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Higher education and innovation as factors of competitiveness in four Latin American countries

Educación superior e innovación como factores de competitividad en cuatro países de América Latina

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Abstract

This work establishes the relationship between competitiveness and innovation in higher education overall competitiveness in 4 Latin American countries: Argentina, Brazil, Chile and Mexico. Data are from the World Competitiveness Report prepared annually by the World Economic Forum from 2007 to 2013, the latter year saw 148 countries ranked from 1 to 148, 1 being the most competitive and less competitive 148. Basic, efficiency and innovation: overall competitiveness and three groups of factors are analyzed. After working with pillar 5, higher education and training and the post 12, innovation; relationships between factors, pillars and components for the four countries are established. The analysis shows that Chile has increased competitiveness, based on basic and efficiency factors, occupies on average, 32nd in both cases. Brazil and Mexico are economies that show similarities in strength efficiency factors and weakness in the basic factors. Argentina appears behind his best behavior manifests itself in innovation. The competitiveness of the five pillar in the quality of school management, where the four countries rank well. Another element that has good rating is the enrollment of the university system and the local availability of research. But this pillar also has deformities, as education in math and science behind the four countries listed, place beyond. Regarding the pillar of innovation, the best performances have Brazil, sustained competitiveness in innovation capacity in expenditure on business R & D and in a good university industry relationship. Argentina despite dynamism present in this pillar, has one major drawback is the low government consumption of high-tech goods in 2013 was in place 140.

Resumen

Este trabajo establece la relación entre competitividad e innovación en la educación superior competitividad global en 4 países latinoamericanos: Argentina, Brasil, Chile y México. Los datos provienen del Informe de Competitividad Mundial elaborado anualmente por el Foro Económico Mundial desde 2007 hasta 2013, en este último año se clasificaron 148 países del 1 al 148, siendo 1 el más competitivo y 148 el menos competitivo. Básica, eficiencia e innovación: se analiza la competitividad global y tres grupos de factores. Después de trabajar con el pilar 5, educación superior y formación y el puesto 12, innovación; se establecen las relaciones entre factores, pilares y componentes para los cuatro países. El análisis muestra que Chile ha aumentado la competitividad, en base a los factores básicos y de eficiencia, ocupa en promedio, el lugar 32 en ambos casos. Brasil y México son economías que muestran similitudes en la fortaleza de los factores de eficiencia y debilidad en los factores básicos. Argentina aparece detrás de su mejor comportamiento se manifiesta en la innovación. La competitividad de los cinco pilares en la calidad de la gestión escolar, donde los cuatro países se clasifican bien. Otro elemento que tiene buena calificación es la matrícula del sistema universitario y la disponibilidad local de investigación. Pero este pilar también tiene deformidades, como la educación en matemáticas y ciencias detrás de los cuatro países que figuran, lugar más allá. En cuanto al pilar de la innovación, los mejores resultados tienen Brasil, la competitividad sostenida en la capacidad de innovación en el gasto en I + D empresarial y en una buena relación universidad-industria. Argentina a pesar del dinamismo presente en este pilar, tiene un inconveniente importante es el bajo consumo del gobierno de bienes de alta tecnología en 2013 estaba en el lugar 140.

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Introduction

The aim of this paper is to establish the relationship between the competitiveness of higher education and innovation and overall competitiveness in four Latin American countries. These countries are: Argentina, Brazil, Chile and Mexico. The following considerations are taken into account for the inclusion of these countries: Argentina is the Latin American country with the highest coverage in higher education and the highest rate of completion of studies in the population of young people between 25 and 29 years of age, according to data from the Economic Commission for Latin America (ECLAC). Chile is the country with the most competitive economic system, according to the World Economic Forum (WEF), and Brazil and Mexico are the two largest economies, as well as those that have improved their competitiveness since 2010.

The degree of competitiveness of the countries is based on data from the World Competitiveness Report, which is produced annually by the World Economic Forum on the basis of the Global Competitiveness Index (GCI), which was introduced in 2005.

Competitiveness includes general competitiveness, competitiveness in basic factors, efficiency factors and innovation factors. Of the twelve pillars of competitiveness considered by this organisation, two of them are particularly addressed: number five, which is higher education and training, and number twelve, which is business innovation and sophistication.

This paper aims to answer the following research question: How competitive are the four selected countries globally, and what is the relationship between overall economic competitiveness and the performance of higher education and innovation?

The working hypothesis to be demonstrated is that in the selected countries the levels of competitiveness, both in general and in higher education, pillar five, and innovation, pillar twelve, move in the same direction, i.e. that the latter two pillars have a positive relationship with respect to overall competitiveness.

Theoretical and reference framework

There are at least three different theoretical models on how to observe the competitiveness of countries: the first is structured by the WEF, the second by the Institute for Management Development (IMG) and the third by the German Development Institute.

The World Economic Forum produces an annual Global Competitiveness Report, which since 2005 has been based on the Global Competitiveness Index (GCI), which is constructed considering both microeconomic and macroeconomic factors and seeks to measure the level of competitiveness achieved by each country. It defines competitiveness as "the set of institutions, policies and factors that determine a country's level of productivity. This level establishes the degree of prosperity that an economy can achieve. Productivity also determines the rates of return on investment. An economy with a higher competitiveness index is more likely to achieve better growth rates.

The WEF model bases competitiveness on twelve pillars (Sala-i-Martin, et al., 2013) which it groups into three types of factors: 1) Basic factors for competitiveness; 2) Efficiency factors; and 3) Innovation and business sophistication factors.

Basic factors. This group is composed of four pillars. First pillar, institutions, which are determined by the legal and administrative framework of countries, is where individuals move. Second pillar, infrastructure; this includes transport, where there are roads, railways, ports and air transport; electricity, and telecommunications. Third pillar, the macroeconomic environment; macroeconomic stability is important for business, but above all for the overall competitiveness of countries. Fourth pillar, health and basic education; a country must have a health system that maintains a healthy workforce, but it must also have sufficient and quality basic education.

Efficiency-enhancing factors. This type of factor predominates in countries that are driven by efficiency, the group is made up of six pillars: fifth pillar, higher education and training, this pillar is fundamental for economies that want to move value in their production chain in both processes and products. Pillar six, an efficient goods market, where goods and services can be properly traded in the economy.

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Pillar 7, an efficient labour market, efficiency and flexibility of the labour market are vital to ensure that workers are located where their productivity is highest, where they have incentives and where they contribute their best efforts to the work process. Eighth pillar, financial market development, recent crises have highlighted the importance of the financial market in the development of countries. Pillar nine, technological readiness, focuses on a country's capacity to adequately adapt to new technologies. Tenth pillar, market size, refers to the size of the population and its purchasing power, as the creation of economies of scale is of great importance for a country's development.

Innovation and business sophistication factors. Eleventh pillar, business sophistication, is a pillar that is closely linked to quality in the production and distribution of goods and services and the appropriate use of technologies in the economy. Twelfth pillar, innovation, refers to the innovative capacity of the economy, as pointed out by Sala-i-Martin et al. (2013), this pillar is the one that is most closely related to the fifth pillar of higher education, and of course to the so-called knowledge economy.

Using these pillars and groups of factors as a tool, for 2013, the WEF classifies countries into five groups as follows:

Stage 1 countries. These are countries whose competitiveness is determined by the basic factors. In the 2013 report, this group is composed of 38 countries.

Stage 2 countries. These are efficiency-driven economies. This group consists of 31 economies.

Stage 3 countries. Economies driven by innovation and business sophistication, 37 economies.

In addition, there are two stages that are called in transition.

Countries in transition from stage 1 to stage 2. This group consists of 20 economies.

Countries in transition from stage 2 to stage 3. 22 economies.

In the case of our countries of interest, Argentina, Brazil, Chile and Mexico are in transition from stage two to stage three.

In education and its relationship with the economy and, more specifically, with the competitiveness of countries, it is found that:

Smith (1776/2008) was concerned with the division of labour, the formation of skills and their differentiation in wages and jobs as a consequence of education. Marshall rejected the idea of human capital and, as Blaug (1970) points out, this was the reason for the great lapse in studies of the relationship of education to the economy. Despite this disdain, Marshall considered that the preparation of the labour force was a central element in boosting productive processes, the development of higher productive activity required more education of workers, and he called education the "Energy that makes the individual more efficient and flexible in his work".

In the classics, the analysis of the concern for economic growth was centred on the accumulation of capital per worker to explain differences in productivity, from which comes mechanisation as a means to advance productivity (Faberger, et al., 2010).

With the emergence of human capital studies in the 1960s, the economics of education emerged as a discipline and work on the relationship between economics and education intensified. The work of Schultz, Becker, Denison and Mincer was pioneering in those years. In the field of production function and growth theory, Solow's work on the share of capital and labour in total output was very influential.

Already in the 1990s, Carnoy (1995) pointed out the influence of education on economic productivity and pointed out that this influence could be established in five directions: a) an explanation based on human capital, which is based on the fact that individuals who acquire greater skills through education are better able to produce more and better; b) there is an explanation based on economic disequilibrium, which comes from the classical current of economics and which Schultz (1990) later treats as the re-establishment of economic equilibrium.

A person with more education has a greater capacity to adapt to changes in the economic system, as he/she is able to make better decisions; c) the capacity to adapt and to understand production processes better, as he/she has a better capacity to adapt to production, he/she will have the capacity to produce better goods and services; d) an explanation from the organisational improvement, by having more education they will have a better capacity to organise themselves and with that they will see an increase in productivity, and e) from the improvement of the training capacity, an individual with more education will have a better capacity to follow instructions and achieve a better application of written recommendations in the production processes (López-Leyva et al. , 2012, p. 95).

Lange and Topel (2006), drawing on the formulations developed by Lucas, state that the level of productivity of an economy depends on the average level of accumulated human capital per worker, so a surge of investment in human capital could lead to a surge in productivity growth. These investments would increase the overall productivity of the society and through the complementarity effect, an individual has more human capital when the other members of the community have higher skills. Also through the complementarity effect, growth in other forms of human capital strengthens educational attainment.

These authors (Lange and Topel, 2006) show, by means of an exercise for the 50 states of the United States, that growth in schooling increases the productivity of the economies of the entities and the quality of the labour force they have.

Economists have shown considerable interest in relating education to economic variables, specifically to levels of growth. In this respect, Pritchett (2006) establishes a set of stylised facts about economic growth: (a) growth rates in the leading OECD countries have been fairly stable over the last 100 years; (b) a divergence in average output per worker has been observed between the leading countries and poor countries; (c) a slowdown in economic growth is noticeable, especially in developing countries, mainly from 1970 onwards; (d) average growth rates have been very volatile, especially for developing countries;

(e) not all growth in output per worker can be attributed to changes in the capital-labour ratio, but growth in productivity is an important part of the process; (f) not all growth in output per worker can be attributed to changes in the capital-labour ratio, but growth in productivity is an important part of the process.

He believes that it is difficult to explain the expansion in economic growth by increasing schooling, as the following statements are not consistent with the stylised facts expressed in the previous paragraph: 1) schooling has expanded massively in OECD countries; 2) a marked convergence in education levels across countries has been observed; 3) schooling has grown faster since before the economic slowdown; 4) schooling per worker is not volatile, on the contrary it is very persistent, 5) in most developing countries the contribution of the schooling rate to productivity growth rates has been shown to be very low or negative.

From the 1950s onwards, with the neoclassical growth theory proposed by Solow in 1956 (Solow, 1979), based on a model based on the assumptions of perfect competition. In this model, productivity growth is a result of the increase in the amount of capital associated with the capacity of each worker, and as the capital-labour ratio increases, the marginal productivity of capital begins to decline. The capital-labour ratio becomes constant and productivity stops growing. In this proposal, both variables, the capital stock and the labour force, are determined by exogenous elements.

One of Solow's (1979) successes was to introduce an exogenous category which he called technical progress. In his interpretation, technology or knowledge is a public good, therefore accessible to society as a whole.

Daude (2013) establishes that per capita income in Latin America as a percentage of per capita income in the United States has decreased in the period from 1960 to 2008, in the first year this variable represented 0.225 with respect to the United States and by 2008 it dropped to 0.182, although there are exceptions in Brazil and Chile where this figure increased. On average, according to this author, the 52% drop in this variable in the region is explained by the Solow residual.

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For example, this residual includes the quality of education, where the average of the PISA test in 2009 for eight Latin American countries reached 408 points, almost one hundred points below the OECD average, which corresponds, according to the author, to two years of schooling. The non-equivalence between years of schooling and skills attained is one of the main flaws of these growth models, when considering schooling as a measure of the level of education.

Restuccia (2013) performs an exercise similar to the one mentioned above and finds that in 1960 the average per capita income in Latin America represented 30% of the income in the United States and by 2009, it dropped to 23%. Argentina fell from 48% to 33%; Brazil rose from 19% to 20%; Chile rose from 38% to 42% and Mexico fell from 27% to 25%. Breaking this fall down into three factors, he finds that the explanation for this is due to the fall in the total productivity factor.

On the growth aspect Abramovitz adds the concept of social capability (Faberger, et al., 2010) which is formed by: a) technical competence, provided by education; b) experience in organisation and management of large-scale enterprises; c) financial institutions and markets capable of handling large-scale capital; d) honesty and trust, e) government stability and its effectiveness in defining and enforcing laws and promoting economic growth.

In the early 1990s, with the work of Aghion and Howitt (1992) and Romer (1990) developed what is called the "new growth theory", according to which differences in economic development between countries should be understood as a product of differences between the endogenous knowledge developed and accumulated within the borders of each nation (Faberger, et al., 2010).

Methods and data

First, overall competitiveness over the seven years was analysed for the four countries. Competitiveness was considered by factor groups: core, efficiency and innovation factors. Factor competitiveness was compared with overall competitiveness. The data are shown in Table 1.

Country		2007	2008	2009	2010	2011	2012	2013	Media
Argentina	Competitiveness	85	88	85	87	85	94	104	90
	Basics	83	89	84	82	84	96	102	89
	Efficiency	78	81	84	86	84	86	97	85
	Innovation	83	81	76	71	77	88	98	82
Brazil	Competitiveness	72	64	56	58	53	48	56	58
	Basics	101	96	91	86	83	73	79	87
	Efficiency	55	51	42	44	41	38	44	45
	Innovation	41	42	38	38	35	39	46	40
Chile	Competitiveness	26	28	30	30	31	33	34	30
	Basics	33	36	32	37	29	28	30	32
	Efficiency	28	30	33	35	34	32	29	32
	Innovation	36	44	43	44	42	45	45	43
Mexico	Competitiveness	52	60	60	66	58	53	55	58
	Basics	56	60	59	66	67	63	63	62
	Efficiency	50	55	55	61	53	53	55	55
	Innovation	60	70	67	69	55	49	55	61

Table 1 Behaviour of overall competitiveness and factor competitiveness 2007-2013
Source: Own Elaboration with data from the Global Economic Report. Various years

Table 2 shows the performance data for Pillar 5, Higher Education and Training, which is composed of eight components: enrolment in secondary education, enrolment in tertiary education, quality of the education system, quality of education in mathematics and science, quality of school administration, access to the internet by schools, availability of research and training services, and level of staff training. Only seven elements were considered in this paper, as enrolment in secondary education was not included.

Country		2007	2008	2009	2010	2011	2012	2013	Media
Argentina	Pillar 5	51	56	55	55	54	53	49	53
	University enrolment	19	22	20	19	21	20	15	19
	Quality of education system	105	105	94	90	86	89	104	96
	Quality of mat. and science	95	98	98	106	113	115	116	106
	Quality of school admin.	30	26	23	16	22	34	33	26
	Internet Access Schools	85	90	89	111	106	87	79	92
	Local research	45	60	57	42	44	60	60	53
	Staff training	75	86	81	79	76	78	100	82
Brazil	Pillar 5	64	58	58	58	57	66	72	62
	University enrolment	75	76	73	65	68	80	85	75
	Quality of education system	120	117	103	103	115	116	121	114
	Quality of mat. and science	117	124	123	126	127	132	136	126
	Quality Admin. Schools	66	58	66	73	61	52	49	61
	Internet Access Schools	70	67	64	72	86	88	98	78
	Local Research	32	26	29	36	36	34	38	33
	Staff training	45	46	52	53	33	33	44	44
Chile	Pillar 5	42	50	45	45	43	46	38	44
	University enrolment	41	41	38	43	38	38	21	37
	Quality of education system	78	86	107	100	87	91	74	89
	Quality of mat. and science	107	107	116	123	124	117	107	114
	Quality Admin. Schools	19	19	17	15	14	14	16	16
	Internet Access Schools	39	41	38	42	45	48	48	43
	Local Research	34	46	41	31	33	36	42	38
	Staff training	40	48	39	33	37	38	46	40
Mexico	Pillar 5	72	72	74	79	72	77	85	76
	University enrolment	73	74	75	80	79	78	79	77
	Quality of education system	92	109	115	120	107	100	119	109
	Quality of mat. and science	113	127	127	128	126	124	131	125
	Quality Admin. Schools	49	53	49	52	49	51	65	53
	Internet Access Schools	62	76	77	89	82	82	90	80
	Local Research	52	55	53	55	41	44	50	50
	Staff training	65	87	78	84	80	67	72	76

Table 2 Pillar five competitiveness performance of selected countries (2007-2013)
Source: Data from the Global Competitiveness Report. Various years

Table 3 presents the data for pillar 12, innovation, which has seven components: innovation capacity, quality of scientific research institutions, business spending on R&D, university-business collaboration in R&D activities, consumption of high-tech goods by the public sector, availability of scientists and engineers, and patents per million inhabitants.

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Country		2007	2008	2009	2010	2011	2012	2013	Media
Argentina	Pillar 12	91	98	86	73	78	91	104	89
	Innovation capacity	81	79	69	62	77	95	91	79
	Institutional quality	87	90	59	46	41	47	49	60
	Business R&D expenditure		81	75	72	72	91	105	83
	Uni-Industry Relationship		75	63	53	48	57	61	62
	Government consumption bienes High-tech	113	123	121	130	127	131	140	126
	Scientists-Engineers	76	81	84	76	75	80	83	79
	Patents/million inhab.	47	45	63	52	55	66	66	56
Brazil	Pillar 12	44	43	43	42	44	49	55	46
	Innovation capacity	29	27	29	29	31	34	36	31
	Quality Institutions	42	43	41	42	42	46	42	43
	Business R&D expenditure		31	29	29	30	33	37	32
	Uni-Industry ratio		50	34	34	38	44	49	42
	Government consumption bienes High-tech	67	84	60	60	52	53	69	64
	Scientists-Engineers	60	57	60	68	91	113	112	80
	Patents/million inhab.	55	58	59	61	60	46	51	56
Chile	Pillar 12	45	56	49	43	46	44	43	47
	Innovation capacity	50	57	60	59	66	83	63	63
	Quality Institutions	51	62	57	55	51	42	47	52
	Business R&D expenditure		64	56	52	60	61	58	59
	Uni-Industry ratio		51	41	39	44	39	40	42
	Government consumption bienes High-tech	40	53	54	44	47	37	27	43
	Scientists-Engineers	31	35	23	24	29	29	25	28
	Patents/million inhab.	49	40	54	50	53	46	44	48
Mexico	Pillar 12	71	90	78	78	63	56	61	71
	Innovation capacity	58	67	90	86	76	75	75	75
	Quality Institutions	65	79	65	60	54	49	54	61
	Business R&D expenditure		71	79	90	79	59	61	73
	Union-Industry Ratio		84	62	59	45	42	44	56
	Government consumption bienes High-tech	93	104	93	96	75	67	63	84
	Scientists-Engineers	96	105	94	89	86	71	77	88
	Patents/million inhab.	56	56	60	60	58	58	57	58

Table 3 Performance of the twelfth pillar of innovation and business sophistication (2007-2013)
Source: Data from the Global Competitiveness Report. Various years

Analysis and discussion of results

An analysis of overall competitiveness is carried out considering the three groups of factors: basic, efficiency and innovation. A review is made of the performance of each of the two pillars with respect to overall competitiveness. The components of each of the pillars were then analysed.

Analysis of overall competitiveness

Table 1 shows the overall competitiveness of the countries where Argentina reaches on average the 90th place, with three years: 2007, 2009 and 2011 that reached the 85th place and in contrast in 2013 it went down to the 104th place, which implies a loss of 19 places. The basic factors in this country showed a behaviour very close to the general competitiveness, reaching an average of 89, with the same variations, which shows a high degree of correlation, almost equal to 1. Where this country is better placed is in the innovation factors, which on average reached 82nd place, with years such as 2010.

When it reached 71st place, and 2013 in 98th place, however, they do not show influence on the general competitiveness, because they do not fall as fast as it does. Efficiency factors had an average of 85, a better ranking by four places than overall competitiveness, reaching its worst level in 2013, as it appeared in 97th place, which compared to 2007, 78th place, is a loss of 19 places. Its performance is the furthest away from overall competitiveness, with the lowest correlation. Based on the data presented, Argentina is a country that is losing competitiveness in the international arena. Its worst position is in general competitiveness and in the basic factors, with a high correlation between the two. The best position is in innovation.

Brazil is better placed than Argentina in general competitiveness, achieving an average of 58, but in 2007 it was in 72nd place. In basic factors it performs poorly, as on average it was in 87th place, but it shows improvement, as in 2007 it was in 101st place, and by 2013 it was in 79th place, and also maintains a high correlation with general competitiveness. But those that show the greatest similarity with general competitiveness were the efficiency factors and their behaviour is much better with an average of 45, with little dispersion; but the best average in competitiveness is found in the innovation factors, in 40th place, with its worst year in 2013, since it was in 46th place, it shows a low correlation with general competitiveness, and it is also the only indicator that tends to fall. This is a country that has a modern sector in its economy, with a good innovation index and high business sophistication, but has not solved its problems of infrastructure, credibility of its institutions, macroeconomic performance and basic education and health, but it does show a sustained improvement by maintaining a high correlation in the values of the series. This country must address and resolve in the short term the basic requirements of competitiveness.

Chile is the Latin American country with the best position in general competitiveness, since on average over the seven years it ranked 30th, with its best position in 2007, in 26th place, but its tendency is to lose competitiveness. The basic factors tend to improve and on average rank 32nd, in the same place as the efficiency factors, with the difference that the latter tend to lose competitiveness.

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This improvement in the basic factors makes them negatively correlated with respect to overall competitiveness. The trend in innovation is also towards a loss of competitiveness. Brazil, in contrast to Brazil, lags behind in innovation with respect to the other two types of factors, averaging 43rd place, with little dispersion, but better attention to the basic factors.

Mexico is in 58th place in the competitiveness average, with a tendency towards improvement in this variable, as it reached 66th place in 2010 and 53rd place in 2012. Its worst position is in basic factors, as its average is 62nd, reaching 67th place in 2011, with no improvement in these factors and a low correlation with respect to overall competitiveness. Its best position is in efficiency factors, where it is ranked 55th on average, but its tendency is to lose competitiveness.

In innovation factors it is in 61st place, where it shows a marked improvement since it was in 49th place in 2012. The competitiveness boost is found in the factors of innovation and business sophistication. Like Brazil, it must address the basic requirements.

When analysing by groups of factors, using the averages of each group, it is found that the country that shows the highest overall competitiveness is Chile, in 30th place, Brazil and Mexico have the same average in 58th place, but in 2013, Mexico is in 55th place and Brazil in 56th place, Argentina appears far behind in 90th place on average. In basic factors, Chile also leads, but it is Brazil that has improved its competitiveness the most. In efficiency factors, it is also Chile, but it is Brazil that depends most on these factors, which on average appears in 45th place. In innovation factors, it is Brazil that presents the greatest competitiveness, appearing in 40th place. Brazil is the country that presents the greatest dispersion, since in basic factors it is in 87th place and in innovation factors in 40th place.

Analysis of higher education and training

When reviewing table three and analysing pillar number five, which corresponds to higher education and training, it can be seen that Argentina has improved its position, as in the average of the seven years it is in 53rd place, with a marked advance in 2013, when it moved up to 49th place.

This country is well placed in terms of enrolment in higher education, with an average of 19, with a marked improvement in 2013, when it was ranked 15th, a leap from 22nd place in 2008. Enrolment shows a strong positive relationship with respect to Pillar 5. The worst indicator is achieved in the quality of teaching in mathematics and science, which is in 106th place on average and with a tendency to worsen, as in 2007 it was in 95th place and then 116th in 2013, losing 21 places in seven years. Where it does well is in university administration, where it is 26th on average and in 2010 it was 16th, although slightly, it is tending to worsen. The rating for Internet access is not good, as it is in 92nd place on average; this indicator shows a slight improvement, as in 2010 it was in 111th place and jumped 32 places to appear in 79th place in 2013; its figures are not related to Pillar 5. In terms of research capacity, this country is in 53rd place on average, appearing in 42nd place in 2010; its trend is towards improvement.

In personnel training, Argentina shows a tendency to lose competitiveness, as in 2007 it was in 75th place and by 2013 it had fallen to 100th place, maintaining an average of 82, with no correlation with pillar 5 and showing a tendency to lose competitiveness.

Brazil has an average competitiveness in pillar five of 62 with a worsening trend, as in 2013 it was ranked 72nd, the worst performance in the seven years. This pillar bears no relation to overall competitiveness, as the correlation coefficient is almost zero. In enrolment, it does not show good competitiveness either, as it recorded an average of 75, but also for this indicator, 2013 was a bad year, as it appeared in 85th place, although this component is the one that shows the best correlation with Pillar 5, both tend to worsen in the same proportion.

But an even worse situation is presented in the quality of the higher education system, which reached 114th place on average, but in 2013 went down to 121st place and never reached an indicator lower than 100. The indicator with the lowest performance is the quality of mathematics and science teaching, which on average appears in 126th place, but like the other indicators, its worst performance was shown in 2013, when it appeared in 136th place, of the 148 countries, only twelve countries showed a lower performance than Brazil.

In quality of university administration, it reached 61st place, which improves on previous places, but also shows an improving performance, with a high negative correlation with pillar number five, and is the only indicator that improves its position. Internet access does not perform well as it appears in 78th place, but like other indicators, its worst position was in 2013 with 98th place. The best performance is achieved in local capacity for research, which appears in 33rd place, also tends to worsen, as in 2013 it was in the place

In personnel training it shows a tendency, albeit slight, to improve its competitiveness, as in 2007 it was in 45th place and moved up to 44th place in 2013, and this was its average for the period. It has a very low correlation coefficient with pillar 5.

Chile has an average of 44 in this pillar with a tendency to improve, as in 2013 it was in 38th place, and has a low correlation with overall competitiveness. The behaviour of enrolment is very irregular, its average is 37, but its worst indicator is shown in 2010 when it appears in 43rd place and by 2013 it goes to 21st place, a difference of 22 places, however it is the indicator that has the highest correlation with pillar five, and tends to improve. The quality of the higher education system shows a large difference in Pillar 5, reaching 89th place on average, with a peak of 107th place in 2009, showing a slight improvement over the period. In terms of quality in mathematics and science, it shows a similar trend to the other countries, reaching an average of 114, but also with an irregular behaviour, with its worst year in 2011, when it reached 124th place, and with three years in which it reached 107th place, its trend is worsening.

Chile is a country that holds a good position in terms of university administration, appearing on average in 16th place, with a homogeneous behaviour with a tendency to improve. In terms of access to the Internet by universities, it is in 43rd place, which is on a par with its Pillar 5, but its tendency is to worsen. In terms of local availability of research, it has an average of 38, with its worst performance in 2008, when it appears in 46th place, and its best performance in 2010, in 31st place, showing a slight improvement. Personnel training remains close to 40th place, with a slight tendency to improve.

Mexico in pillar number five appears in 76th place, far behind general competitiveness, with a tendency to worsen, as in 2013 it appeared in 85th place, and also maintains a correlation coefficient of almost zero with respect to general competitiveness.

Enrolment shows an indicator of 77, with a similar behaviour to Pillar 5, i.e. with a worsening trend. The quality of the higher education system shows an average of 109, with a tendency to decline, as in 2007 it was in 92nd place and by 2013 it had fallen to 119th place, which is the worst year for this indicator. But the mathematics and science indicator shows an even worse performance, as the average reaches 125th place, which is one place better than Brazil, it also shows a tendency to decline as in 2007 it was in 113th place, which is not good at all, but went to 131st place in 2013. As in the cases of the previous countries, the indicator of quality in the administration of the higher education system shows a better performance, since it is located on average in 53rd place, although also with a tendency to worsen since in 2007 it was in 49th place and by 2013 it reached 65th place. In Internet access by the universities it does not present an appropriate indicator, since on average it appears in 80th place, but the same as the previous ones, it shows a tendency to decline since in 2007 it was in 62nd place and by 2013 it moved to 90th place.

The best indicator in this fifth pillar is the availability of research, which is in 50th place, with a tendency to improve. Another indicator that has improved, albeit slightly, in recent years is personnel training, which does not correlate with Pillar 5.

In terms of enrolment, the country with the best performance is Argentina, in 19th place. In terms of the quality of the higher education system, Chile is the country with the best indicator with 89 and Brazil the worst with 114. The indicator with the worst performance is quality in mathematics and science, where all four countries are above 100th place. As for university administration, this indicator performed well, as the furthest behind was Brazil in 61st place, but the best placed country, Chile, came in 16th place, which is an excellent ranking. In Internet access, Chile is also the best positioned, in 43rd place, and Argentina the furthest away in 92nd place. Finally, in the local availability of research, the best positioned country is Brazil in 33rd place.

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The country with the best position in this pillar is Chile in 44th place, where its main element is university administration, which is ranked 16th .

Chile shows the greatest dispersion in this pillar, with an excellent indicator in university administration, but a very low ranking in mathematics and science education. The third place is occupied by Brazil in 62nd place on average, below the general competitiveness, the best place for Brazil is the availability of research, which on average appears in 33rd place. Finally, Mexico is in 76th place on average, and its strongest element is also the local availability of research.

Analysis of innovation and business sophistication

Table 3 shows the behaviour of pillar 12, where Argentina shows a tendency to lose competitiveness in this pillar, as in 2007 it was in 91st place, to move to 104th place in 2013, on average it remained in 89th place. Innovation capacity also loses points, as it was ranked 81st in 2007 and 91st in 2013, maintaining a high positive correlation with Pillar 12, both showing a downward trend. The quality of institutions is the only factor that tends to gain positions, as in 2007, this country was in 87th place and by 2013 it was in 49th place, but in 2011 it was in 41st place, with no correlation with the twelfth pillar.

In the expenditure by companies on innovation activities, Argentina remains in 83rd place on average, in 2007 it was in 87th place and by 2003 it was in 105th place, this is the factor that maintains the highest correlation with respect to the twelfth pillar, as it varies in the same direction. A factor that gains positions is the university-industry relationship, from 80th place in 2007 to 61st place in 2013 and maintains an average of 62, its best point was in 2011, when it reached 48th place. The factor that shows the worst performance is the consumption of high-tech goods by the government, moving from 113th to 140th place, which means that only eight governments out of the total considered performed worse than the Argentine government, on average it remained in 126th place. The best place among the factors of the twelfth pillar is occupied by patents, although it loses places, it ranks better than the other factors, in 2007 it was in 47th place and by 2013 it moved to 66th place, with an average of 56, which is the lowest average of all the factors.

In this pillar, Brazil also tends to lose competitiveness, as in 2007 it was in 44th place and by 2013 it moved to 55th place, maintaining an average of 46th place in the period, the correlation with overall competitiveness is very low. The innovation capacity factor is also trending downwards, from 29th place in 2007 to 36th place in 2013, but this is a good ranking for a Latin American country, and it is the factor where Brazil ranks best, averaging 31st place. The quality of research institutions remains very close to the average rank of 43, with a very small drop. It is the same situation for business R&D expenditure, which moves very close to the 32nd place, which is also a good place. In the university-industry relationship, there is no trend of change as the average of the data draws a horizontal line at 42nd place.

Government consumption of high-tech goods shows a tendency to improve, averaging 69th place, although this is not a good place for a country like Brazil. The training of scientists and engineers tends to worsen, ranking 60th in 2007 and 112th in 2013, maintaining a high correlation with pillar 12. The utility of patents shows a tendency to improve, ranking 55th in 2007 and 51st in 2013.

In the case of Chile, although overall competitiveness tends to fall, pillar 12 shows a slight improvement, as in 2007 it was in 45th place and by 2013 it had risen to 43rd place, the relationship with overall competitiveness is very low. In terms of innovation capacity, there is a tendency to lose places, from 50th in 2007 to 63rd in 2013. A different behaviour is in terms of the quality of the institutions where an improvement is observed, the same happens in the expenditure of the companies in R+D. In terms of university-industry relations, the country shows a good performance and is in 42nd place on average, with an improving trend.

The government has played an active role in improving its consumption of high-tech goods, moving from 40th place in 2007 to 27th place in 2013. The training of scientists into engineers is also trending upwards, from 31st place in 2007 to 25th place in 2013, and is the indicator with the best position in this pillar. Finally, the usefulness of patents also shows an improvement.

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In Mexico, pillar 12 shows an improvement as it was ranked 71st in 2017 and 61st in 2013, although its relationship with overall competitiveness is not high, both variables tend to improve. Innovation capacity shows a decreasing competitiveness since in 2007 it was ranked 58th and in 2013 it moved to 75th place, so its correlation with Pillar 12 is null. The quality of institutions is a factor with a tendency to improve, as it jumped from 65th to 54th place in 2013, and this variable is highly correlated with Pillar 12, in fact it is one of the determining factors of this pillar.

The factor that has the highest correlation with Pillar 12 is the university-industry relationship, as it tends to improve in the same proportion as Pillar 12. Another factor that has a high correlation is government consumption of high-tech goods, which shows a jump from 93rd to 63rd place over the period, implying a good improvement, although this is one of the least competitive indicators. The training of scientists and engineers shows an improvement, although it is still the factor that shows the lowest competitiveness, as it was ranked 88th on average, but in 2013 it reached 77th place. Finally, the usefulness of patents shows a slight drop from 56th to 57th place with an average of 58th place.

In pillar 12, the best-placed country is Brazil in 46th place, closely followed by Chile in 47th place. The former bases its competitiveness on business R&D expenditure in 32nd place and innovation capacity in 41st place.

Chile, on the other hand, is based on the training of scientists and engineers in 28th place, on the university-industry relationship in 42nd place and on the consumption of high-tech goods by the government in 43rd place. The country with the greatest dispersion in this pillar is Argentina, which ranks 126th in government consumption of high-tech goods, but 56th in patents.

When analysing the relationship between pillar five and pillar twelve, in the case of Argentina there is a low correlation since higher education shows improvement and in pillar twelve it tends to lose competitiveness. Brazil is the only country where there is a high correlation between both pillars, both show a slight loss of competitiveness, but their relationship is very close.

In the case of Chile, there is also a correlation, although not a high one, with both pillars gaining competitiveness. In Mexico, both pillars lose competitiveness and there is no correlation.

Conclusions

Chile is the country that shows the best competitiveness, this based on the basic and efficiency factors, in both cases it occupies the same average place, 32. In the same place of average competitiveness, in 58th place, are Brazil and Mexico, but in 2013, Mexico was in 55th place and Brazil in 56th place, but with different dynamics, in the case of Brazil it has strengthened in the factors of innovation and efficiency, lagging behind in basic factors. Mexico has also performed well in efficiency factors. These economies show similarities in terms of their strength in efficiency factors and their weakness in basic factors. In the case of Argentina, it appears to lag far behind, but its best performance is in innovation. Then three economies, Argentina, Brazil and Mexico fail to address their basic factors, but they are more competitive in innovation and efficiency. It can be pointed out that they are abnormal economies that present a modern sector closely linked to international economic dynamics, which coexists with a sector that has not managed to meet the basic requirements, where this phenomenon is most acute in Brazil.

The dynamism of competitiveness in pillar five is found in the quality of school administration, which is an element where all four countries rank well, but especially Chile, which on average appears in 16th place. Another element that scores well is the enrolment of the university system, as well as the local availability of research.

Another element that lacks competitiveness is the quality of the education system, despite all the higher education evaluation programmes that have been implemented, but in general, these evaluation policies have focused on improving the institutional aspect of universities, but not on evaluating the quality of education or the level of knowledge offered.

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In terms of the innovation pillar, Brazil has the best performance, a situation that has already been noted. This competitiveness is based on its capacity for innovation, business spending on R&D and a good university-industry relationship. Argentina, despite showing dynamism in this pillar, has a major disadvantage, which is the government's low consumption of high-tech goods; in 2013 it was in 140th place, among the worst of the 148 countries analysed.

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