The role of the technological capacity of regional partners in new technological specialization

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Abstract

This study addresses the underexplored roles of regional linkages and the technological capacity of partners in facilitating technological branching, particularly in developing countries. By analysing 127 classes of technologies across 136 Brazilian regions from 1997 to 2020, we find strong evidence that intraregional linkages decrease the likelihood of regions entering new technological specializations. In contrast, interregional linkages significantly promote the entry of new technologies, highlighting their role in technological branching. Furthermore, the relationship between interregional linkages and technological branching is moderated by the technological capacity of regional partners. Collaborations with specialized regions enhance technological branching, while connections to nonspecialized regions limit this potential. This underscores the critical importance of partners' technological capacity in facilitating successful technological branching. Therefore, regions should adopt a strategic networking approach that prioritizes linkages with specialized regions to increase the probability of technological branching. Policymakers must support initiatives that promote these linkages, especially when partners offer technological complementarity, to foster new avenues of technological diversification.

Keywords: Regional linkages; Branching; New technological entry; Technological capacity

JEL Code: O19, O31, R11

1. Introduction

The literature on innovation economics has increasingly focused on understanding the role of technological specialization and knowledge complexity (Balland and Boschma, 2021a; Krafft *et al.*, 2014; Montresor and Quatraro, 2017; Petralia *et al.*, 2017). These studies have demonstrated that local capabilities, a primary source of regional change, can be developed from a region's competitive advantage in new domains where relevant capabilities already exist. In this context, scholars argue that regional linkages can provide access to crucial knowledge essential for regional technological branching (Ascani *et al.*, 2020; Balland and Boschma, 2021a; Tavassoli and Carbonara, 2014).

However, despite the importance of these linkages, our understanding of how intraregional and interregional connections affect regional branching remains limited. The mixed evidence from previous studies encompassing concepts such as productivity, efficiency, spillover effects, and agglomeration dynamics regarding their role in fostering innovation highlights this gap (Broekel *et al.*, 2015; De Noni *et al.*, 2017, 2018; Santoalha, 2019). This mixed evidence can be attributed to the distinct nature of intraregional and interregional linkages. While intraregional connections facilitate knowledge flow among local actors, interregional linkages grant access to resources and knowledge that may otherwise be unavailable, suggesting that interregional linkages are particularly valuable, helping regions overcome challenges related to technological lock-in and path dependence. Consequently, it becomes clear that relying solely on local production may not suffice to sustain innovation and diversification. Understanding the unique roles of both types of linkages is essential for fostering regional technological diversification, particularly as interregional linkages can provide complementary capacities that enhance technological branching, especially in peripheral regions (Balland and Boschma, 2021c; De Noni *et al.*, 2017; De Noni and Ganzaroli, 2024; Santoalha, 2019).

Furthermore, the effectiveness of interregional linkages is likely contingent on the technological capacity of the partner regions involved. The complementarity of exchanged knowledge and resources is crucial for enabling regions to explore novel technological pathways. Previous studies indicate that regions are more likely to develop new activities when neighbouring regions possess specialized expertise (Boschma *et al.*, 2017; Santoalha, 2019). For instance, Noni et al. (2018) found that collaborative linkages with technology-intensive regions enhance innovation and competitiveness. Regions with high levels of technological knowledge production are more inclined to connect with one another, benefiting from knowledge spillovers. In contrast, less developed regions often rely on nonlocal linkages for innovation due to their limited local capacities, underscoring the significance of technological capacity and strategic partnerships in fostering regional branching (De Noni *et al.*, 2018).

Despite these insights, scholarly attention has predominantly focused on developed countries and regions near the technological frontier, leaving a substantial gap regarding developing countries. Few studies have explored the intricate relationships between technological diversification and both intra- and interregional linkages, with most focusing on a limited number of developed economies (Balland and Boschma, 2021a; De Noni and Ganzaroli, 2024). Consequently, we lack a robust and comprehensive understanding of the nature of regional linkages and their influence on the entry of new technological capabilities in developing economies. This study aims to address this gap by examining the effects of regional linkages on technological specialization within these contexts. Using patent data from the Brazilian Patent Office (INPI - National Institute of Industrial Property) concerning 136 Brazilian regions from 1997 to 2020, we investigate how both intraregional and interregional linkages, alongside the technological capacity of regional partners, influence the likelihood of regions entering new technological specializations.

Thus, our contribution to the literature is threefold. First, while existing research highlights the importance of regional linkages for technological diversification, there is limited understanding of how intra- and interregional linkages affect the development of new activities, particularly in terms of how interregional linkages can compensate for weak or absent regional capabilities. Second, our focus on the technological capacity of regional partners emphasizes the importance of complementarity in determining regional branching. Third, there is a substantial lack of literature addressing developing countries in this domain; our examination of Brazilian firms can provide valuable insights into regional branching within this context.

Our results indicate that intraregional linkages tend to decrease the likelihood of a region entering a new technological specialization, while interregional linkages contribute to the entry of new technologies in Brazilian regions. This suggests that local connections (intraregional linkages) can lead to a lock-in effect, thereby restricting technological branching. In contrast, connections with other Brazilian regions (interregional linkages) can expand and stimulate the flow of knowledge and ideas, fostering regional technological diversification.

Furthermore, when we focus on the capacity of regional partners, our results show that linkages with specialized regions facilitate the entry of new technologies. Conversely, connections to nonspecialized regions decrease the probability of new technology entering a region. These findings emphasize that it is not merely connections with other regions that foster technological branching. Instead, the technological capacity of partners plays a critical role in this process. Specifically, a new technology is more likely to enter a region when it is linked with other regions that possess expertise in that technology, as these connections facilitate the transfer of knowledge, skills, and innovative practices that promote technological branching.

In light of these findings, we suggest that regions should adopt a strategic approach in their networking efforts. They should prioritize partnerships with specialized regions to enhance their technological capabilities. The implications of this are profound, as regions that neglect to foster such targeted linkages may find themselves at a competitive disadvantage and unable to leverage the full potential of technological advancements. Therefore, our findings not only emphasize the importance of the nature of regional linkages but also call for policymakers to support initiatives that promote linkages with specialized regions. Ultimately, this approach aims to enhance regional technological diversification and allow regions to better position themselves in an increasingly interconnected and technologically driven global landscape.

The paper proceeds as follows. The next section reviews the related literature and develops our main hypotheses. Section 3 describes the data and measures of regional linkages and new technology. In Section 4, we present and discuss our findings. The final section offers a conclusion.

2. Literature review

It is broadly accepted that territories differ in terms of their ability to diversify and adapt to change (Rigby, 2015). This claim of the ability of these territories to develop both new technologies in general and new technological advantages also holds true (Balland and Rigby, 2017). Several empirical studies related to the innovation economy indicate an unequal distribution of regional knowledge production (Audretsch and Belitski, 2020; Boschma *et al.*, 2022; Crescenzi and Jaax, 2016; Mewes and Broekel, 2020) and emphasize the importance of local capabilities, particularly technological relatedness, as a source of regional change (Balland and Boschma, 2021b; De Noni *et al.*, 2018; Tavassoli and Carbonara, 2014).

The concept of technological relatedness is based on the view that knowledge has an architecture that is constructed on the foundation of similarities in the ways that different types of knowledge can be used. This situation occurs when knowledge subsets that are close substitutes for one another or require similar sets of cognitive abilities and skills to be used are simultaneously present in the knowledge space[1] (Balland and Rigby, 2017). The idea that technological relatedness favours regional diversification has been documented for a number of regions (Balland *et al.*, 2018; Boschma *et al.*, 2023; Colombelli, 2016; Montresor and Quatraro, 2017; Rigby, 2015) and specific technologies in developed countries, including green technologies (Montresor and Quatraro, 2020; Santoalha and Boschma, 2021), biotechnologies (Boschma *et al.*, 2014) and technologies related to Industry 4.0 (Balland and Boschma, 2021b).

In addition, the literature has argued that (distinct) regions are connected via common goals and the need to expand and promote innovative-inventive activity (Barzotto *et al.*, 2019; Tóth *et al.*, 2021; Wanzenböck and Piribauer, 2018). These studies confirmed the importance of technological relatedness in the process of technological change. That is, regions face diversification costs that decrease as the level of proximity to related technological areas increases; therefore, such regions should be more likely to introduce new specializations that are similar or related to those they already possess because these specializations feature similar (but not identical) capabilities, such as knowledge, skills, and institutions (Balland and Boschma, 2021a).

Although this body of literature has emphasized the benefits and effectiveness of relatedness in the process of technological branching in various countries and regions, we still have much to learn about the effect of regional linkages on technological diversification. Even less is known about how the technological capacity of partners affects this relationship, especially in the context of regions in developing economies such as Brazil. In fact, only the study by Balland and Boschma (2021) examined the extent to which interregional linkages affect the diversification process in European regions.

Empirical evidence supports the claim that these regional linkages can promote innovation, i.e., that stimulating the flow of knowledge and ideas in different geographic regions is likely to be relevant for technological branching in regions. However, it is important to distinguish between intra- and interregional linkages because the significance of these types of linkages for these processes can differ (Broekel *et al.*, 2015; De Noni *et al.*, 2017; Santoalha, 2019).

While intraregional linkages can be important for connecting different regional actors and providing new knowledge to the organizations involved, interregional linkages can also facilitate this process by introducing resources that were previously unavailable to such regions. Theoretical arguments concerning the specific mechanisms that underlie such processes range from arguments focused on productivity and efficiency to those oriented towards spillovers and agglomeration effects (De Noni et al., 2017; Santoalha, 2019). Interregional linkages are viewed as providing regions with access to external knowledge that can allow them to combat or circumvent the tendency of regions towards technological lock-in and path dependence (Noni et al., 2018; Tavassoli & Carbonara, 2014). Therefore, interregional linkages provide access to complementary and additional capacities, thus increasing technological branching in regions, especially peripheral regions (Wanzenböck & Piribauer, 2018). A reason for this effect is that inventive local production may not be sufficient to sustain innovation and technological diversification.

Thus, intraregional linkages can support the recombination and sharing of knowledge within regions. However, they may also lead to technological lock-in, potentially restricting technological branching in the region. This occurs when regions become heavily reliant on

[1] Inspired by the concept of "product space" (Hidalgo et al., 2007), the notion of the knowledge space is determined via an analysis of co-occurrences in technological areas.

established linkages and familiar technologies, causing them to overlook or undervalue new opportunities and innovations. As regions concentrate on existing capabilities, they can become resistant to adopting novel technologies or exploring diverse pathways. This dependence on familiar networks can stifle creativity and limit a region's ability to adapt to technological advancements, ultimately constraining its potential for technological branching. Based on this, we formulate our first hypothesis:

Hypothesis 1: The more ***intraregional*** *linkages a region has, the* ***lower*** *the probability of a new technology entering that region.*

On the other hand, interregional linkages could play a crucial role in providing access to complementary and shared knowledge between regions, which can significantly stimulate regional branching and help avoid technological lock-in. By fostering linkages with different regions, regions can tap into new ideas and innovations that may not be present in their local networks, enhancing creativity and adaptability. Therefore, we expect that interregional linkages have a positive influence on the entry of new technological specializations and technological branching. Thus, we formulate the second hypothesis

Hypothesis 2: The more ***interregional*** *linkages a region has, the* ***greater*** *the probability of a new technology entering that region.*

However, the effectiveness of these interregional connections relies on the complementarity of the knowledge and resources exchanged, allowing regions to explore novel technological pathways more effectively. An important aspect to consider is the role of absorptive capacity and the relatedness between regions. The ability to absorb external knowledge from other regions and translate it into innovation often depends on the existing technological capacity derived from regional linkages. This synergy between absorptive capacity and relatedness enhances the potential for successfully integrating new ideas, ultimately fostering greater regional branching

Previous studies suggest that regions are more capable of developing new activities in which their neighbouring regions are already specialized (Balland and Boschma, 2021c; Boschma *et al.*, 2017; De Noni *et al.*, 2018). Noni et al. (2018) found that regions tend to be more innovative and competitive when they develop collaborative linkages with technology-intensive regions. Furthermore, regions that exhibit a high level of technological knowledge production are more likely to connect with one another and/or with nearby areas (P. A. Balland & Boschma, 2021), as local capacities tend to encourage and benefit from knowledge spillover effects (Jaffe *et al.*, 1993). In addition, in many cases, less developed regions rely on nonlocal linkages to innovate, as their own local capacities and networks tend to be weak and limited (Balland and Boschma, 2021c; Fitjar and Rodríguez-Pose, 2011; De Noni and Ganzaroli, 2024).

In fact, it is essential to understand that regions require technological capacity to effectively utilize external knowledge, thereby circumventing the tendency toward technological stagnation and lock-in. In this sense, it is important for regions to collaborate with other regions that possess technologies beyond their current scope. However, this does not imply that such technologies can exist outside the region's portfolio, as absorptive capacity is also necessary in this context. Based on these insights, we formulate our final two hypotheses:

Hypothesis 3: Regions that establish more links with ***nonspecialized*** *partners in a technology are less capable of technological branching or entering into a new technological specialization.*

Hypothesis 4: Regions that establish more links with specialized partners are more capable of technological branching or entering into a new technological specialization.

3. Empirical model

3.1. Data sources and technological branching

This section explains the data we used, the variables constructed, and the method employed to analyse the effect of regional linkages and the technological capabilities of regional partners on technological branching in 135 mesoregions in Brazil for the period 1997–2020[2].

We employed patent data drawn from the Brazilian Patents Office (*INPI - National Institute of Industrial Propert -INPIy*), and following other studies (Balland and Boschma, 2021a; Montresor and Quatraro, 2017; Rigby, 2015), we estimate an entry model that assesses the probability of a region specializing in a new technology, providing insights into technological branching. We assigned patents to 127 technological classes[3] (International Patent Classification) – *i* and to 135 Brazilian regions – ,*r* based on the addresses of the inventors.

Our dependent variable is technological branching, measured by the entry, or not, of new technological specializations in a technology in a region, in line with the literature concerning the emergence of new activities in a regional context (Balland and Boschma, 2021a; Balland *et al.*, 2018; Montresor and Quatraro, 2017). We define new technological specialization by examining the regional acquisition of a new technological specialization *i* at time *t*, which indicates a technological specialization that the region did not possess at the previous time (*t–1*). *NewEntry* is thus linked to the emergence of a revealed technological advantage (RTA). We denote the new technological specialization as follows:

$$NewEntry_{r,i,\Delta t} = \begin{cases} 1 \ if \ M_{r,i,t} = 1 \ \& \ M_{r,i,t-1} = 0 \\ 0 \ if \ M_{r,i,t} = 0 \ \& \ M_{r,i,t-1} = 0 \end{cases}$$

with

$$M_{r,i} = \begin{cases} 1 \quad if \quad RTA_{r,i} = \dfrac{Pat_{r,i} \big/ \sum_i Pat_{r,i}}{\sum_r Pat_{r,i} \big/ \sum_r \sum_i Pat_{r,i}} > 1 \\ 0 \ otherwise \end{cases}$$

The probability of entering a new technological specialization is assessed for time windows of five years. As we have patent data for the period 1997–2020, we calculate these for six subsequent periods *t:* 1997–2000; 2001–04; 2005–2008; 2009–2012; 2013–2016; and 2017–2020. All independent variables are measured in the period before the time window of four years.

3.2.Regional Linkages and Technological Capabilities of Regional Partners

We construct two measures to assess the effect of regional linkages on the new entry of technological specialization: intraregional linkages (*IntraLinks*) and interregional linkages (*InterLinks*).

IntraLinks are based on coinventors residing in the same region. For each technology i, this measure counts the number of copatents between inventors located in the same region r.

[2] Two regions do not have patents at the INPI in the period, they are: Norte do Amapá (AP) and Centro-Sul Cearense (CE).

[3] Four technological classes do not have a patent at the INPI in the period, they are: C99; D99; E99 and E99, referring to subject matter not otherwise provided for in the section.

InterLinks are based on coinventors residing in different regions. For each technology i, this measure counts the number of linkages that inventors in region r have with inventors in other Brazilian regions. For example, suppose that a patent in technology i is copatented by six inventors: three in region A, two in region B, and one in region C. We compute nine *InterLinks* and six *IntraLinks* for region A, eight *InterLinks* and two *IntraLinks* for region B, and five *InterLinks* and zero *IntraLinks* for region C, all in technology i. Note that if the patent includes more than one technology, we account for the *InterLinks* for each technology.

To understand how regional capabilities influence the effect of interregional linkages on technological branching, we developed two new indicators based on regional technological specialization. The first indicator, referred to as *SpecLinks*, measures the number of specialized regions in technology i to which region r is linked. This indicates that region r has some activity in this technology but is not specialized, and it is linked with regions that are specialized in this technology *i*. The second indicator, referred to as *NoSpecLinks*, measures the number of linkages with nonspecialized regional partners in technology i. This means that interregional links are formed between regions that both have some activity in technology i but are not specialized in it. For example, considering the previous example, a patent in technology i is copatented by six inventors, three located in region A, two in region B, and one in region C. Region B is specialized in technology *i*. We computed 3 *NoSpecLinsk* and 6 *SpecLink*s for region A, 8 *NoSpecLink*s and 0 *SpecLinks* for region B, and 3 *NoSpecLink*s and 2 *SpecLinks* for region C in technology *i*. For example, considering the previous example, a patent in technology i is copatented by six inventors: three located in region A, two in region B, and one in region C. Region B specializes in this technology i. We computed 6 *SpecLinks* and 3 *NoSpecLinks* for region A, 0 *SpecLinks* and 8 *NoSpecLinks* for region B, and 2 *SpecLinks* and 3 *NoSpecLinks* for region C in technology *i*.

We also include four control variables. First, we include regional capabilities, proxied by relatedness density (RD). We expect that the greater the relatedness density (RD) is, the greater the probability of that region entering a new specialization. Second, we control for technology complexity (TCI) by ranking the diversity and sophistication of the technology know-how required to introduce the technology[4]. We expect that the greater a technology's complexity (TCI) is, the lower the probability of that region entering into a new technological specialization because it is more difficult for regions to enter into more complex technologies. Third, we include gross domestic product (GDP) per capita to account for the level of economic development within a region. We expect that the greater a region's GDP per capita is, the greater the probability of that region acquiring a new specialization. Fourth, we include the natural logarithm of population size to account for variations in population sizes across regions. Again, we expect a positive effect in this context. We also incorporate time fixed effects.

4. New technological specialization in Brazilian mesoregions

Table 1 presents the findings of the new technological specialization model.

[4] Both RD and TCI were calculated using the EconGeo package in R, with the function's relatedness_density and TCI

Table 1: New entry of technological specialization, RTA>1.0

VARIABLES	(1)	(2)	(3)	(4)	(5)
Number of intraregional linkages (IntraLinks) (ln)		-0.145***	-0.174***	-0.043	-0.111***
		(0.040)	(0.036)	(0.036)	(0.040)
Number of interregional linkages (InterLinks) (ln)		0.097**			
		(0.044)			
Number of specialized linkages (SpecLinks) (ln)			0.236***		0.281***
			(0.048)		(0.050)
Number of nonspecialized linkages (NoSpecLinks) (ln)				-0.123**	-0.197***
				(0.055)	(0.057)
Relatedness density (RD)	0.027***	0.027***	0.027***	0.027***	0.027***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Technological Complexity Index (TCI)	-0.605***	-0.657***	-0.672***	-0.745***	-0.741***
	(0.082)	(0.087)	(0.086)	(0.088)	(0.088)
GDP per capita (ln)	0.305***	0.315***	0.313***	0.319***	0.314***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Population (ln)	0.106***	0.126***	0.121***	0.127***	0.118***
	(0.027)	(0.028)	(0.028)	(0.028)	(0.028)
Constant	-4.059***	-4.323***	-4.255***	-4.340***	-4.218***
	(0.371)	(0.379)	(0.379)	(0.379)	(0.379)
Period FE	Yes	Yes	Yes	Yes	Yes
Observations	42,544	42,544	42,544	42,544	42,544
Number of IDMI	13,446	13,446	13,446	13,446	13,446
chi2_c	491.3	478.0	471.9	477.6	468.3
ll	-17153	-17145	-17135	-17145	-17128

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

Initially, as expected, the coefficients of our control variables, relatedness density (RD), GDP per capita, and population, are positive and significant, suggesting that RD, size, and GDP per capita tend to increase the probability of new technology entry in regions. Additionally, the technological complexity (TCI) index is negative and significant, indicating that the more complex the technologies are, the more difficult it is to enter new technological specializations.

Regarding intraregional linkages (*IntraLinks*), our analysis reveals a negative and significant effect on the entry of new technological specializations in all specifications. This result suggests that more connections within a region tend to decrease the likelihood of entering new technologies. This aligns with the idea presented in the literature that intraregional linkages often facilitate the reinforcement of existing capabilities and knowledge bases, potentially leading to a lock-in effect (Balland and Boschma, 2021c). Such an effect occurs when regions become overly reliant on familiar technologies, thus hindering innovative processes and the exploration of new technological pathways. This negative coefficient underscores the potential challenges that regions with pronounced intraregional connections might face in diversifying their technological portfolios. This result suggests a need to reassess the role of local networks, indicating that while intraregional linkages promote collaboration and knowledge sharing within a region, they may simultaneously limit the potential for technological branching. This, in turn, could impede regional competitiveness in a dynamic global economy.

On the other hand, we find a positive and significant effect of interregional linkages on new technological specialization. This result emphasizes the critical role of connections between regions in fostering innovation and technological diversification. Interregional linkages provide access to diverse knowledge, skills, and resources not available within a single region, thereby facilitating the entry of new technologies. This means that external links can help regions overcome the limitations of their existing knowledge bases and stimulate the development of new capabilities. This is because interregional linkages are particularly valuable because they grant regions access to external knowledge, which can help combat or circumvent the tendency towards technological lock-in and path dependence (De Noni *et al.*, 2018). By offering access to complementary and additional capacities, these linkages significantly increase technological branching in regions, especially in peripheral regions. In this context, our results suggest that local inventive production alone may not suffice to sustain innovation and technological diversification. Thus, strategic interregional collaboration can be pivotal in driving regional technological branching.

Regarding the role of the technological capacity of regional partners in new technological specialization, our results indicate that being connected to specialized regions (*SpecLinks*) has a positive relationship with technological diversification. This suggests that linkages with specialized regions tend to contribute to the entry of new technologies in Brazilian regions. Conversely, connections to nonspecialized regions (*NoSpecLinks*) decrease the probability of new technology entering a region, suggesting that adding connections with other regions that are not technologically specialized comes at a price, tending to impede the entry of new technologies in Brazilian regions. These findings emphasize that it is not merely connections with other regions that foster technological branching. Instead, the technological capacity of regional partners plays a critical role in this process. Specifically, a new technology is more likely to enter a region when it is linked with other regions that possess expertise in that technology. These connections facilitate the transfer of knowledge, skills, and innovative practices, thereby promoting technological branching. Therefore, the impact of regional linkages on technological diversification is contingent upon the technological capacity of the partner regions. Hence, interregional linkages tend to positively affect technological branching only if the partner region is technologically specialized.

As a robustness check, we also ran the same estimations, defining regional entry as a new specialization, based on RTA > 1.5 and RTA > 2. In these same estimations, we also used this new threshold of RTA > 1.5 and RTA > 2 in the construction of other variables RD, TCI, *SpecLink* and *NoSpecLink*. The findings for our key variables remained the same, and the results are presented in Appendix A.

CONCLUSIONS

Despite many studies highlighting the importance of regional linkages, particularly interregional linkages, for accessing external sources of innovation and avoiding lock-in, little attention has been given to the extent and role of regional partners' technological capacity in shaping regional diversification. Most studies assume that regions establish these linkages to access knowledge that is not readily available within their local systems but overlooks the fact that partners may not always possess the knowledge that is absent in these regions. Consequently, substantial empirical evidence supporting this hypothesis, especially its impact on regional diversification, is lacking. Moreover, existing research on these topics has predominantly focused on European regions (Balland and Boschma, 2021; De Noni, 2024), leaving a gap in understanding intra- and interregional linkages and how regional partners' technological capacity influences the introduction of new technological capabilities, especially in developing economies.

This study addresses this gap within the Brazilian context by separately examining the effects of intraregional and interregional linkages on the likelihood of Brazilian regions developing new technological capabilities. Additionally, we analyse the role of regional partners' technological capacity in this process.

Our study highlights that while intraregional linkages tend to decrease the probability of the entry of new technological specializations in Brazilian regions, interregional linkages promote this probability. Therefore, our findings suggest that intraregional connections reinforce existing capabilities, potentially leading to technological lock-in, whereas interregional collaborations facilitate access to diverse knowledge and resources crucial for overcoming local constraints and driving technological diversification. However, the effect of interregional linkages on technological branching is shaped by the technological capacity of the regional partner. Partnerships with technologically specialized regions positively influence the introduction of new technologies, underscoring the critical role of partner region expertise in promoting regional diversification, while collaborations with technologically nonspecialized regions tend to impede technological branching.

These results emphasize the need for targeted policies that foster strategic interregional collaboration, especially with technologically specialized regional partners, and mitigate the potential drawbacks of intraregional linkages, thereby enhancing Brazil's capacity for sustained technological diversification. In this way, policymakers should prioritize fostering interregional collaboration to develop new technological specializations. Policies should incentivize and facilitate partnerships between regions with complementary technological strengths to promote diversified technological development across Brazil. In addition, policymakers should bear in mind that while intraregional linkages promote local collaboration and knowledge sharing, policies should mitigate potential lock-in effects by encouraging diversification strategies within regions. Finally, policymakers should strategically promote connections with technologically specialized regions to maximize the positive impact on technological branching. By aligning policies with these insights, policymakers can effectively support the regional branching of Brazilian regions.

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Appendix A:

Table A1: New entry of technological specialization using RTA>1.5

VARIABLES	(1)	(2)	(3)	(4)	(5)
Number of intraregional linkages (IntraLinks) (ln)		-0.159***	-0.170***	-0.093***	-0.135***
		(0.035)	(0.031)	(0.034)	(0.035)
Number of interregional linkages (InterLinks) (ln)		0.093**			
		(0.042)			
Number of specialized linkages (SpecLinks) (ln)			0.223***		0.247***
			(0.050)		(0.052)
Number of nonspecialized linkages (NoSpecLinks) (ln)				-0.039	-0.096*
				(0.049)	(0.051)
Relatedness density (RD)	0.029***	0.029***	0.029***	0.029***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Technological Complexity Index (TCI)	0.047	0.014	0.008	-0.032	-0.020
	(0.085)	(0.088)	(0.088)	(0.089)	(0.090)
GDP per capita (ln)	0.246***	0.261***	0.260***	0.266***	0.260***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Population (ln)	0.047*	0.075***	0.071***	0.076***	0.069**
	(0.026)	(0.027)	(0.027)	(0.027)	(0.027)
Constant	-3.378***	-3.755***	-3.691***	-3.771***	-3.671***
	(0.365)	(0.376)	(0.376)	(0.376)	(0.376)
Period FE	Yes	Yes	Yes	Yes	Yes
Observations	44,470	44,470	44,470	44,470	44,470
Number of IDMI	13,666	13,666	13,666	13,666	13,666
chi2_c	410.1	401.0	394.6	401.2	392.1
ll	-16524	-16512	-16505	-16515	-16503

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

Table A2: New entry of technological specialization using RTA>2.0

VARIABLES	(1)	(2)	(3)	(4)	(5)
Number of intraregional linkages (IntraLinks) (ln)		-0.182***	-0.223***	-0.105***	-0.156***
		(0.034)	(0.030)	(0.033)	(0.034)
Number of interregional linkages (InterLinks) (ln)		0.054			
		(0.042)			
Number of specialized linkages (SpecLinks) (ln)			0.307***		0.358***
			(0.053)		(0.056)
Number of nonspecialized linkages (NoSpecLinks) (ln)				-0.113**	-0.185***
				(0.049)	(0.050)
Relatedness density (RD)	0.033***	0.033***	0.033***	0.032***	0.033***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Technological Complexity Index (TCI)	0.389***	0.397***	0.394**	0.335**	0.332**
	(0.144)	(0.152)	(0.155)	(0.156)	(0.161)
GDP per capita (ln)	0.204***	0.230***	0.225***	0.234***	0.227***
	(0.031)	(0.032)	(0.031)	(0.031)	(0.031)
Population (ln)	-0.005	0.038	0.031	0.037	0.029
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
Constant	-2.771***	-3.337***	-3.245***	-3.327***	-3.207***
	(0.368)	(0.380)	(0.380)	(0.380)	(0.380)
Period FE	Yes	Yes	Yes	Yes	Yes
Observations	45,920	45,920	45,920	45,920	45,920
Number of IDMI	13,834	13,834	13,834	13,834	13,834
chi2	951.2	988.5	1014	987.0	1020
ll	-15708	-15689	-15674	-15687	-15667

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