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Variety, technological intensity and economic growth at the regional level in Argentina

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Abstract:
The objective of this paper is to study the relationship between productive structure and economic performance at the subnational level in Argentina. Based on a dataset at the subnational level, we study the impact on economic growth of three types of productive patterns: i) productive efficiency (W), ii) related variety (RV), and iii) unrelated variety (UV). In addition, we explore to what extent this impact is conditioned by the level of technological intensity of productive structures. Results show that unrelated variety positively impacts on economic growth when it happens within a context of high levels of technological intensity of productive structures. When this is not the case, the impact might even be negative, or there may be no impact at all.

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The objective of this paper is to study the relationship between productive structure and economic performance at the subnational level in Argentina. The traditional school of economic development has postulated that international gaps in the productive structure are reproduced within national boundaries and generate an unbalanced regional growth (Kaldor, 1972; Myrdal, 1968; Young, 1928). Based on processes of cumulative causation, regions that have different types of advantages – comparative, locational, infrastructural, etc. – grow on the basis of economies of scale and agglomeration due to increasing returns to production, giving rise to trajectories of persistent divergence. More recently, several authors of evolutionary economic geography have contributed to the explanation of these processes from the concepts of path-dependence and place-dependence (Boschma and Frenken, 2018; Boschma and Martin, 2010; Martin and Sunley, 2015; Neffke et al., 2011). Therefore, the productive dynamics of territories is inertial – it tends to reproduce its specialization patterns over time; and it is idiosyncratic – it depends on specific characteristics to each territory.

In Argentina, these divergent dynamics are evident in the structural heterogeneity that exists at the subnational scale in multiple dimensions, resulting in provinces with very different levels of development (Niembro and Starobinsky, 2021). There is a high concentration of productive, technological and innovation capabilities, forming "islands of modernity" of a few innovative firms, mostly concentrated in the central region of the country, that coexist with a majority of firms using obsolete technologies (Katz, 2018; UNIDO, 2019). This reality justifies the study of the relationship between productive dynamics and economic growth from a subnational perspective rather than from a macro approach.

In this context, the questions that guide the research are: what kind of productive patterns explain a better economic performance? What is the role of variety in economic performance? To what extent is the impact of variety on economic growth affected by the level of technological intensity of the production pattern?

Within the framework of evolutionary economic geography, we will approach the study of three types of productive patterns at the subnational level: i) productive efficiency (W), ii) related variety (RV), and iii) unrelated variety (UV) (Boschma and Iammarino, 2009; Frenken et al., 2007; Martin and Sunley, 2015; Saviotti and Frenken, 2008). W gains allude to productivity improvements. The generation of RV refers to diversification around pre-existing sectors in the provincial productive profile, based on the creation of activities that are productively and technologically close. The generation of UV refers to the creation of new industries.

This article seeks to complement the available contributions for the Argentine case (Barletta and Erbes, 2021; Eliçabe et al., 2018; Mancini et al., 2022; Niembro and Sarmiento, 2021; Niembro and Starobinsky, 2021; Rotondo et al., 2016) and provide new empirical evidence on some issues not yet explored. First, it is proposed to extend the study to all industries and not to limit it to manufacturing, as most of the reviewed papers do. At the international level, a new productive configuration is emerging in which knowledge-based services (KBS) are becoming increasingly important, and Argentina is no exception. KBS is the fourth-largest export complex in Argentina, after oilseeds, grains and automotive. It accounts for 10% of Argentina's total exports of goods and services and for 7% of registered employment (INDEC, 2022; OEDE, 2022).

Secondly, we explore to what extent the level of technological intensity of productive profiles affects the impact of the different productive paths on their economic growth. This contribution is based on the idea that variety creation can take place in industries with low technological and low knowledge intensity, particularly in developing countries such as Argentina. In this regard, the presence of intra-national productive heterogeneity is a differential attribute of developing countries, especially within large countries of the Latin American region. Therefore, exploring the Argentinean case might contribute with key productive policy criteria to deal with divergent paths of economic development.

Empirical analysis is based on a database with information at the subnational (province) level, retrieved from the National Ministry of Labor, Employment and Social Security (in Spanish, MTEySS), the Economic Commission for Latin America and the Caribbean (ECLAC), the Iberoamerican Network for Science and Technology Indicators (in Spanish, RICYT), and the National Institute of Statistics and Census (in Spanish, INDEC). The resulting database consists of panel data with economic, productive, social, demographic and science, technology and innovation (STI) information for all the provinces for the period 2004-2019.

Results show that related variety has a negative impact on economic growth in provinces where the productive structure has low technological intensity, while the impact is not significant in provinces with higher levels of technological intensity. Unrelated variety also impacts negatively on the former, but it positively impacts on the latter. Finally, productive efficiency always has a positive and significant impact on economic growth, although it is higher in the case of high-tech productive structures. These results point out the importance of industrial policy to foster productivity, beyond the technological intensity of sectors. Economic growth depends on increasing efficiency across sectors within a productive structure. The results also raise some questions regarding public policy for structural change which is not articulated with other industrial policies connected to technological intensity.

The article is further organized as follows. Based on the literature review, section 1 presents the conceptual arguments regarding the relationship between variety, technological intensity and regional growth, and the research hypotheses. Section 2 describes the data and variables and provides descriptive statistics. Section 3 presents the methodology strategy followed to test the hypothesis and the estimation results. Finally, concluding remarks end the paper as section 4.

1. Variety, technological intensity, and growth

Since the seminal article by Frenken et al. (2007), which introduces the concepts of related and unrelated variety (RV and UV, respectively), several studies have been carried out to provide evidence of this relationship at the regional (subnational) level, mainly for developed countries (see appendix 1).

The concept of RV was introduced by Frenken et al. (2007) to account for Jacobs' externalities. According to Jacobs (1969), industrial diversification in a specific geographic area facilitates the circulation of knowledge flows between firms in different industries, with positive impacts on innovative and economic performance. Ever since then, several studies have attempted to measure the effect of Jacobs' externalities on regional growth, with inconclusive results (Beaudry and Schiffauerova, 2009). Given these inconclusive results, Frenken et al. (2007) suggest that, for Jacob's externalities to occur within a region, there must be some cognitive and productive proximity between productive activities, thus introducing the idea of RV. Many empirical studies at the international level verify this relationship between regional growth and RV (Aarstad et al., 2016; Boschma et al., 2012; Boschma and Iammarino, 2009; Cortinovis and van Oort, 2015; Essletzbichler, 2007; Falcioğlu, 2011; Firgo and Mayerhofer, 2018; Frenken et al., 2005; Fritsch and Kublina, 2016; Hartog et al., 2012; Tomasz and Paweł, 2021).[1] In other words, the creation of related activities in terms of knowledge, capabilities, and resources, within the same industry, has a positive impact on regional performance measured in terms of the evolution of employment.

Following this literature, we propose to test the impact of variety on growth at province level. Hypothesis 1 is based on the idea that the higher the degree of related variety of the productive profile, the more knowledge spillovers will take place as firms obtain new and better ideas from other firms in the same sector that are co-localized, and this will improve economic performance at the aggregate – provincial – level (Boschma and Iammarino, 2009).

H1. Related variety (RV) is positively related to economic growth.

A similar hypothesis is put forward for the relationship between UV and growth. Although Frenken et al. (2007) suggest that UV does not produce inter-industry knowledge spillovers due to the high cognitive and productive distance between distant industries, we propose to empirically verify this relationship for the Argentinean case and we expect to find a positive relationship. There is a long tradition within Latin American literature related to the impact of diversification on economic development. The starting point is a reduced productive structure, which is concentrated in few and low value-added industries. The lack of diversification also

[1] Similarly, the product space approach introduced by Hausman and Hidalgo (Hausmann and Klinger, 2007; Hidalgo et al., 2018), gave rise to the notion of relatedness. Since then, many studies have contributed to the evidence on cognitive and technological proximity between economic activities at the level of firms, regions, and countries (Buyukyazici et al., 2024; Martynovich and Taalbi, 2023; Fitjar, Benneworth and Asheim, 2019; Fornahl et al., 2011; Hidalgo et al, 2007).

impacts on the probabilities of moving upwards in the value-added chain (Dutrénit and Katz, 2005; Erbes et al., 2016). Therefore, we propose that unrelated diversification positively affects gross product growth.

H2. Unrelated variety (UV) is positively related to economic growth.

The third hypothesis relates to productive efficiency. We consider that not only variety but also efficiency impacts on economic performance of provinces (H3). As mentioned in the introduction, the productivity gap with the international technological frontier in developing countries such as Argentina is high, but it is also high within these countries and is observed at different levels: between regions, between industries, and within each industry.

A distinctive feature of these economies is the large productivity differences between firms of different sizes. This gap is explained by the presence of a small group of large firms that innovate and generate technology, and a large group of smaller firms that show a significant technological lag, high levels of labor informality, reduced access to credit, and low-skilled employment, among other factors that explain their low level of productivity. Infante (2011) has documented this phenomenon for Latin America based on the distinction of three productive groups according to the size of firms and the occupational category of the workers: high (large firms with high productivity), medium (small and medium-sized enterprises, SMEs, with an intermediate level of productivity), and low (low productivity microenterprises with high labor informality). In Latin America, the high group produces two thirds of GDP and generates 20% of employment, the middle one generates 22.5% of GDP and represents 30% of employment, while the low group produces 10.6% of GDP and generates 50.2% of employment (Infante, 2011; ECLAC, 2012). Thus, while large firms account for a large part of the GDP with little employment generation, the micro and informal firms make a very marginal contribution to the product but generate half of the employment in the Latin American region. These disparities translate into very unequal productivity levels, with the product per employee of the high group being 16.3 times higher than that of the low group and 4.5 times higher than that of the intermediate group (ECLAC, 2012).

Therefore, the idea behind H3 is that economic growth is explained not only by variety but also by productivity gains, since more laggard regions can increase efficiency of their industries without generating variety. Literature in this case states that, by definition, if developing countries are placed below the technological international frontier, then the implementation of technological upgrades, qualitative improvements, new productive practices, and even an improvement in the use-producer links might induce productivity gains within existent industries (Dutrénit and Katz, 2005). In addition, the further from the technological frontier, the easier and cheaper it is to improve productivity by means of process innovations.

H3. Productive efficiency (W) is positively related to economic growth.

Finally, we propose two hypotheses that introduce the role of the technological intensity level of provincial productive structures. The relationship between variety and economic performance has been tested mainly in developed countries, with productive structures of high relative technological intensity (the United Kingdom, Italy, Netherlands, the United States, etc.). However, as the literature review presented in appendix 1 shows, some scholars consider the role played by technological intensity in the relationship between variety and regional economic performance (Cortinovis and van Oort, 2015; Fritsch and Kublina, 2016; Hartog et al., 2012). H4 and H5 are particularly relevant for the Argentine case, where structural heterogeneity is high and the specialization profiles of most of the provinces have a primary and agricultural manufacturing bias with a low level of technological intensity (Mancini et al., 2022). In addition, given the recurrent economic crisis and the deindustrialization process that took place during the last decades (Cao and Vaca, 2006; Castillo and Martins, 2005), we cannot assume H3 without testing to what extent diversification might imply moving towards even lower levels of value-added industries. In this context, H4 and H5 suggest that the impact of RV and UV on the economic growth of Argentine provinces is conditioned by the technological intensity of the productive profiles.

H4. RV will have a greater impact on economic growth in provinces with productive profiles with greater technological intensity.

H5. UV will have a greater impact on economic growth in provinces with productive profiles with greater technological intensity.

All in all, the hypotheses aim at exploring the relationship between different paths of industrial development within contexts of productive heterogeneity at the intra-national level. Studies focused on developed countries explore different paths of industrial evolution towards more knowledge-intensive sectors, which explains their status as developed countries. In developing countries such as Argentina, the hypothesis of re-primarization cannot be ignored and differential paths of industrial development within the country might provide more valuable information for policy criteria than average values at the country level. In addition, to the extent that there is no evidence of structural change in Argentina during the last decades (Cimoli et al., 2005), looking at productive profiles of provinces might shed light on structural determinants of the economic performance of the country, thus identifying elements that condition any public policy aimed at structural transformations.

2. Data and variables

A database with information at the subnational (province) level was built to test the proposed hypotheses. The territory of Argentina is divided into 23 provinces and one autonomous city (in Spanish, Ciudad Autónoma de Buenos Aires or CABA). Therefore, the Argentine political map is divided into 24 jurisdictions. Hereinafter, by provinces we refer to these 24 territories.

Information was retrieved from the National Ministry of Labor, Employment and Social Security (in Spanish, MTEySS), the Economic Commission for Latin America and the Caribbean (ECLAC), the Iberoamerican Network for Science and Technology Indicators (in Spanish, RICYT), and the National Institute of Statistics and Census (in Spanish, INDEC). The resulting database consists of panel data with economic, productive, social, demographic, and STI information for all the provinces for the period 2004-2019, which is the period that maximizes the number of observations for the key variables.

Following Frenken et al. (2007), the related variety (RV) and unrelated variety (UV) measures were calculated from employment data at 2- and 4-digit industry information (ISIC Rev. 3 classification) for each of the 24 provinces. UV is a measure of entropy for a two-digit industry and indicates the degree to which the share of employment is evenly distributed across sectors at two digits. Formally:

$$UV = \sum_{g=1}^{G} P_g \, log_2 \left(\frac{1}{P_g}\right)$$

where Pg is the share of employment of each 2-digit industry ($g = 1, \dots, G,$) over total provincial employment. UV ranges from 0 (when all employment is concentrated in only one two-digit industry) to $log_2(G)$.

RV indicates the degree to which 4-digit employment is uniformly distributed within its respective 2-digit industry. The underlying assumption is that activities within the 2-digit industry are characterized by a high level of cognitive and productive proximity. Formally:

$$RV = \sum_{g=1}^{G} \quad P_g \, H_g$$

$$Hg = \sum_{i=1;Si \, \epsilon \, Sg}^{I} \quad \frac{p_i}{P_g} g \; log_2 \left(\frac{1}{p_i/P_g} \right)$$

where P_g is the weight of employment in the 2-digit industry S_g and p_i is the share of employment in the 4-digit activity Si (where I= 1,..., I) belonging to the same 2-digit industry S_g. The value of the index ranges between 0 (when employment in each 2-digit industry is concentrated in only one of the 4-digit activities) and $log_2(I) - log_2(G)$, when all 4-digit activities within the 2-digit industries have an equal weight in employment.

There is consensus in the literature on trade and productive diversification about the convenience of using these measures, even though there are some limitations that need to be considered (Frenken et al., 2007; Fritsch and Kublina, 2018). First, these measures are sensitive to the level of sectoral disaggregation. Second, it is assumed that the cognitive distance is wide between 2-digit industries and narrow between 4-digit activities, when this is not necessarily the case following the ISIC classification. For example, wholesale trade and retail trade are classified as two different industries at 2 digits, when it is to be expected that the cognitive distance between them is not necessarily wide.

In addition, and independently from the proposed measure, there is a further limitation for the Argentine case when calculating the measures based on registered employment. In some industries and regions, labor informality represents a significant proportion of total employment. Thus, since data are not available for all sectors, subsectors, and provinces, it is not possible to calculate the total employment, registered and unregistered.

Finally, productive efficiency (W) was approximated with average wages per province per year. Despite the limitations of this variable to account for labor productivity, it is commonly used as a proxy (Mancini et al., 2022).

Table 1 summarizes the characteristics of the variables included in the database and the information sources.

2.1. Descriptive statistics

Figure 1 depicts the average values of UV, RV and W for the period 2004-2019 for each of the 24 provinces.[2] As mentioned in the introduction, Argentina is a country with significant internal gaps, with a concentration of employment, production, and technological capabilities in the provinces of the central region (Barletta and Erbes, 2021; Eliçabe et al., 2018; Mancini et al., 2022; Niembro and Sarmiento, 2021; Rotondo et al., 2016). This is clear in the UV map, which shows higher values of this measure for the central provinces. Similarly, the so-called “Pampeanas” provinces (Santa Fe, Córdoba, Buenos Aires, and Entre Ríos) show the highest values for the RV measure; two other

[2] Average values and standard deviation for each province are included in appendix 2.

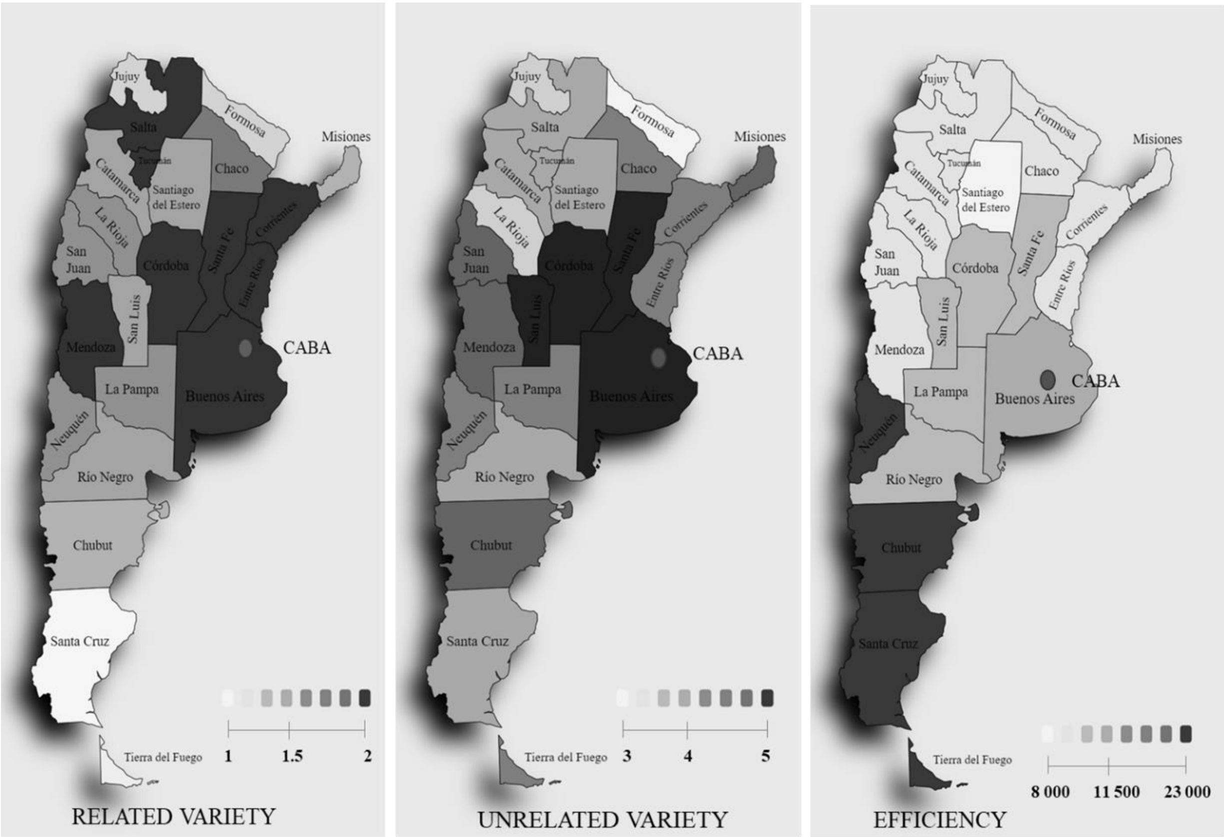
provinces with high values of RV appear outside this zone. Finally, the map for efficiency shows a South-North logic, ranging from high to low wages. In this case, the provinces with the highest salaries are oil-producing ones.

Table 1 – *Summary of variables – key features*

Variable	Description	Unit	Source	Period
Dependent variables				
ΔP	Annual gross product growth rate.	0-∞	ECLAC	2004-2020
ΔPpc	Annual gross product per capita growth rate.	0-∞	ECLAC	2004-2020
Independent variables				
UV	Degree to which employment shares are evenly distributed across two-digit industry. Standardized.	0-∞	MTEySS	1996-2019
RV	Degree to which employment is evenly spread across four-digit subsectors within each two-digit industry. Standardized.	0-∞	MTEySS	1996-2019
W	Average wage. Standardized.	0-∞	MTEySS	1996-2020
Tech	Share of employment in medium-high and high technological intensive manufacturing + knowledge intensive services, based on OECD's classification, to total employment.	0-1	MTEySS	1996-2020
Control variables				
Pop	Number of inhabitants. Annual growth rate.	0-∞	INDEC	1996-2020
X	Total annual exports. Annual growth rate.	0-∞	INDEC	1996-2020
S&T	Number of researchers (in full-time equivalent) per million inhabitants. Annual growth rate.	0-1	RICYT	2004-2020
Year	Time dummies (2004 to 2019).	0/1		
Case identificators				
i	Province identificatory	0-24		
t	Time	2004-2019		

Notes: (i) MTEySS – Ministry of Labor, Employment and Social Security; ECLAC – Economic Commission for Latin America and the Caribbean; RICTY – Iberoamerican Network for Science and Technology Indicators; INDEC – National Institute of Statistics and Census. (ii) Technological intensity of productive structure was calculated considering OECD taxonomy for manufacturing (Hatzichronoglou, 1997) and an ad hoc classification for knowledge intensive services (KIS), based on Consoli and Elche-Hortelano (2010) and Lachman and López (2022). The following codes (ISIC Rev. 3) are considered for definition of KIS: 72.21 Publishing of software; 72.22 Other software consultancy and supply; 72.3 Data processing; 72.4 Database activities; 72.6 Other computer related activities; 73 R&D; 74.11 Legal activities; 74.12 Accounting, book-keeping and auditing activities, tax consultancy; 74.13 Market research and public opinion polling; 74.4 Advertising; 74.14 Business and management consultancy activities; 74.2 Architectural and engineering activities and related technical consultancy; and 74.3 Technical testing and analysis. (iii) P, Ppc, RV, UV and W were standardized and estimated in natural logarithms (Frenken et al., 2007).

Figure 1 – *RV, UV, and efficiency – average values (2004-2019)*



Note: CABA is the Autonomous City of Buenos Aires.

The technological intensity at the provincial level (Tech) was calculated as the ratio between employment in high-tech industries and services to total labor. As was mentioned before, the classification of industries according to their technological intensity is based on OECD's taxonomy (Hatzichronoglou, 1997) for manufacturing and on Consoli and Elche-Hortelano,(2010, and Lachman and López, 2022, for services. The high-tech group includes medium-high and high technological intensive manufacturing industries and KIS. Then, a province *i* belongs to the high-tech group (High) on year *t* if the share of employment in the high-tech sectors is above the mean of the total sample (meaning country average). Consequently, the Low group includes all provinces with a share of employment in the high-tech sectors at each *t* time below the country mean.[3]

Figure 2 depicts average values of Tech for the period 2004-2019.[4] Once again, the central-west region shows the highest levels, followed by the south and the central-east regions. In the

[3] As a robustness check, different classifications were calculated, including median value and quantiles (at the cost of significance of results, given the size of the sample). Econometric results remained the same and are available upon request.
[4] Average values and standard deviation for each province are included in appendix 3.

north, values are lower. This indicator is a good illustration of the magnitude of the structural asymmetries in Argentina. While the average value for the whole period for Buenos Aires is 0.26 (meaning that 26% of labor is employed in high and medium-high sectors), this value drops by up to 0.024 in the case of Catamarca (a northern province). In other terms, the difference between the provinces with the highest share of employment and those with the lowest is more than ten times.

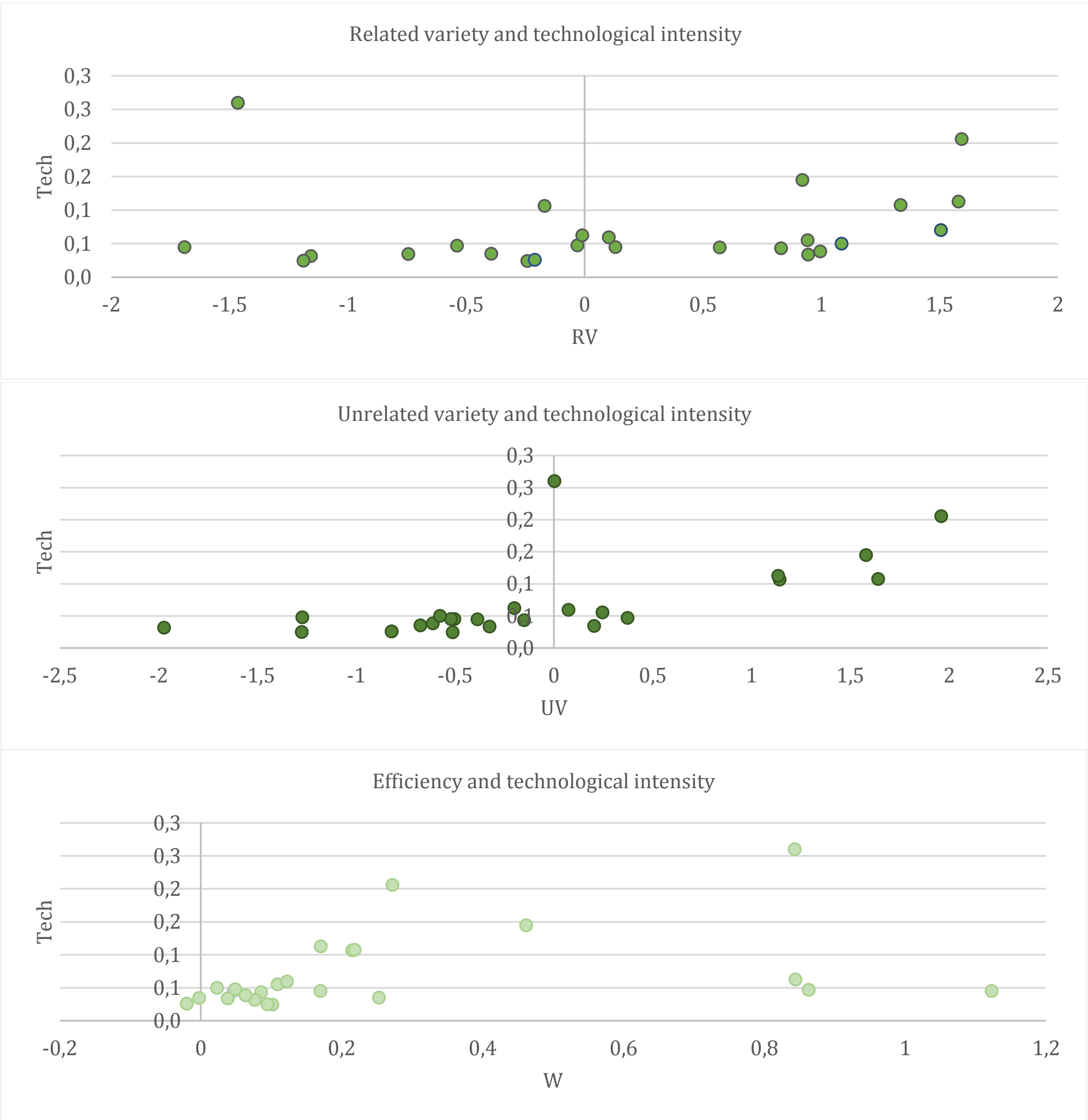
Figure 2 – *Technological intensity and classification – average values (2004-2019)*

Note: CABA is the Autonomous City of Buenos Aires.

Figure 3 summarizes the relationship between the variables of interest and the average technological intensity of provinces. The first observation is the positive relationship between the three variables about productive paths and the technological intensity of provinces. The only extreme outlier is Tierra del Fuego, which is a free trade zone with a special industrial regime based mainly on the maquila.[5] For this reason, the province has a high indicator of technological intensity, with low values for RV, UV, and efficiency. In addition, in the case of the efficiency variable, other outliers are added that correspond to provinces with high salaries due to hydrocarbon exploitation.

[5] Law 19.649/1972.

Figure 3 – *RV, UV, efficiency, and technological intensity – average 2004-2019*



Finally, table 2 presents average values for the rest of the variables and the growth rate of the variables of interest.[6] Similar values are registered between the high-tech and the low-tech groups in the case of gross product average growth rate (1.025 High and 1.025 Low); however, the high-tech group slightly outperforms the low-tech group in terms of per capita values (1.013 vs. 1.12). Given the structural nature of these variables, variations between provinces are expected to be higher than variations within (across time), and that is why differences are reduced in the case of

[6] A correlation matrix is included in appendix 4.

average values between the high-tech and the low-tech groups. RV, UV and W are higher in the High group (0.624, 1.230 and 0.355 versus -0.033, –0.496 and 0.155, respectively) and significant differences are observed for the variable Tech: the relative participation of high-tech labor in the High group is more than 3.7 times the proportion registered in the Low group.

Table 2 – *Descriptive statistics – average (sd) 2004-2019*

	Total sample	**High**	**Low**
ΔP	1.025	1.025	1.025
	(0.060)	(0.068)	(0.058)
ΔPpc	1.012	1.013	1.012
	(0.060)	(0.067)	(0.058)
RV	0.133	0.624	–0.033
	(0.974)	(1.135)	(0.854)
UV	–0.060	1.230	–0.496
	(0.978)	(0.678)	(0.610)
W	0.259	0.355	0.155
	(1.103)	(1.151)	(0.062)
Tech	0.070	0.155	0.041
	(0.019)	(0.062)	(0.012)
Pop	0.013	0.013	0.014
	(0.007)	(0.009)	(0.006)
X	0.089	0.056	0.101
	(0.379)	(0.172)	(0.427)
S&T	0.062	0.052	0.065
	(0.167)	(0.109)	(0.183)
Obs.	384	97	287
Provinces	24	8	18

Notes: For interpretative purposes, ΔL, ΔP and ΔPpc were estimated as the ratio between each variable value in t and t-1.
Source: own elaboration.

4. Estimation strategy and results

The estimation strategy consists of a fixed effect linear regression, which is consistent with the dependent variables and like the estimation strategies of Frenken et al. (2007), which allows comparability of results. Following Frenken et al. (2007), a fixed effects model was selected, given the expected presence of province-level specificities that are time-invariant. The model estimates the impact of RV, UV and W on two measures of economic performance: gross product growth (ΔP) and gross product growth per capita (ΔPpc). Formally:

$$\Delta EP_{it} = \beta_1 + \beta_2 RV_{it} + \beta_3 UV_{it} + \beta_4 W_{it} + Z_{it} + \epsilon_i \quad (1)$$

where economic performance (ΔEP) of province i at time t depends on the growth rate of related variety (ΔRV), unrelated variety (ΔUV) and efficiency (ΔW), and a vector of structural variables (Z), that includes the relative level of employment in high and medium-high intensity industries (Tech), total population (Pop), total annual exports (X), number of researchers in FTE (S&T), and time dummies (Year). $\in_i$ is the usual error term. The Hausman (1978) test for efficiency between random and fixed effects, RE and FE, the Wooldridge (2010) Serial Correlation Test, and the Wald Test for heteroscedasticity were estimated afterwards, in order to assess the specification of the model. P-values are reported after the estimation results.

Equation (1) allows for testing of H1 to H3, where the sign and significance of β_2 to β_4 account for the impact of changes of RV, UV and W on the economic performance of provinces. Then, in order to test H4 and H5, we split the sample, and equation 1 will be estimated for the groups of provinces with high and low technological intensity.

Table 3 exhibits the estimation results for equation 1. Firstly, there is a negative relationship between related variety and gross value and per capita value added. This result is the opposite of what is expected and leads to a rejection of H1. Therefore, contrary to the evidence found in the literature, for the case of Argentina it is verified that the creation of activities close to existing industries has a negative impact on the economic performance of the provinces. The explanation for this result has to do with specificities of the Argentinean case for the years studied. The annual variation of the related variety index at the provincial level, although it does not show significant jumps, is negative in most of the years of the period 2004-2019. This is particularly verified in the provinces that show the best performance in the same period in terms of the evolution of value added. Thus, the result confirms that the generation (destruction) of variety in itself is not a positive (negative) factor for economic performance. The processes of variety generation may not be virtuous, as the creation (destruction) of activities close to the existing productive structure may occur in activities of low (high) technological and innovation intensity. Secondly, H2 is also rejected, but in this case it is because unrelated variety does not impact the economic growth of provinces. Again, this result indicates that the creation of new sectors in the provincial economic structure is not, in itself, a positive factor for economic growth, insofar as the generation of unrelated variety can take place in activities of low technological and innovation intensity. Finally, H3 is confirmed, since W positively impacts economic growth for the two considered dependent variables (gross and per capita product). This result shows that productivity gains have a positive impact on provincial growth regardless of the industry in which they occur.

Table 4 exhibits the estimation results for equation (1) by splitting the sample according to the technological intensity of productive structures of provinces (over and below average values). Results are heterogeneous but tend to confirm H4 and H5. The impact of RV on product growth remains negative but only in the case of low-tech groups: -0.01443 and -0.01440 in the case of gross and per capita product growth, respectively. This result supports the starting premise that, in developing countries like Argentina with large technological asymmetries, the generation of variety does not necessarily translate into a positive factor for growth if it takes place in territories with specialization profiles that are not very intensive in knowledge and technology. In these cases, the generation of variety tends to happen in low value-added manufacturing activities and in non-knowledge-based services, with even negative impacts on regional dynamics.

The impact of UV is significant and positive in the case of the high-tech group, versus a significant and negative impact in the case of the low-tech one, and this remains for both value-added estimations. Within the high-tech group, the impact of UV is 0.08353 and 0.08354 for gross and per capita value added, respectively. Within the low-tech group, these values drop by up to –0.01429 and –0.01431. This is a very interesting result that supports H5, since, once again, the level of technological intensity of the specialization pattern is not neutral to the variety creation. This result suggests that provinces with high technological capabilities have the possibility of diversifying into new industries with higher productivity and dynamism in terms of the possibilities of generating value added, while those with low capabilities diversify into low productivity and low dynamic industries with no impact or a negative impact on value added.

Finally, as with the results observed for the whole panel, productive efficiency (W) has a positive and significant impact on product growth, and it is significantly higher within the high-tech group: 0.40175 and 0.40185 versus 0.16003 and 0.15991 for gross and per capita value added within the high- and low-tech groups, respectively.

Table 3 – *Estimation results – total sample*

	ΔP	ΔPpc
Variable		
RV	–0.02253+	–0.02250+
	(0.011)	(0.011)
UV	–0.00052	–0.00055
	(0.012)	(0.012)
W	0.24535**	0.24527**
	(0.080)	(0.080)
Constant	0.21939**	0.21919**
	(0.050)	(0.050)
Observations	360	360
R-squared	0.740	0.73948
Number of pcia	24	24
Year FE	YES	YES
Population	YES	YES
Tech intensity FE	NO	NO
Exports	YES	YES
S&T FE	NO	NO
Employment	YES	YES
Hausman Test p-value (H0 adequately modeled by RE)	0.0057	0.0058
Wald Test p-value (H0: heteroscedasticity)	0.0002	0.0001
Wooldridge Serial Correlation Test p-value (H_0: no serial correlation)	0.5423	0.5423

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

Table 4 – *Estimation results – high-tech and low-tech groups of provinces*

	ΔP		ΔPpc	
	High-Tech	**Low-Tech**	**High-Tech**	**Low-Tech**
RV	–0.01319	–0.01443*	–0.01321	–0.01440*
	(0.028)	(0.007)	(0.028)	(0.007)
UV	0.08353*	–0.01429+	0.08354*	–0.01431+
	(0.023)	(0.008)	(0.023)	(0.008)
W	0.40175+	0.16003*	0.40185+	0.15991*
	(0.200)	(0.056)	(0.200)	(0.056)
Constant	0.10970	0.17923**	0.10969	0.17899**
	(0.214)	(0.043)	(0.215)	(0.043)
Observations	91	269	91	269
R-squared	0.886	0.730	0.88539	0.72874
Number of provinces	7	18	7	18
Year FE	YES	YES	YES	YES
Population	YES	YES	YES	YES
Tech intensity FE	YES	YES	YES	YES
Exports	YES	YES	YES	YES
S&T FE	YES	YES	YES	YES
Employment	YES	YES	YES	YES
Hausman Test p-value (H0 adequately modeled by RE)	0.1436	0.0446	0.1433	0.0444
Wald Test p-value (H0: heteroscedasticity)	0.0021	0.0002	0.0010	0.0003
Wooldridge Test p-value (H0: no serial correlation)	0.5667	0.4964	0.5667	0.4963

Notes: Robust standard errors are in parentheses. ** = $p<0.01$, * = $p<0.05$, + = $p<0.1$.

Although some of the results are at odds with the literature about diversification discussed in section 1, they are consistent with the literature about productive heterogeneity within Latin America. Our results, which are different from Frenken et al. (2007), show a significant and negative impact of RV on product growth in provinces with productive profiles biased to low-tech industries. The only positive impact is observed in the case of W. Therefore, our results confirm a negative association between diversification and economic growth, thus confirming the alternative hypothesis of a de-industrialization towards industries with lower levels of value added. Our results also differ from those of Frenken et al. (2007) and other cases reviewed in section 2 among provinces with a greater presence of high-tech industries. This answer to our research questions points out the need for UV to take place in articulation with an increase of technological intensity of productive structures.

All in all, our results also point to the relevance of considering productive structures from a subnational perspective to the extent that average values at the country level might ignore the presence of strong productive heterogeneity. In cases like this, a national policy aimed at promoting variety might even negatively impact on development, leading to higher levels of unemployment and lower levels of income. In addition, our results show that there is plenty of margin for improvements on economic performance by means of productive efficiency gains, and this is valid regardless of the technological level of productive profiles.

5. Concluding remarks

The aim of this study was to explore the effects of three different types of productive dynamics on regional economic growth in Argentine provinces. Starting from the conceptual contributions of the evolutionary economic geography approach, in this paper we proposed that productive dynamic is a process that is: i) path dependent; ii) place dependent, iii) involves all industries, not just manufacturing, and iv) is led by three trajectories: unrelated variety (UV), related variety (RV), and productive efficiency (W).

An empirical contribution was made following the RV and UV approach of Frenken' et al. (2007) to account for diversification. In addition, we introduced a measure of productive efficiency, since, for countries far from the technological frontier, as in the Argentinean case, economic growth can also be driven from an increase of productivity in existing industries and not only from diversification. We were also interested in investigating to what extent the level of technological intensity conditioned the impact of variety on economic growth, as suggested by prior research from European countries (Cortinovis and van Oort, 2015; Fritsch and Kublina, 2016; Hartog et al., 2012).

We proposed testing five hypotheses. The first three of them state that RV, UV, and W have a positive impact on economic growth (H1 to H3, respectively). The other two hypotheses propose that RV and UV have a higher impact on economic growth in provinces with high technology-intensive productive profiles (H4 and H5, respectively). The five hypotheses were tested using a panel of 24 provinces in Argentina, with data for the period 2004-2019, considering the available information.

We found no empirical evidence to support the positive impact of diversification on the economic growth of Argentine provinces. As with Cortinovis and van Oort (2015), no significant relationship was found between UV and provinces' economic growth. Instead, in the case of RV, a significant and negative impact on economic growth was verified for both product growth and per capita product growth as dependent variables.

Empirical results have also showed that productive efficiency has a positive impact on economic growth in Argentine provinces. This outcome corroborates H3 and highlights the importance of innovation, not only for variety creation but also for increasing productivity in existing industries. This finding is particularly relevant for developing countries like Argentina, with the presence of high intra- and inter-industry productivity gaps within the country and with the international frontier. The heterogeneous productive structure is characterized by large productivity gaps between firms of different size in the same industry, and between firms belonging to the same industry but located in different territories with unequal access to qualified human resources, infrastructure, and connectivity, among other factors that directly affect competitiveness. In this context, productive efficiency gains are key drivers of economic performance.

When the sample is divided between provinces with high and low technological intensity productive profiles (H4 and H5), we found that the impact of diversification on economic growth is conditioned by the technological intensity. Similar to the outcomes of Cortinovis and van Oort (2015), we found that, for provinces with low technological intensity productive profiles, related variety has a negative impact on economic growth, while no significative impact was found for provinces with high technological intensive productive profiles. Hence, it is possible to think that low technological intensity conditions variety generation in the sense that this variety takes place in industries with low productivity that do not contribute to regional economic growth. Another possible explanation of this result is that RV can take place in industries with a high proportion of informal employment and, as the database contains only registered employment, the employment created by the generation of variety, if informal, is not captured by available data. Finally, the findings support H5, since economic growth is positively affected by UV in provinces with high technology intensity patterns, while a negative relationship is verified for lower technology-intensive provinces. In a similar way, Cortinovis and van Oort (2015) found that, in more technology-intensive European regions, UV is positively associated with productivity growth.

The outcomes add important insights to the debates on diversification and economic growth, both in academic and public policy fields, particularly for Latin American regions. At least two central outcomes emerge. In the first place, economic growth depends on productive efficiency, regardless of the level of technological intensity. In the second place, diversification has differential effects across provinces, according to their technological intensity level. Then, variety is not, in itself, positive for economic growth at the subnational level. In terms of RV, no evidence was found about the role of agglomeration economies in economic growth. In turn, UV has a positive impact on growth only when the technological and knowledge capability of the province is high. In other words, technological and knowledge endowments seem to be more important than diversity for the economic growth of provinces. This outcome opens a new research agenda to study the role played by specialization in economic growth, which we will explore in the next step. Particularly, if the same rationality is applied, we can expect provinces that are highly specialized in technology-intensive industries to have a better economic performance than those specialized in low technology-intensive industries. In other words, since diversification by itself is not enough to increase economic growth, there is no reason to believe that specialization by itself has a negative impact on growth.

Finally, some policy recommendations arise. First, economic growth in lagging industries and regions can be fostered by policies aimed at improving efficiency, productivity, and competitiveness. Second, productive diversification by itself should not necessarily be an industrial policy objective. On the contrary, increasing the content of knowledge, innovation, and R&D capabilities in productive profiles seems to be a necessary precondition for advancing processes for generating variety and creating new medium- and high-technology sectors. Thus, our outcomes challenge the idea that isolated industrial diversification policies are conducive to economic growth. Since diversification opportunities of one region depend on technological and productive endowments, a diversification process does not necessarily mean the creation of activities with high productivity and value added that could contribute to economic growth. In addition, the beneficial effects of agglomeration externalities cannot be exploited in regions without innovation and technological capabilities, in line with the idea of pecuniary knowledge externalities proposed by Antonelli (2008). Therefore, results reached in this research suggest that, in developing economies, the high degree of heterogeneity among firms, industries and regions makes it necessary to think of different policy objectives that recognize this structural heterogeneity.

Appendix 1

Table A1.1 – *Summary of empirical articles on variety (based on employment data*) and regional growth*

Authors (year)	Country	Period	Hypotheses on variety	Methodology	Number of digits for RV and UV calculation	Dependent variables	Results
Frenken, van Oort, and Verburg (2007)	Netherlands	1996-2002	- VR is positively associated with employment growth - VR is positively associated with productivity growth - UV is negatively associated with regional unemployment growth	Ordinary least squares (OLS)	RV = 5 in 2** UV = 2***	• Employment growth • productivity growth • unemployment growth	- VR has a positive and significant impact on the employment growth rate - VNR reduces unemployment growth
Falcioglu (2011)	Turkey	1980-2000	VR is positively associated with productivity growth	Dynamic panel data models	RV = 3 in 2	• Productivity growth	- RV has a positive and significant impact on productivity growth
Tomasz and Paweł (2021)	Poland	2004–2017	- VR positively affects the employment growth rate - There is a negative correlation between VR and unemployment growth - RV positively affects the growth of real wages at the regional level - UV is negatively related to regional unemployment growth	Dynamic panel model, two-step using the SYS-GMM estimator proposed by Blundell and Bond	RV = 2 in 1 UV = 1	• Employment growth, • wage growth, • unemployment rate	- RV has a negative effect on unemployment - UV has a positive effect on unemployment - RV has a significant and positive effect on wages - UV has no significant impact on wages
Firgo and Mayerhofer (2018)	Austria	2000-2013	- RV is positively associated with employment growth - UV is positively associated with employment growth - RV positively affects manufacturing employment growth - RV and UV positively affect employment growth in services	Autoregressive models	RV = 4 in 2 UV = 1	• Growth in total employment (manufacturing and services)	- RV and UV have a positive impact on total employment growth - UV positively affects services employment growth - UV and RV have no effect on manufacturing employment growth
Hartog, Boschma, and Sotarauta, (2012)	Finland	1993-2006	The impact of RV on regional employment growth depends on the degree of technological intensity of the sectors	Dynamic panel data models	RV = 5 in 2 UV = 2	• Employment growth	- VR has no impact on employment growth - VR in technology-intensive sectors has a positive impact on employment growth

Cortinovis and van Oort (2015)	27 EU member states and Norway	2004-2012	- RV is positively associated with employment growth - UV is negatively associated with unemployment growth - UV is positively associated with employment growth - The effects of RV and UV are more pronounced in more technology- and knowledge-intensive economies	Spatial models with panel data	RV = 4 in 2 UV = 2	• Employment growth • productivity growth	- No significant relationship was found between UV and regional economic performance - In more technology-intensive regions, RV is associated with a higher rate of employment growth and lower unemployment - In more technology-intensive regions, UV is positively associated with productivity growth
Fritsch and Kublina (2016)	Western Germany	1999-2008	- RV has a positive impact on employment - UV has a positive impact on employment - The impact of variety on performance is greater in regions with higher R&D intensity	Panel regressions with fixed effects	RV = 5 in 2 UV = 2	• Employment growth	- RV has a positive impact on employment growth - UV has a positive impact on employment growth - The interaction between R&D intensity and RV has no impact on employment growth - The interaction between R&D intensity and UV has a positive impact on employment growth
Mancini, Jelinski, and Lavarello (2022)	Argentina	2008-2018	- RV is positively associated with employment growth - RV is positively associated with an increase in relative productivity - In the contexts of generalized contractions in industrial activity, regions with a higher degree of UV are more likely to limit the rise in unemployment - Sectoral specialization in certain knowledge-diffusing activities reinforces the effect of variety on employment and relative productivity	OLS	RV = 4 in 2 UV = 2	• Employment growth • productivity growth	- RV has a positive impact on employment and wages - UV contributes to maintaining regional employment in periods of macroeconomic contraction - The presence of software industries enhances the impact of UV on employment

Notes: * Only one paper was included (Hartog et al., 2012) that performs the calculation of variety from data on productive establishments and not employment, as it is a relevant background when incorporating the degree of sectoral technological intensity. ** means that the related variety is calculated based on the distribution of employment among the 5-digit branches belonging to each 2-digit sector. *** means that the unrelated variety is calculated based on the presence of employment in 2-digit sectors. The same interpretation applies to the other cases.

Appendix 2

Table A2.1 – *Related variety – average and standard deviation 2004-2019*

Province	Mean	SD
Buenos Aires	1.838	0.030
CABA	1.685	0.019
Catamarca	1.420	0.046
Chaco	1.606	0.051
Chubut	1.353	0.077
Córdoba	1.835	0.018
Corrientes	1.691	0.097
Entre Ríos	1.665	0.031
Formosa	1.212	0.089
Jujuy	1.205	0.086
La Pampa	1.505	0.076
La Rioja	1.469	0.126
Mendoza	1.690	0.025
Misiones	1.306	0.042
Neuquen	1.473	0.047
Rio Negro	1.386	0.048
Salta	1.702	0.057
San Juan	1.499	0.030
San Luis	1.437	0.081
Santa Cruz	1.091	0.024
Santa Fe	1.780	0.035
Santiago del Estero	1.428	0.056
Tierra del Fuego	1.142	0.065
Tucumán	1.723	0.040

Table A2.2 – *Unrelated variety – average and standard deviation 2004-2019*

Province	Mean	SD
Buenos Aires	4.831	0.031
CABA	4.729	0.038
Catamarca	4.164	0.043
Chaco	4.198	0.043
Chubut	4.403	0.029
Córdoba	4.609	0.045
Corrientes	4.215	0.031
Entre Ríos	4.262	0.021
Formosa	3.771	0.101
Jujuy	3.959	0.078

La Pampa	4.167	0.039
La Rioja	3.959	0.047
Mendoza	4.369	0.029
Misiones	4.358	0.037
Neuquen	4.248	0.057
Rio Negro	4.120	0.034
Salta	4.137	0.031
San Juan	4.323	0.050
San Luis	4.611	0.064
Santa Cruz	4.162	0.076
Santa Fe	4.745	0.030
Santiago del Estero	4.081	0.057
Tierra del Fuego	4.303	0.118
Tucumán	4.1472071	0.10751

Table A2.3 – *Efficiency – average and standard deviation 2004-2019*

Province	**Mean**	**SD**
Buenos Aires	11730	13306
CABA	14134	16164
Catamarca	9569	10246
Chaco	8866	10022
Chubut	19216	21900
Córdoba	10439	11823
Corrientes	8763	9844
Entre Ríos	9365	10717
Formosa	9253	10737
Jujuy	9477	10669
La Pampa	10436	12206
La Rioja	8897	9874
Mendoza	9662	10805
Misiones	8249	9142
Neuquen	18979	21702
Rio Negro	11485	13138
Salta	9085	10421
San Juan	9835	10938
San Luis	11003	12448
Santa Cruz	22512	25792
Santa Fe	11048	12573
Santiago del Estero	8029	8899
Tierra del Fuego	18967	20200
Tucumán	8575	9687

Appendix 3

Table A3.1 –*Technological intensity – average and standard deviation 2004-2019*

Province	Mean	SD
Buenos Aires	0.206	0.005
CABA	0.145	0.006
Catamarca	0.024	0.003
Chaco	0.045	0.006
Chubut	0.047	0.006
Córdoba	0.113	0.003
Corrientes	0.034	0.003
Entre Ríos	0.043	0.002
Formosa	0.032	0.011
Jujuy	0.025	0.006
La Pampa	0.045	0.006
La Rioja	0.048	0.006
Mendoza	0.055	0.005
Misiones	0.034	0.006
Neuquen	0.062	0.005
Rio Negro	0.035	0.006
Salta	0.038	0.003
San Juan	0.059	0.007
San Luis	0.106	0.008
Santa Cruz	0.045	0.004
Santa Fe	0.107	0.004
Santiago del Estero	0.026	0.003
Tierra del Fuego	0.260	0.052
Tucumán	0.050	0.007

Appendix 4

Table A4.1 – *Correlation matrix*

	ΔL	ΔP	ΔPpc	RV	UV	W	Tech
ΔL	1						
ΔP	0.645*	1					
ΔPpc	0.631*	0.994*	1				
RV	−0.110*	−0.076	−0.005	1			
UV	−0.010	−0.003	0.017	0.478*	1		
W	−0.178*	−0.440*	−0.445*	0.170*	−0.055	1	
Tech	0.040	0.032	0.005	0.118*	0.619*	0.056	1

Note: * sig 0.05.

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