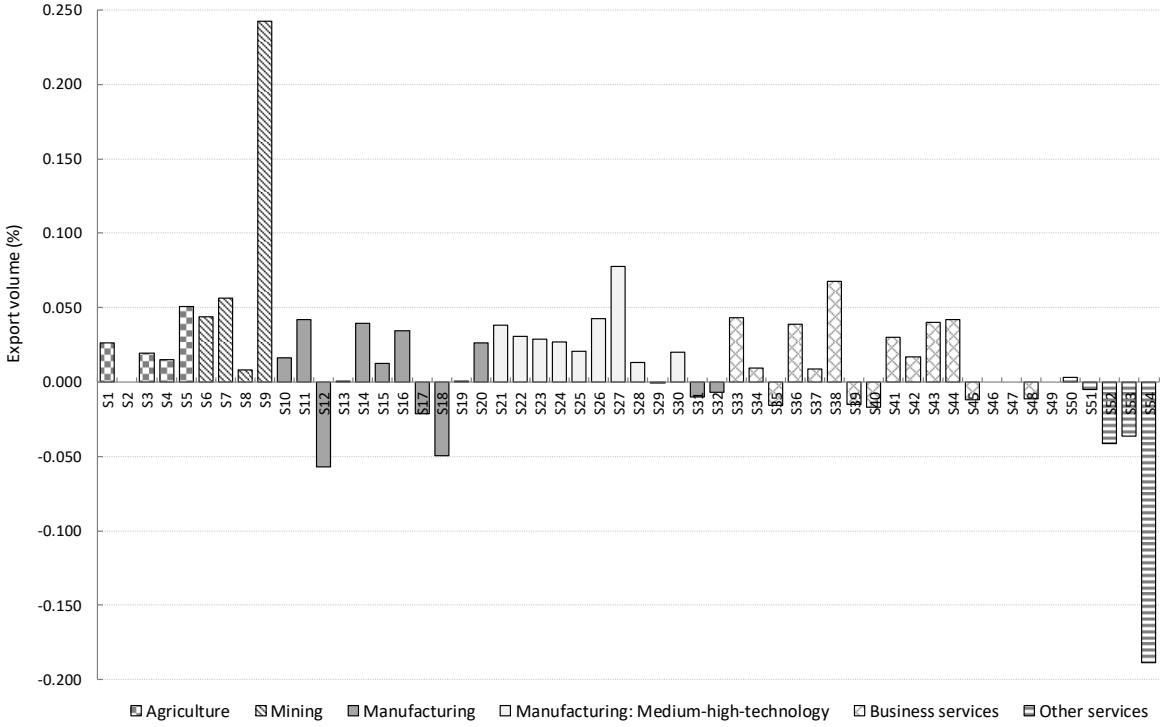
Sector	Total	Subtotal		
		Information and communication	Financial insurance activities	Professional, scientific and technical activities
Goods	0.044	0.022	0.021	0.001
Services	0.174	0.087	0.014	0.073
KIBS	*0.685*	*0.271*	*0.037*	*0.377*
Other services	*0.009*	*0.028*	*0.007*	*-0.026*
Total	0.060	0.030	0.020	0.010

Source: Authors' own.

Mining and quarrying (S9), the manufacture of basic metals (S27), and trade (S38) present the most significant export growth (Figure 7). The highest growth in exports in manufacturing is from the medium and medium-high technology sectors, such as paper and paper products (S22), refined petroleum products (S23), chemical products (S24), non-metallic mineral products (S26), metal products (S27), and the manufacture of motor vehicles (S30). These manufacturing sectors can benefit from higher productivity in KIBS, and since they have an upstream position in the production chain, they can drive gains across the economy. Effects on the exports are less relevant due to the relatively small share of KIBS sales for exports (direct effect) and to export sectors with relatively inelastic export demand (indirect effect).

The service sectors with the highest export growth are trade (S38), storage, and complementary activities in transport (S43), and post office (S44). When KIBS productivity increases, exports from some sectors fall. This reduction may be assigned to the relative price change that modifies the terms-of-trade of interregional flows with impacts on foreign exports.

Figure 7. Change in export volume by sector (%)



Note: The names of the sectors are available in Haddad and Araújo (2022). The growth rates in KIBS exports are not represented in this Figure: 0.72% in information and communication (S46), 0.68% in financial insurance activities (S47), and 0.67% in professional, scientific and technical activities (S49).

Source: Authors' own.

4.4 Sensitivity analysis

We focus on the sensitivity of a particular parameter, the price elasticity of export demand, which is central to our evaluation of the impacts of the shock of KIBS productivity on the competitiveness of Colombian exports. The price elasticity of export demand of the CEER model is estimated through a time series database with the specification of changes in prices and quantities of Colombian exports.[2] The results of the CEER model depend on the confidence in the estimate of this parameter. We, therefore, perform a formal sensitivity analysis of the main results regarding uncertainty in this parameter.

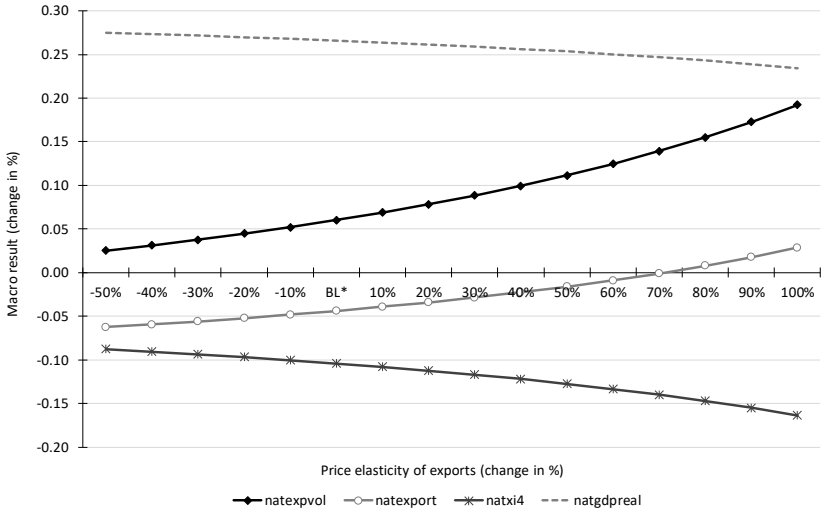
Figure 8 shows the variation of the CEER model outcome after an increase (decrease) in the parameter of the price elasticity of exports of all commodities in relation to the values of this parameter at baseline. The parameter sensitivity results are presented for the variables: export volume (*natexpvol*), foreign-currency value of exports (*natexport*), exports price index (*natxi4*), and real GDP from the expenditure side (*natgdpreal*). Lower price elasticity of exports implies lower export volume growth and higher GDP growth. Our results are consistent with Hertel et al.

[2] Haddad and Araújo (2022) present the estimation of the price elasticity of export demand for each commodity of the CGE model for Colombia.

(2007), who showed that small price elasticity of export demand generates large terms of trade effects by reducing the responsiveness of export demand.

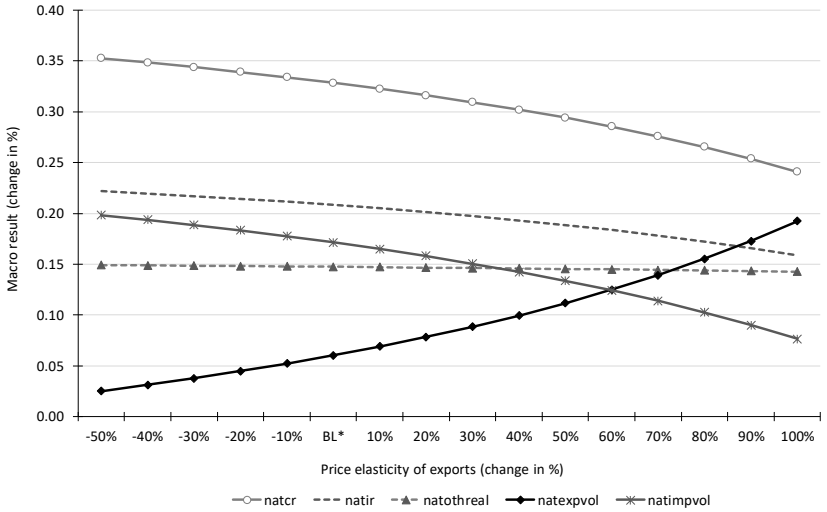
We also assess the sensitivity of the real GDP components from the expenditure side to changes in the price elasticity of exports. Figure 9 shows that the lower GDP growth associated with higher price elasticities and demand for exports is related to lower growth in real household consumption (*natcr*), and aggregate real investment expenditure (*natir*).

Figure 8. Sensitivity of the main results to changes in the price elasticity of export demand



Note: * BL: Baseline. Export volume (*natexpvol*), Foreign-currency value of exports (*natexport*), Exports price index (*natxi4*), Real GDP from the expenditure side (*natgdpreal*).

Figure 9. Sensitivity of the real GDP components from the expenditure side to changes in the price elasticity of export demand



Note: * BL: Baseline. Real household consumption (*natcr*), Aggregate real investment expenditure (*natir*), Aggregate real government demand (*natothreal*), Export volume (*natexpvol*), Import volume (*natimpvol*).

5. Conclusions

KIBS value added embodied in Colombian exports has a spatially concentrated pattern. This concentration occurs in urban areas with a high population and supply of skilled labor, i.e., Bogotá D.C., Antioquia, and Valle del Cauca. Therefore, servicification has potential asymmetric locational impacts, benefiting areas with agglomeration economies. The results of our simulations based on the CEER model show that the productivity shocks in the KIBS sectors can propagate through inter-industry linkages and generate a potential competitiveness gain for Colombian exports. However, these effects are weakened due to the KIBS' low vertical integration with tradable sectors in the Colombian economy. We assess the sensitivity of the CEER model outcome regarding the uncertainty under the price elasticity of export demand, a key parameter in our analysis, showing its importance to the model's results.

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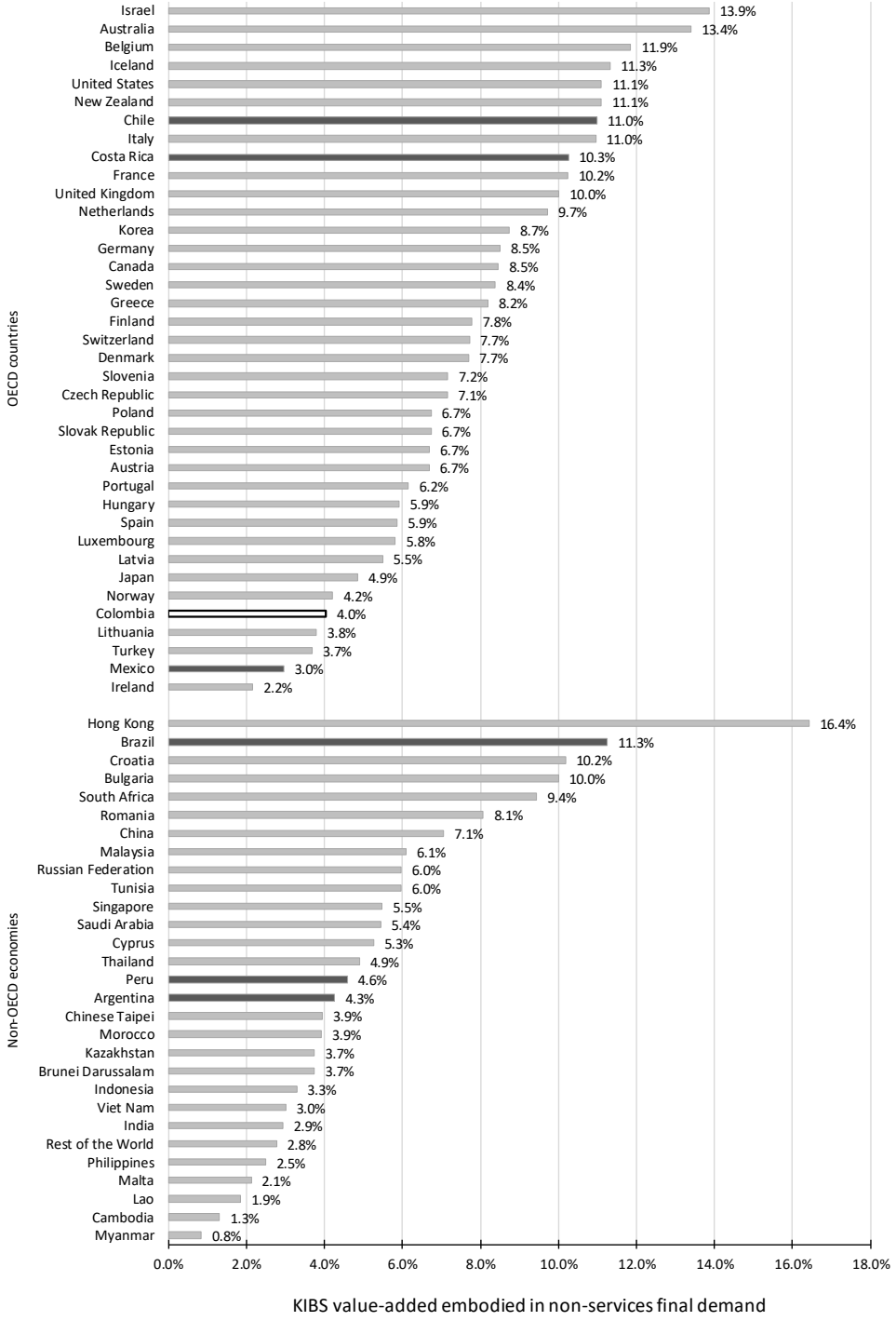
Appendix

Table A.1. Spatial patterns of non-services and services value added embodied in exports of goods and services: Colombia, 2015

Region		Value added embodied in exports (in 2015 COP billions)			Value added embodied in exports (in %)		
		Non-services	Services (except KIBS)	KIBS	Non-services	Services (except KIBS)	KIBS
R1	Antioquia	8,097.38	2,803.17	1,955.09	12.23	13.59	18.10
R2	Atlántico	2,220.15	1,399.37	570.74	3.35	6.78	5.28
R3	Bogotá D.C.	3,917.72	4,650.62	3,682.83	5.92	22.55	34.09
R4	Bolívar	1,652.65	907.69	343.10	2.50	4.40	3.18
R5	Boyacá	1,111.76	694.96	165.91	1.68	3.37	1.54
R6	Caldas	809.38	318.75	160.75	1.22	1.55	1.49
R7	Caquetá	29.70	50.64	11.37	0.04	0.25	0.11
R8	Cauca	1,113.14	226.85	146.61	1.68	1.10	1.36
R9	Cesar	5,009.75	444.01	172.00	7.57	2.15	1.59
R10	Córdoba	311.25	213.62	114.54	0.47	1.04	1.06
R11	Cundinamarca	3,074.37	851.73	385.38	4.64	4.13	3.57
R12	Chocó	579.03	62.47	5.83	0.87	0.30	0.05
R13	Huila	1,464.31	473.36	113.88	2.21	2.29	1.05
R14	La Guajira	3,550.91	311.72	25.68	5.36	1.51	0.24
R15	Magdalena	882.90	298.32	63.75	1.33	1.45	0.59
R16	Meta	12,911.23	1,104.58	435.36	19.50	5.36	4.03
R17	Nariño	470.75	173.69	49.41	0.71	0.84	0.46
R18	Norte de Santander	549.92	274.46	66.67	0.83	1.33	0.62
R19	Quindío	218.69	124.83	42.64	0.33	0.61	0.39
R20	Risaralda	640.11	332.74	181.76	0.97	1.61	1.68
R21	Santander	4,060.62	1,228.11	470.56	6.13	5.95	4.36
R22	Sucre	121.54	136.63	25.53	0.18	0.66	0.24
R23	Tolima	1,034.53	331.16	132.77	1.56	1.61	1.23
R24	Valle del Cauca	3,631.43	1,920.25	1,286.51	5.48	9.31	11.91
R25	Arauca	1,672.03	111.83	23.91	2.53	0.54	0.22
R26	Casanare	6,134.83	910.53	135.53	9.26	4.41	1.25
R27	Putumayo	894.76	84.87	21.84	1.35	0.41	0.20
R28	San Andrés	0.87	125.66	9.65	0.00	0.61	0.09
R29	Amazonas	2.28	28.73	1.18	0.00	0.14	0.01
R30	Guainía	32.65	6.36	0.34	0.05	0.03	0.00
R31	Guaviare	9.23	11.10	0.84	0.01	0.05	0.01
R32	Vaupés	0.68	8.57	0.13	0.00	0.04	0.00
R33	Vichada	6.97	5.25	0.56	0.01	0.03	0.01
	Colombia	**66,217.52**	**20,626.65**	**10,802.66**	**100.00**	**100.00**	**100.00**

Source: Authors' preparation from the Interregional Input-Output Matrix for Colombia (IIOM-COL), 2015.

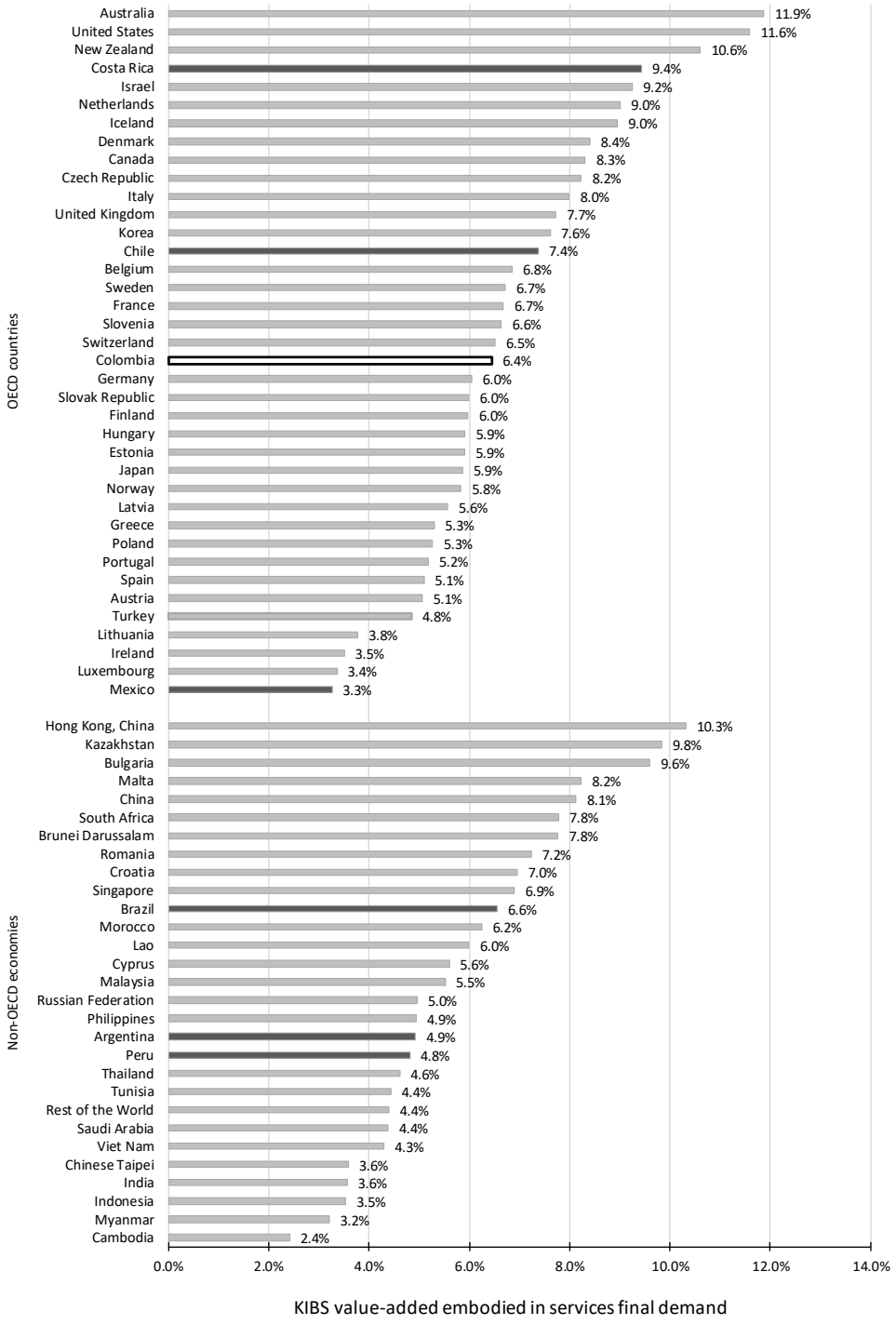
Figure A.1. Domestic KIBS value added embodied in non-services final demand



Note: KIBS: Telecommunications (D61), IT and other information services (D62T63), Financial and insurance activities (D64T66), and Professional, scientific and technical activities (D69T75). Non-services sectors: agriculture, mining, and manufacturing.

Source: Authors' own from the 2021 edition of OECD Inter-Country Input-Output (ICIO) Tables for 2018.

Figure A.2. Domestic KIBS value added embodied in services final demand



Note: KIBS: Telecommunications (D61), IT and other information services (D62T63), Financial and insurance activities (D64T66), and Professional, scientific and technical activities (D69T75)

Source: Authors' own from the 2021 edition of OECD Inter-Country Input-Output (ICIO) Tables for 2018.