ANALYSIS

Ariel Coremberg
Beatriz Nofal
University of Buenos Aires and
Argentina's Ministry of Foreign Affairs

A satellite account for measuring the new economy

> If knowledge can create problems, it is not through ignorance that we can solve them.
>
> Isaac Asimov

MEASURING THE NEW ECONOMY

When analyzing the possible effects that innovation may have on employment, a country's role in trade, and global value chains, the creation of a methodological framework that has been empirically verified is fundamental. In this article, we will use the rigorous framework that forms part of the UN System of National Accounts (SNA) to compare sectors and time periods in a way that is consistent with a GDP-based methodology.

To determine the impact of innovation on the economy, we need to distinguish "what should be measured" from "how it should be measured," as Hulten (2004) argued. We also need to avoid what Nobel laureate Tjalling Koopmans called "measurement without theory" in 1970.[1]

Innovation is often described as a basic input activity or in terms of the outcomes that it generates. Investment in research and development (R&D) into products or processes is the most common measure on the input side, while patent numbers are the most common measure on the output side. However, this perspective can only be used to identify expenses or investments that are directly related to innovation and does not allow researchers to discern the sources, transmission, adaptation, and dissemination of these results at the micro-, meso-, and macroeconomic levels.

Nor does the traditional classification of innovations into final products, inputs, and processes explain the impact that innovation can have on the production sector or on welfare. For the innovations that have been acquired or generated to have the desired effect on productivity, firms need to reorganize their production processes, which prompts the need to identify organizational innovations. Likewise, reorganizing the production process would imply a series of complementary expenses and investments for these innovations to take effect, as Brynjolfsson and MacAfee (2011) have analyzed. Finally, bearing in mind the way that international trade currently operates, innovations will have different impacts depending on how the firm or sector in question is integrated into global value chains.

If we accept that the aim of innovation is to increase the knowledge in a society, we need to define the value of that knowledge in economic terms and, more specifically, how its use generates more production, greater productivity, and, ultimately, more knowledge. This poses the challenge of identifying and measuring the knowledge used and generated in the production process—that is, knowledge capital.

A review of the literature points to a set of methodologies that attempt to measure innovation activities and the results of this: compound indicators, indicators of technological intensity, prospective methodologies, satellite accounts, and knowledge accounting.[2]

COMPOUND INDICATORS

The Global Innovation Index (GII) is a more detailed set of simple indicators for other phenomena that affect innovation performance at the national level. It is published by Cornell University, INSEAD, the World Intellectual Property Organization (WIPO) and a core research team in association with the private sector, representatives from the Confederation of Indian Industry, and the firms A.T. Kearney and du Emirates Integration Telecommunications Co.

The GII is a set of indicators that evaluate the performance of different national innovation systems and allows these to be compared. Each country's GII is made up of over 80 indicators, which are grouped into different input pillars that represent different aspects of innovation. Two of these capture evidence of innovation outputs: creative outputs and knowledge and technology outputs. Five describe input factors: institutions, business sophistication, market sophistication, infrastructure, and human capital and research. Each of these pillars is calculated as the weighted average of individual indicators. For example, the market sophistication pillar includes diverse quantitative and qualitative indicators which range from the share of private-sector credit in GDP to the ease of protecting minority investors using distance to frontier scores based on qualitative indicators of governance.

Figure 1 presents the distance between Latin America and the Caribbean and the developed world for different dimensions.

There are significant gaps between Latin America and the developed world in all dimensions. The distance to frontier is especially noticeable at the core of the innovation system for both the generation of innovation and knowledge outputs (patents, ISO 9001 certification, scientific publications, etc.) and input indicators (investment, R&D expenditure, etc.). This gap is somewhat narrower for creative outputs, which is mainly due to the region's notable cultural products. The indicators for Brazil, Chile, Mexico, and Uruguay are all above the regional average. Argentina is a striking example as the features of its national innovation system are typically "Latin American," except for infrastructure and, most notably, human capital and R&D.[3]

However, like any compound indicator, the GII weights components equally without a methodological criterion and thus does not allow each indicator's contribution to employment, growth, or productivity to be calculated, or to be compared with macroeconomic and sector-specific aggregates. For example, the GII does not allow one to determine how far each innovation input (such as education and skills, R&D, and the use of ICTs) contributes to generating macroeconomic and mesosectoral productivity. Although the GII includes patent numbers as an example of innovation results, patents are not the only innovation output and they cannot be compared with productivity metrics.

10%

OF GDP IS MADE UP OF INTANGIBLE ASSETS

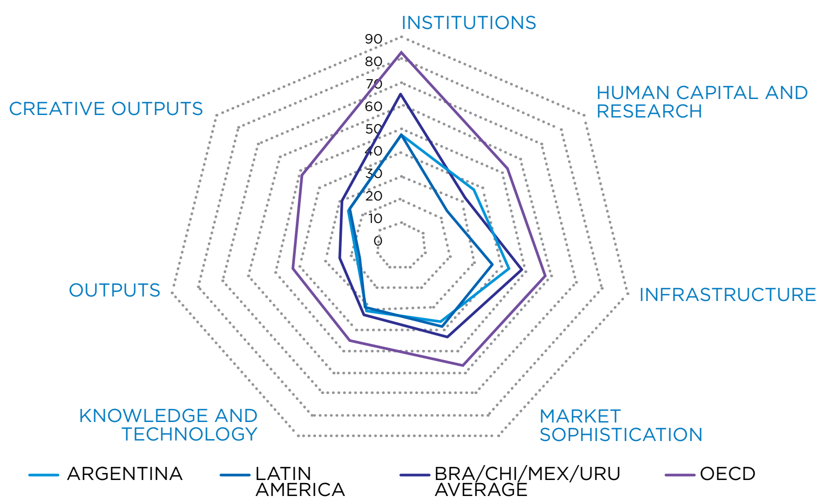
TECHNOLOGICAL INTENSITY INDICATORS

The traditional approaches put forward by the OECD (2013a) and Eurostat (2013) disaggregate production activities according to their technological intensity via the share of R&D expenditure over production value, or value added, or employment of highly skilled labor.

The OECD set out to classify trade flows between countries to determine the relationship between growth, globalization, and innovation. To do so, it created a classification of industrial activities according to their degree of technological intensity, dividing the different manufacturing sectors into high, medium-high, medium-low, and low technological intensity. Technological intensity is defined in relative terms according to the R&D efforts undertaken in each sector or branch of manufacturing.[4] The ranges used to differentiate the technological intensity of industries were as follows: branches that invest more than 5.5% of their turnover in R&D activities are considered high-technology; 5.5%–1.5%, medium-high; 1.5%–0.5%, medium-low; and those that invest less than 0.5% are seen as industries with low technological intensity.

However, the OECD subsequently instigated the design and standardization of the measurement of R&D and innovation activities internationally. The earliest measurements of innovation inputs are in the Frascati Manual, which was followed by the Oslo Manual and the Bogotá Manual, which allow innovation to be approached as a complex process that generates changes in the organization of production, networking, the adaptation of innovations, and new products and processes.

FIGURE 1
GLOBAL INNOVATION INDEX (GII) BY REGION AND AGGREGATE DIMENSIONS



Source: Compiled by the authors.

INNOVATION SATELLITE ACCOUNT

The SNA approach allows theories and methodologies to be adapted to a phenomenon such as innovation, which needs to be defined and measured in a way that encompasses products and activities that are not necessarily compatible with traditional GDP classifications. This issue takes the form of so-called satellite accounts (SAs). To measure the potential impact of innovation on a country's economy, researchers tend to simulate what are known as "indirect and induced effects" through production linkages.

The standard classifications of products and industries (CPC and ISIC) arrange all industries and products at the same hierarchy level. The SNA is flexible enough to regroup them so that a key sector can be analyzed. By so doing, the standard supply and use tables can be estimated for the sector that one wishes to measure by expanding on details that do not appear in the standard presentation. This analysis is contained in the NAs: activities and products need to be regrouped based on a query or focus that usually touches on several activities or aspects of them.

The best-known international examples are the NAs for tourism and health. Recent examples of NAs for Argentina include studies on the intellectual property industries (Massot, Prieto, and Wierny, 2013) and the business of soccer (Coremberg, Sanguinetti, and Wierny, 2016). These experiences have focused on the supply side by including production activities that are associated with, connected to, and generated by the main activity. However, they do not fully calculate the demand side, for which they would need to include not just foreign trade flows but also consumption and investment.

50%

OF GROSS FIXED CAPITAL FORMATION IN EUROPE IS FOR GOODS THAT ARE ONLY MEASURED PARTIALLY

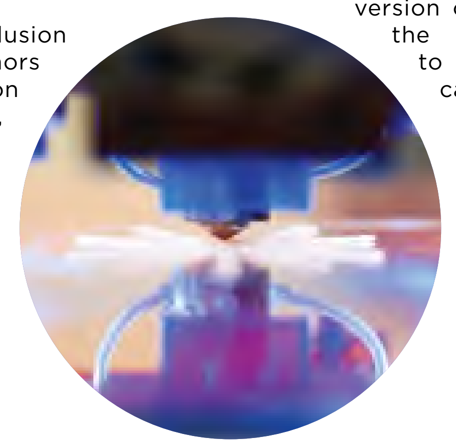
Few NAs have been developed for knowledge, although significant work has been carried out by official NA bodies such as the CBS in the Netherlands and the Bureau of Economic Analysis (BEA) in the United States. In line with the 2008 SNA recommendations, the BEA has counted R&D and expenditures on intangible intellectual property assets as investments since 2013. These include the creation of entertainment, literary, or artistic originals and other intangible assets that have already been capitalized, such as software, adjusting estimates of GDP, savings, investment, and foreign direct investment. The OECD has also created work groups to measure so-called knowledge-based capital (KBC), but it does so partially, only taking intangible assets and the capital of employees in certain jobs into account.

An exhaustive estimate of the knowledge NA would allow researchers to identify and quantify knowledge-generating production activities, but it would not quantify the impact of knowledge on productivity, employment, and trade in production activities that demand, acquire, and adapt innovation and knowledge but do not generate these. Similarly, although the 2008 NSA and the BEA have capitalized R&D and the creation of intellectual property assets, they continue to omit a series of intangible assets that have a major impact on firms' productivity, profitability, and competitiveness.

KNOWLEDGE CAPITAL

Productivity has been stagnating in Latin America and did so even during the period of growth that came with the commodities boom. Despite the effort that many production sectors have made, the macroeconomic gap between the region and developed countries for a range of partial indicators for the intensity of investment in technology continues, despite a substantial improvement in labor skill. However, productivity performances have varied within the region. Using the methodologies analyzed thus far, it is not clear which differential variable at the mesosectoral level will enable R&D to lead to major productivity gains and thus greater competitiveness in international trade.

This is the conclusion reached by authors such as Brynjolfsson and McAfee (2011), who point out that one of the most important factors for innovation to generate increased productivity and profitability in firms is for it to be accompanied by a reorganization of the production process and investment in intangible assets and human capital. The most productive firms reorganize their production processes, incentive systems, information flows, and other aspects of organizational capital to take maximum advantage of technology. This, in turn, requires a more skilled workforce. According to these authors, each dollar invested in hardware requires another ten to be invested in complementary organizational capital. For the organization to be successful, high levels of investment in intangible assets are needed, which organizational capital is part of. Intangible assets are generally much harder to generate and change, but they are also more important to the organization's success.



The 2008 SNA and the *Measuring Capital OECD Manual* (2009) include traditional capital assets within the asset boundary: tangible capital goods (machinery, constructions, livestock for breeding, etc.) and some intangible assets (software, goodwill, patents, etc.) and natural resources (subsoil assets, agricultural land) that are subject to property rights. Changes to the latest version of the SNA include the recommendation to explicitly measure capital services in line with recent advances in measuring productivity and the sources of growth: World KLEMS is the standard initiative used to measure and compare productivity internationally and ARKLEMS+LAND is the Argentine version of this.

TABLE 1
KNOWLEDGE CAPITAL

TANGIBLE ASSETS	**ICTS**	HARDWARE
		TELECOMUNICATIONS
INTANGIBLE ASSETS	**ICTS**	SOFTWARE
		DATABASES
		MINERAL AND PETROLEUM EXPORATION
	PROPERTY OF INNOVATION	SCIENTIFIC R&D
		ARTISTIC AND ENTERTAINMENT ORIGINALS
		NEW PRODUCTS/SYSTEMS IN FINANCIAL SERVICES
		DESIGN AND OTHER NEW PRODUCTS/ SYSTEMS
	ECONOMIC COMPETENCIES	BRAND VALUE
		ADVERTISING
		MARKETING
		FIRM RESOURCES
		STAFF TRAINING
		HIRED HUMAN CAPITAL
		ORGANIZATIONAL STRUCTURE

Source: Coremberg (2016), Corrado et al. (2005) and Mas and Quesada (2015).

As Mas and Quesada (2015) mention, for investment in ICTs and R&D to have a positive effect on firms' productivity, profitability, and market value, a series of complementary investments need to be made to facilitate the efficient adaptation of the remaining components of the production system: education and worker training, brand creation and building, customer loyalty, and other expenses outlaid within the company or subcontracted on the market.

Jorgenson (2001) defines investment as "the use of current resources in the expectation of the investor achieving greater future return." A broader definition would be any use of resources that reduces current consumption in order to increase it in the future (Corrado, Hulten, and Sichel, 2005). It therefore follows that investment in both the generation and use of knowledge needs to be included alongside investment in infrastructure, machinery, and equipment.

In this way, a series of outlays on intangible assets are included within the asset boundary for knowledge capital (see table 1).

Note that this definition expands the asset boundary beyond that used in the 2008 SNA: several factors that the SNA handles as running costs that form part of intermediate consumption are capitalized as production factors here, namely expenditure on design and systems, advertising, market research, expenditure on redesign of organizational structure, and training human capital.

The inclusion of private-sector expenditure on intangible assets in the investment category has significant effects on both the aggregate value of the economy and macroeconomic investment. Mas and Quesada (2015) found that the inclusion of intangible assets increases developed countries' GDP by approximately 10%, doubles investment levels in the United

States, and represents almost 50% of traditional net capital formation in the European Union.

Likewise, building on these proposals from Corrado et al. (2005) and Mas and Quesada (2015), we have included human capital stock in knowledge capital in the form of firms' investment in staff training and hired human capital, as firms demand and use skilled labor trained by other firms; through expenditure on staff training; the experience that workers have accumulated previously in the labor market; and the training they accrue through the education system.

What we are proposing here is for knowledge capital to include expenditure on both the tangible and intangible assets used to generate knowledge and innovation, along with assets that incorporate accumulated knowledge into production according to the classification set out in table 2.

Real-estate assets and unskilled labor are excluded, as they do not include or generate new knowledge. Consequently, we describe them here as "nonreproductive capital" in a way that is analogous to the exclusion of housing as capital, in that nonrental housing is not associated with production activity carried out by certain economic agents.

In this way, by including assets that generate knowledge and the organizational capital needed for knowledge to be used effectively within the production process, we are not only expanding the accounting method for a given country's wealth but also identifying the production services that uses of these assets generate, which enables us to quantify the impact of knowledge capital on growth.

EXTENDED ACCOUNTING

The methodology that we are putting forward identifies knowledge capital by defining assets that sustain and support growth and welfare. Consequently, building on the approach of Pérez and Benages (2015), we are including intangible assets in the knowledge capital.

To do so, we need to define sector-specific indicators for knowledge intensity and identify how these contribute to economic growth. In keeping with Pérez and Benages (2015), we define sector-specific indicators for knowledge intensity as the value of knowledge services used in relation to their production value. We do not classify sectors a priori into categories that are more or less knowledge-intensive, which prevents the discontinuity caused by thresholds that arbitrarily separate groups from one another while enabling us to analyze innovation dynamically. This is expressed as follows:

(1)

$$p_j V_j = \sum_{i=1}^{m} r_{i,j} K_{i,j} + \sum_{h=1}^{n} w_{i,j} L_{i,j}$$

where *pV* is the value added of sector *j*, r_i, is the cost of the use of class *i* capital used by sector *j*, and *w* is the unit wage paid for class *h* work in sector *j*. Grouping production factors by the level of knowledge incorporated *k* allows us to define the knowledge intensity of the value added for sector *j* as:

$$I^k = \frac{K_j^k}{p_j^k V_j}, \text{ con}$$

$$K_j^k = \sum_{i=1}^{m} r_{i,j}{}^k K_{i,j}{}^k + \sum_{h=1}^{n} w_{i,j}{}^k L_{i,j}{}^k$$

TABLE 2

EXPANDED KNOWLEDGE CAPITAL

EXPANDED KNOWLEDGE CAPITAL	**TANGIBLE ASSETS**	**NON-ICTS**	MACHINERY AND EQUIPMENT
			INFRASTRUCTURE
		ICTS	HARDWARE
			TELECOMMUNICATIONS
	INTANGIBLE ASSETS	**ICTS**	SOFTWARE
			DATABASE
		PROPERTY OF INNOVATION	MINERAL AND PETROLEUM EXPLORATION
			SCIENTIFIC R&D
			ARTISTIC AND ENTERTAINMENT ORIGINALS
			NEW PRODUCTS/SYSTEMS IN FINANCIAL SERVICES
			DESIGN AND OTHER NEW PRODUCTS/ SYSTEMS
		ECONOMIC COMPETENCIES	BRAND VALUE
			ADVERTISING
			MARKETING
			FIRM RESOURCES
			STAFF TRAINING
			HIRED HUMAN CAPITAL
			ORGANIZATIONAL STRUCTURE
NON REPRODUCTIVE CAPITAL	REAL ESTATE		
	UNSKILLED LABOR (PRIMARY EDUCATION OR LESS)		

Source: Compiled by the authors.

The sum of all sector-specific aggregate values gives the macroeconomic GDP.

The impact of knowledge capital on growth and productivity can be measured using the growth accounting approach. Macroeconomic growth accounting to identify the main sources of a country's economic growth yields the following equation:

(2)

$$\hat{V} = \varepsilon_k \hat{K}_k + \varepsilon_{nk} \hat{K}_{nk} \varepsilon_L \hat{H} + \hat{A}$$

where *V* is GDP; K_k is aggregate knowledge capital services; K_{nk} is nonreproductive capital services; *H* is hours worked; *L* is human capital services; *A* is total factor productivity (TFP) or the Solow residual; and ε_i represents the product elasticity of each primary input. Likewise, the growth rate for each of the factors is a Tornqvist aggregate of all subclasses of capital and labor (Coremberg, 2009).

Capital services are estimated by reweighting capital stock by asset type according to use costs rather than by asset prices, as per the standard methodology used in, for example, OECD (2009) and Coremberg (2009). If factor elasticities (e) are obtained from national accounts, the contribution of knowledge to economic growth will be given by the share of each knowledge-generating factor of production in GDP, which we can express as a, multiplied by the growth rate.

However, the economic literature has argued that greater expenditure on R&D, improving human capital, ICTs, or technical progress incorporated into machinery and equipment has an additional effect on economic growth that goes beyond its costs.

If there is any type of externality, the accumulation of knowledge capital can be induced by growth in productivity. The learning-by-doing effects that derive from the externality that aggregate investment brings about in firm productivity through increases in the stock of knowledge, as described in Arrow (1962) and Romer (1986), can be extrapolated perfectly to knowledge capital typologies. So, too, can the externalities generated by returns on investment in machinery and equipment, as described in Bradford DeLong and Summers (1991). In this case, true elasticities, ε, may be greater than 1.[5]

In ideal terms, knowledge capital contributes to economic growth through its growth rate weighted by its use cost, but also through the externalities that it generates. In the case of positive externalities, the true factor elasticities (ε) of knowledge capital outstrip its share in terms of costs (α). In this case, the factor elasticity of knowledge capital and measured TFP can be shown to yield the following:

$$\varepsilon_k = \alpha_k + \gamma_k$$

$$\hat{A}^M = \hat{A}^V + \gamma_k \hat{K}_k$$

where γ is the externality generated by knowledge capital.

This demonstrates that, given that these externalities cannot be measured directly, they are included in measured TFP. Given that TFP is a residual, it also captures phenomena other than externalities that may increase the productivity and efficiency of the economy, such as scale effects, markups, quality effects, or embodied technical change that was not captured correctly when factors were measured. However, if the externalities are macroeconomically significant, the growth in TFP can be expected to be positive and significant.

The following scheme summarizes this argument:

ΔK_k ------------------------ ΔQ

ΔK_k ------------------------ $\Delta (Q/L)$

ΔK_k ------------------------ ΔPTF si y solo si $\varepsilon_k > \alpha_k$

To verify potential externality, we would need to prove the correlation between knowledge capital and TFP econometrically. We would also need to establish the temporal precedence of innovation and knowledge generation using a causality test. However, even if these factors are verified, the coefficients may still be biased, inconsistent, and subject to endogeneity problems if knowledge capital is not specified correctly or if another component, such as natural capital, is excluded from these sources of growth (Coremberg, 2016). However, if measured TFP is low or negative, this could be symptomatic of two alternative phenomena. First, the nonexistence or macroeconomic irrelevance of the externalities of a given emblematic or special production factor, in this case, one that originates in investment in a certain type of knowledge capital. Second, the limited use of this factor by the economy.

EMPIRICAL EVIDENCE

In this section, we analyze

Latin America's growth profile by restricting the contribution of knowledge capital to ICT capital services, workforce skill, ad TFP. The inclusion of TFP is justified because part of the knowledge generated by the knowledge society is used in the production sector at no cost. In other words, it has similar nonrivalry and nonexcludability characteristics as intangible assets (see figure 2).

The main factor that explains GDP growth in Latin America is non-ICT capital, followed by labor and knowledge capital, as per the limited definition from the database used here. Using this restricted measurement, the contribution of knowledge capital varies throughout the region. A decomposition of this contribution may provide more evidence regarding the factors that explain its performance, as is shown in figure 3.

The fundamental variable that explains knowledge capital is TFP. This variable underlies the positive and negative performance of the contribution of knowledge capital in each country. ICT capital and workforce skill make a notable contribution in Costa Rica and Chile. The "quality" of the workforce is a key factor in all countries included in the sample.

However, given the limited definition and the absence of a measure of natural capital in the Total Economy Database (TED), we cannot attribute the dynamism of TFP directly to the externalities of intangible assets or ICTs, nor can we specify the scale of this.

MEASURING TRADE

Standard analyses of international trade and growth stress that trade flows allow knowledge to be adapted and spread through imports of high-tech capital goods and inputs. Likewise, exports with high value added may be responsible for spillover effects through the economy due to production chains, in addition to the scale and learning-by-doing effects that they may bring about in firms that take part in international trade. Global value chains are an inescapable fact of life and linkage effects should thus take the spread of knowledge through trade flows into account (Grossman and Helpman, 1991, 2015; Hausmann, Hwang, and Rodrik, 2007; Hausmann et al., 2011).

The methodology for knowledge accounting that we have put forward here can be applied to measuring trade flows. The disaggregation of production value into knowledge factor components can be applied to exports using the assumption of proportionality. This assumption is used by the World Input Output Tables (WIOD) project and the OECD to calculate global value chains. However, the assumption of proportionality supposes that the production functions of domestic output and exportable output are identical.

Different international trade databases allow us to calculate the technological content of exports. However, these draw on unique reference indicators that are based on allocations of fixed value-added coefficients obtained for a single geographic location and period, so our earlier critique of traditional indicators for technological sophistication also applies to them. Comparable indicators based on R&D expenditure are similarly limited, as they exclude other, even more significant components of knowledge capital, such as intangible assets, human capital, and ICTs.

Knowledge accounting for exports would yield the knowledge intensity of the set of assets used in production, provided one accepts the assumption of proportionality.

The knowledge intensity of a given area of activity may be different depending on whether gross value added or total output (sales) is taken as a measure of production. There may be firms that sell products with high knowledge content due to this having been incorporated by other firms into intermediate inputs (purchases) that the selling firm acquires, even though the latter is not knowledge-intensive due to the importance of the machinery or skilled labor that they themselves use in relation to the value added that they generate. Consequently, to be able to apply knowledge accounting to a particular branch of production, we need to be able to quantify the contribution of intermediate inputs to growth in production. With regard to international trade, we need to measure the knowledge intensity of imported and domestic intermediate inputs as well as the intensities of the remaining production factors contained in the exports, as follows:

(3)

$$p_j^X X_j = \sum_{i=1}^{m} r_{i,j} K_{i,j} + \sum_{h=1}^{n} w_{i,j} L_{i,j} + \sum_{l=1}^{p} p_{j,l}^{M} M_{l,j}$$

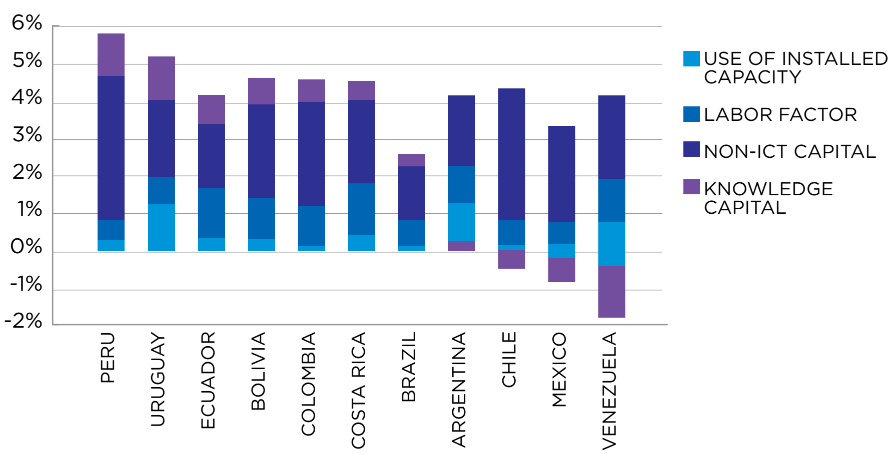
where px is the value of exports at current prices for sector *j*; r_i, is the use cost of the capital used by sector *j*; w_i is the unit wage paid for class *h* work in sector *j*; and pM_i is the price of class intermediate inputs used by sector *j*. Similarly, intermediate inputs can be disaggregated into domestic and imported inputs. Grouping production factors by the level of knowledge incorporated *k* allows us to define the knowledge intensity of sector *j* exports as:

(4)

$$I^k = \frac{K_j^k}{p_j^X X_j}, \text{con } K_j^k = \sum_{i=1}^{m} r_{i,j}{}^k K_{i,j}{}^k + \sum_{h=1}^{n} w_{i,j}{}^k L_{i,j}{}^k + \sum_{l=1}^{p} p_{j,l}^{Mk} M_{l,j}$$

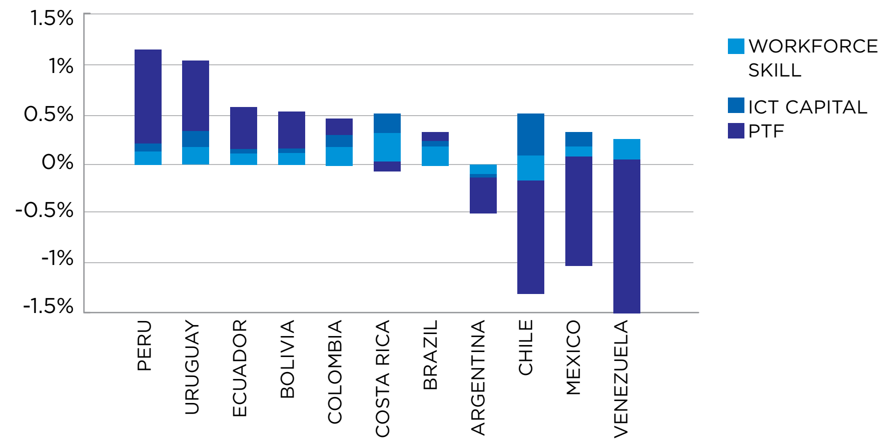
The sum of all sector-specific aggregate values gives the knowledge content of exports. Note that, due to the assumption of proportionality, this is equal to the knowledge intensity of value added plus the knowledge intensity of intermediate inputs.

FIGURE 2
SOURCES OF ECONOMIC GROWTH IN MAJOR COUNTRIES IN LATIN AMERICA (2002–2015)
ANNUAL CONTRIBUTIONS TO GROWTH IN ANNUAL GDP IN %



Source: Compiled by the authors based on data from TED and ARKLEMS+LAND.

FIGURE 3
CONTRIBUTION OF RESTRICTED KNOWLEDGE CAPITAL TO ECONOMIC GROWTH BY ASSET TYPE IN MAJOR COUNTRIES IN LATIN AMERICA (2002–2015).
ANNUAL CONTRIBUTIONS TO GROWTH IN GDP IN %



Source: Compiled by the authors based on data from TED and ARKLEMS+LAND.

THE ROAD AHEAD

The essence of our proposal is to tackle the generation and use of innovation in the economic structure by using methodologies that make it possible to compare sectors with the GDP and one another over time. The aim of doing so is to analyze growing economies and compare them internationally to be able to measure the performance Latin American economies against one another and against the rest of the developing world, especially the BRICS countries, and economies and regional blocs in the developed world.

The methodology that best meets these requirements is the expanded knowledge accounting approach that we have put forward here. Valuing knowledge allows us to quantify the effects of innovation on production activity by considering not only the generation of innovations but also the use of these. Knowledge can be compared across sectors, time periods, and countries if it is measured as an asset that generates production services, basing this calculation on the SNAs and then expanding on them to analyze the sustainability of an economy's growth, as we have proposed here. This approach needs to be exhaustive if we wish to diagnose and predict the effects of disruptive innovation on employment and trade, as it requires a detailed breakdown by sector. Different experiences in Argentina would allow us to reconcile and compare existing economic series and to suggest new surveys and statistical procedures.

This study puts forward a methodology for evaluating the impact of innovation and knowledge on production activity, employment, and trade by delimiting and defining knowledge capital as an asset used by production activities that may potentially generate productivity and sustain growth. The methodology that we have proposed allows innovation and knowledge to be measured by expanding the 2008 SNA asset boundary to obtain a metric that is compatible and comparable with GDP.

Investment in knowledge thus includes not only traditional expenditure on scientific R&D but also nonscientific R&D, such as design, and spending on the creation of entertainment and artistic works, training human capital, advertising, and marketing and other assets included in the literature on intangibles.

NOTES

[1]Una 1. A complete version of this article forms part of an IDB/INTAL Technical Note.

[2] Prospective methodologies such as those of Frey and Osborne (2013) and Arntz, Gregory, and Zierahn (2016) are analyzed in other articles of this issue of Integration & Trade (see the articles by Aboal and Zunino, and Pacini and Sartorio).

[3] Coremberg (2010) provides evidence of major gaps in different types of infrastructure between the Argentine economy, developed countries, and the rest of the region, with and without adjusting for efficiency indicators.

[4]In 1994, the OECD revised its classification of manufacturing industries into 22 sectors, which had been established 10 years earlier based on ISIC Rev. 2 To do so, it drew on more up-to-date information to evaluate the intensity of expenditure on R&D. The relevant information was weighted with an indirect intensity indicator by surveying the intensity of R&D content in the capital goods and intermediate goods used by each sector during production (in addition to the traditional indicator of R&D expenditure as a share of turnover in each sector).

5 For a more exhaustive discussion of other examples of discrepancies between the ε and the α, see OECD (2001), Stiroh (2002), and Coremberg (2009).

REFERENCES

Arntz, M., Gregory, T., and Zierahn, U. 2016. "The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis." OECD Social, Employment and Migration Working Papers No. 189. Paris: OECD Publishing.

Arrow, K.J. 1962. "The Economic Implications of Learning by Doing." *Review of Economic Studies*. 29 (3): 155–173.

Bradford De Long, J., and Summers, L. H. 1991. "Equipment Investment and Economic Growth." *Quarterly Journal of Economics* 106: (2): 445–502.

Brynjolfsson, E., and McAfee, A. 2011. *Race Against the Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy*. Digital Frontier Press.

Coremberg, A. 2009. *Medición de las fuentes del crecimiento en una economía inestable: Argentina. Productividad y factores productivos por sector de actividad*. Buenos Aires: ECLAC.

—. 2010. *El déficit en infraestructura en Argentina*. Buenos Aires: Cámara Argentina de la Construcción.

—. 2012. "La productividad de América Latina ante el auge de precios de productos básicos." Cuadernos Económicos de ICE No. 84. Spain: Ministerio de Economía y Competitividad.

—. 2016. "Accounting for Natural Resources Wealth and Productivity from SNA and Beyond. Testing Natural Resource Curse for Oil and Gas Dependent Countries." Paper presented at the 34th IARIW General Conference. Dresden, Germany.

Coremberg, A., Sanguinetti, J., and Wierny, M. 2016. "El fútbol en la economía argentina. Números sin pasiones." *Journal of Sports Economics & Management*. 6 (1): 46–68.

Corrado, C., Hulten, C., and Sichel, D. 2005. "Measuring Capital and Technology: An Expanded Framework." In: C. Corrado, J. Haltiwanger, and D. Sichel, editors. *Measuring Capital in the New Economy*. Cambridge: NBER.

EU KLEMS. 2007. "EU KLEMS Growth and Productivity Accounts." Accessed: July 31, 2017. http://www.euklems.net.

Frey, C., and Osborne, M. 2013. "The Future of Employment: How Susceptible are Jobs to Computerisation?" Oxford Martin Programme on Technology and Employment.

Grossman, G., and Helpman, E. 1991. *Innovation and Growth in the Global Economy*. Cambridge: MIT Press.

—. 2015. "Globalization and Growth." *American Economic Review*. 105 (5): 100–104.

Hausmann, R., Hidalgo, C., Bustos, S., et al. 2011. *The Atlas of Economic Complexity: Mapping Paths to Prosperity*. Cambridge: CID/Harvard.

Hausmann, R., Hwang, J., and Rodrik, D. 2007. "What You Export Matters." *Journal of Economic Growth* 12 (1): 1–25.

Hulten, C.R..2004. "The Political Economy of Price Measurement: The NAS Report 'At What Price?' and beyond," CRIW Conference Price Index Concepts and Measurement.

ISWGNA. 2009. *System of National Accounts 2008*. New York: European Communities, International Monetary Fund, OECD, United Nations, and the World Bank.

Jorgenson, Dale W. 2001. "Information Technology and the U.S. Economy." *American Economic Review* 91(1): 1–32.

Junker, J.C. 2014. *A New Start for Europe: My Agenda for Jobs, Growth, Fairness, and Democratic Change. Political Guidelines for the Next European Commission*. Strasbourg: European Commission.

Mas, M., and Quesada, J. 2015. "Intangibles en la nueva economía." In: A. Coremberg, editor. *Progresos en medición de la economía*. Buenos Aires: Temas Grupo Editorial.

Massot, J. M., Prieto, K., and Weiry, M. 2013. *The Economic Contribution of Copyright-Based Industries in Argentina*. Geneva: WIPO.

OECD. 2009. *Measuring Productivity OECD Manual*. Paris: OECD.

Pérez, F., and Benages, E. 2015. "Contabilidad del conocimiento: metodología y resultados." In: A. Coremberg, editor. *Progresos en medición de la economía*. Buenos Aires: Temas Grupo Editorial.

Romer, P. M. 1986. "Increasing Returns and Long-Run Growth." *Journal of Political Economy*. 94 (5): 1002–1037.