An estimate of intangible assets for the Mexican economy: 1990-2020

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Abstract

The article presents an overview of intangible investment for the Mexican economy over the last three decades. The series is estimated using an international methodological standard based on the principle of the existence of intangible expenditures, which will not disappear in the production process of a commodity. The results obtained are consistent with international studies. Intangible investment is transversal to the economy and has an average long-term growth rate twice as high as that observed in tangible investment; software is the sector with the most dynamic growth. A pattern of spatial agglomeration of investment is also observed, which responds to the dynamics of the industrial base and the tourism sector in the different metropolitan zones.

Keywords: capital; intangible assets; digitized information; Ownership of Innovation; economic competencies; creative and cultural industries.

1. INTRODUCTION

Since the second half of the 1990s, studies highlighting the importance of knowledge-based economic activities have grown significantly. This structural change is explained by the significant impact of the use of Information and Communication Technologies (ICT) on the economy. Specialized literature identifies two moments in the development of the so-called knowledge economy: the initial moment focuses on the development of ICT (telephony, television, computers, Internet and computer skills) and its consequences on economic growth, and the second highlights the role played by intangible assets, also associated with knowledge, such as software, expenditure carried out on research and development (R&D) and so-called organizational capital (Corrado *et al.*, 2005, 2009 and 2018; Brynjolfsson *et al.*, 2002 and 2017; Mas *et al.*, 2014; Mas, 2020; Roth and Thum, 2013; Jona-Lasinio *et al.*, 2011).

Intangible assets are used more intensively in a knowledge-based economy. It is common for this economy to employ highly skilled, trained workers ranging from scientists to creative people in the arts, complemented by technologically sophisticated physical capital. This accumulates knowledge in design and production and contributes to improving specific capabilities developed within companies. For example, the value of the brand or the trust that a company transmits to the market results from the intangible assets that operate in organizations. Today's overwhelming interest in the knowledge economy provides an opportunity to measure these intangible assets, which are necessary to explain the contemporary economy and, above all, analyze their effects on economic growth.

Thirty-five years ago, Solow (1987) pointed out that the impact of new technologies on productivity could be seen everywhere except in statistics (Solow's *paradox*). Since then, international organizations, statistical offices and the academic community have generated multiple initiatives to expand and modify the treatment of ICT-related information and to gradually consider intangible assets in the National Accounting System (NAS) framework.[1] Software was the first intangible asset recognized as an investment by the NAS in force since 2008. Subsequently, based on a similar criterion, R&D-related investment expenditure began to be considered intangible. In 2013, this integration occurred in the NAS of the United States, followed by the European Community countries. Some NASs are also beginning to include some expenditures associated with mineral exploration and original artists as investments.

However, the most significant amount of intangible assets that experts in the field take into consideration for their measurements are not yet recorded in the NAS. Understandably, official statistical agencies (such as the National Institute of Statistics and Geography [INEGI]) do not estimate, let alone account for, these assets due to conceptual and empirical difficulties. Nevertheless, in the European Community, projects have been generated to estimate intangible assets for a market economy (*intan-invest*) and extend it to incorporate the public sector (*spintan*). These are valuable examples driven by European scholars based on experimental statistics,[2] following the standard methodology proposed by Corrado, Hulten and Sichel (2005) (hereinafter CHS). Consequently, the central objective of this paper is to measure intangible investment flows for the Mexican economy during the period 1991-2020 and for this purpose, a follow-up and adaptation of the CHS methodology was carried out. It should be noted that this paper's authors are unaware of a similar effort having been carried out for Mexico.

The research shows that some stylized facts regarding intangible assets found in other regions of the world, especially developed ones, are reproduced in Mexico. Specifically, for the last 30 years, the Mexican economy has shown a greater dynamism in intangible investment than in tangible investment, which has significant consequences for reassessing the size of GDP and how productive factors, including intangible assets, contribute to the country's economic growth and productivity.

The paper consists of four sections. Section 2 reviews the literature on intangible assets and how their NAS-compatible incorporation has been discussed. Section 3 presents the methodological framework for measuring intangible capital and how it was implemented in Mexico. Section 4 presents the results of the estimations at the aggregate, sectoral and metropolitan zone (MZ) levels. The study ends with conclusions.

2. LITERATURE REVIEW

Nakamura (1999 and 2001) was the first to develop expenditure-based measures for a large number of intangible assets in the US economy. However, it was actually the work of Corrado *et al.* (2005, 2009 and 2018), which denoted a series of studies on the measurement of intangible assets, that provided empirical evidence on their importance for labor productivity growth in Canada (Muntean, 2014), Japan (Fukao *et al.*..., 2009), Australia (Barnes and McClure, 2009), Spain (Mas *et al.*, 2014; Mas, 2020) and the European

Community (Corrado *et al.*, 2018; Goodridge *et al.*, 2013; Roth and Thum, 2013; Jona-Lasinio *et al.*, 2011). The central idea of the standard CHS measurement approach (Corrado *et al.*, 2005) is reclaimed from intertemporal capital theory through the concept that any use of resources (expenditure) that reduces present consumption in order to increase future consumption should qualify or be considered as an investment (Weitzman, 1976; Hulten, 1979), i.e., an asset. [3]

Similar to how traditional (tangible) fixed assets are recorded, expenditure on an intangible asset that will not disappear during the activity but will at least remain partially available for use in subsequent years should be considered as an investment flow. This symmetrical treatment criterion for all expenditures on intangible assets not recorded by official statistical agencies has the enormous advantage of being compatible with the framework used to develop the NAS, facilitating its acceptance among accounting experts and the academic community. Thus, intangible assets can also be considered another source of economic growth.

The aforementioned assessment does not require specific characteristics to define intangible assets and can include a wide range of intellectual, human and organizational capital assets. However, as the subject has developed, alternative definitions have appeared in literature, which focus on the specificity of intangible assets (Schreyer, 2007; Van Criekingen *et al.*, 2021). For example, Cummins's (2005) and Lev and Radhakrishnan's (2005) studies on one of the most important intangible assets concerning quantity and quality, so-called organizational capital, are relevant.[4] There are also the pioneering studies by Brynjolfsson and Hitt (2000) and Brynjolfsson *et al.* (2002), from a microeconomic point of view, which highlight the fact that intangible investment is almost always necessary to complement ICT and software investment with a positive impact on labor productivity. This is in addition to studies that consider the uncertain environment and the specific risk of a company to which expenditure on intangible assets are linked (Hansen *et al.*, 2005).

Many of these initial studies have as a common denominator, i.e., the difficulty in valuing intangible assets, thus hindering the creation or incipient operation of their markets (rental and sale and purchase) compared with the conventional factors of production, labor and tangible capital. As documented in the specialized literature, there is more than one method of measurement. A recent paper on the state of the art of intangible asset measurement records at least six methods (Van Criekingen *et al.*, 2021). Econometric techniques have been widely used, with the specification depending on the assumptions made about the relationships between intangible assets and the rest of the capital assets or their relationship with the product obtained. For example, Lev and Radhakrishnan (2005) use econometric models that explicitly introduce sales and general and administrative expenditures of companies as variables that permit the detection of variations in organizational capital.

At the same time, a way to measure intangible assets based on expenditure has been developed in this respect. The initial literature on intangible assets raised problems of delimitation regarding which assets should and should not be included in a possible extension of the asset boundary of the NAS. This led to the consideration of typology proposals. For example, Black and Lynch (2005) use "intrinsic" characteristics to classify intangible assets into three types, with different levels of difficulty in measuring them: assets that can be bought and sold (type 1), assets that can be controlled by a company but cannot be separated from it or sold (type 2); and assets over which the company has only partial control (type 3). For example, the further you move away from category 1 and into category 3, the more difficult it will be to value at cost. When R&D expenditures are accumulated to create an asset, the implicit assumption is that the "knowledge" produced by these investments has a value equal to the cost incurred in their production. In practice, this is a good approximation to the economic valuation of the "knowledge" asset, compared to the canon originating from the theory that would calculate the present discounted value of future benefits, which is very difficult to observe and estimate. R&D is an asset that falls between category 1 and category 2.

A significant change in measurement, which does not require the use of econometric techniques and which is compatible with the categories used in the preparation of the NASs, has been the proposal of CHS (2005 and 2009), which adapts the usual measurement of tangible capital - conceptually and empirically - to the case of intangible assets.

Official statistical agencies do not yet capitalize intermediate expenditures as intangible capital assets for reasons attributable to the nature of these assets, such as non-rivalry and lack of verifiability, visibility and appropriability of returns (Corrado *et al.*, 2009; Muntean, 2014). It is now recognized that many intermediate forms of expenditure in the economy generate future benefits and qualify as capital, as is the case with expenditure on software, R&D, creative assets and mineral exploration.

From the perspective of a possible reform of the NAS architecture, CHS (2005) follows the aforementioned definition of capital and brings together an organization's knowledge into three broad categories of intangible assets: i) digitized information, ii) ownership of innovation, and *iii)* economic competencies. Finally, empirical works estimating intangible investment flows with these three categories show consistent results and reveal a positive relationship between growth in labor productivity and digitized information via interaction effects with organizational capital (Brynjolfsson *et al.*, 2002 and 2017; Lev and Radhakrishnan, 2005). Other authors use specific dimensions of Ownership of Innovation (R&D) to demonstrate the same effects using the brand equity variable (Roth and Thum, 2013; Cañibano *et al.*, 2000).

There are other issues discussed in the literature that fall outside the scope of this review, but the discussion in this section summarizes the central conceptual and measurement aspects of intangible investment.

3. METHODOLOGICAL FRAMEWORK FOR IMPLEMENTING INTANGIBLE CAPITAL MEASUREMENT

Methodological framework

Insofar as possible, this study follows the methodology initially proposed by CHS (2005). Once they substantiate the extension of the asset frontier in conventional capital theory, they refer their symmetric treatment to intangible expenditures (design, marketing, personnel training and organizational changes) now capitalized as investments in order to make the estimates compatible with the NAS capital categories. The accounting incorporation is illustrated by an economy with three assets, and the form that the basic accounting identity of that intangible expenditure now treated as an investment flow is expressed.

The three produced assets are a consumer good, with a volume of actual output C_t and a P_t^C price, an I_t tangible investment asset with a price P_t^I, and an N_t intangible investment good with a P_t^N price; subscript *t* denotes time. When an intangible good is treated as an investment, the output of the intangible good N_t is incorporated into the production functions[5] of the consumer and tangible investment sectors as capital, which is accumulated and, therefore, no longer used as a contemporary input. Then, in the same way as tangible capital is accumulated, the stock of intangible capital, R_t, is created according to: $R_t = N_t + (1 - \delta_R)R_{t-1}$ (perpetual inventory method); where *R* depreciates at the rate δ_R. Based on these conditions, the production function of each sector, their monetary flows and the corresponding accounting identities can be represented as follows:

Intangible sector:

(1)

$$N_t = F^N(L_{N,t}, K_{N,t}, R_{N,t}, t) \qquad P_t^N N_t = P_t^L L_{N,t} + P_t^K K_{N,t} + P_t^R R_{N,t}$$

Tangible sector:

$$I_t = F^I(L_{I,t}, K_{I,t}, R_{I,t}, t) \qquad P_t^I I_t = P_t^L L_{I,t} + P_t^K K_{I,t} + P_t^R R_{I,t} \tag{2}$$

Consumer sector:

$$C_t = F^C(L_{C,t}, K_{C,t}, R_{C,t}, t) \qquad P_t^C C_t = P_t^L L_{C,t} + P_t^K K_{C,t} + P_t^R R_{C,t} \tag{3}$$

In addition, the balance sheet conditions are represented by: $L = L_N + L_I + L_C$, $K = K_N + K_I + K_C$ and intangible assets: $R = R_N + R_I + R_C$. Note that the intangible capital stock R_t rather than the intangible product is integrated as an input in the production function. The payments for services for using that stock $P_t^R R_t$ appear in the payment equations instead of payments for the intermediate product consumed. The corresponding GDP identity now incorporates the value of the product of the intangible good on the production side, the flow $P_t^N N_t$, and the payments for services of the stock of intangible assets, which is also a flow because it is just that, a payment for the use of this capital ($P_t^R R_t$) on the income side, where P_t^R is called the cost of use:

$$P_t^Q Q_t = P_t^C C_t + P_t^I I_t + P_t^N N_t = P_t^L L_t + P_t^K K_t + P_t^R R_t \tag{4}$$

Suppose we identify $P_t^{Q'} Q'_t$ as the product of the economy without incorporating intangible investment. In that case, it is straightforward to observe, from this accounting identity, that the GDP is more extensive in size than in the case without capitalized intangible assets. It is therefore logical to deduce that:

i) the product is increased from $P_t^{Q'} Q'_t$ to $P_t^Q Q_t$,

ii) the share of intangible investment increases from $P_t^I I_t / P_t^{Q'} Q'_t$ to $(P_t^I I_t + P_t^N N_t)/P_t^Q Q_t$ and

iii) labor participation decreases from $P_t^L L_t / P_t^{Q'} Q'_t$ to $P_t^L L_t / P_t^Q Q_t$

where labor share is the proportion of income paid for the work.

In equivalent studies in the literature, it is standard practice to include a growth accounting exercise, with which it is possible to compare the effects of intangible capital on economic growth and total factor productivity (TFP) between countries. For reasons of space, we shall omit the presentation of results for growth accounting with intangible capital in Mexico and leave it for another paper in progress.

Table 1. Classification of CCI and their identification in the SCIAN industrial catalog

Creative sector	*Economic Census/INEGI*	*Availability based on KLEMS/INEGI*
R+D	5411, 5412, 5413, 5416, 5417, 5419	541
Advertising/design	5414, 5418, 54191	541
Art/Entertainment	71	71
Mass media/film	51911, 512, 515	512, 515-519
Publishing industry	511	511
Software	518, 51913, 5415	517-518, 515-519, 541

Source: Compiled by the authors based on information from economic censuses (INEGI, various years) and the 2020 KLEMS Model.

Methodological implementation

The basis for the implementation of the methodology of CHS (2005) follows the accounting identity of equation 4, which indicates that, in the calculation of the GDP, the expenditure side must be equal to the income side, thus allowing for the estimation of investment flows in intangible assets ($P_t^N N_t$). When a growth accounting exercise is performed, these assets are used to estimate the corresponding stocks (perpetual inventory method) and the cost of use of intangible capital services $P_t^R R_t$.

In this investigation, two strategies are used to estimate the flows of intangible assets. The first is called via surplus and consists of using the total income of the industries that produce the investment of intangible assets. The second is called via expenditure, which consists of using the expenditure made by the economic units on certain intangible items. On this basis, various estimation criteria are generated, considering two sources of information: the economic censuses and the INEGI KLEMS[6] project database. These criteria are based on a classification of creative and cultural industries (CCI) described in Table 1 and identified using the SCIAN classification.

The CCIs are associated with the three fundamental categories of CHS (2005): ownership of innovation, economic competencies and digitized information. Table 2 summarizes the estimation procedure in estimating investment flows, where the first row indicates the criterion and each cell indicates the estimation strategy used (via surplus or

expenditure). Hybrid criteria consider both estimation strategies (surplus and expenditure) in their estimates; in these cases, only the criterion indicated by the cell is considered. In general, Table 2 reflects the adaptation of various recommendations derived from the seminal publication of CHS (2005). Furthermore, this paper links the CCIs and the CHS categories. Only Mas *et al.* (2022) have carried out something similar applied to the case of Spain.

Table 2. Summary of estimated intangible flows: sources and criteria

CHS Classification	*Ownership of Innovation*					*Economic competencies*		*Digitized information*
Creative sector	*R&D*	*Artistic and entertainment*			*Financial*	*Advertising*	*Human Resources*	*Software*
		Media	*Edition*	*Art*				
Economic Censuses								
Criterion A	Surplus	Surplus	Surplus	Surplus		Surplus		Surplus
Criterion B	Expenditure	Surplus	Surplus	Surplus		Expenditure		Surplus
Criterion C	Expenditure	Surplus	Surplus	Surplus		Expenditure	Expenditure	Surplus
Criterion D	Surplus	Surplus	Surplus	Surplus	Surplus	Surplus		Surplus
Criterion E	Expenditure	Surplus	Surplus	Surplus	Surplus	Expenditure		Surplus
Criterion F	Expenditure	Surplus	Surplus	Surplus	Surplus	Expenditure	Expenditure	Surplus
KLEMS								
Criterion A	Surplus	Surplus	Surplus	Surplus		Surplus		Surplus
Criterion Ck	Surplus	Surplus	Surplus	Surplus		Surplus	Expenditure	Surplus
Criterion D	Surplus	Surplus	Surplus	Surplus	Surplus	Surplus		Surplus
Criterion Fk	Surplus	Surplus	Surplus	Surplus	Surplus	Surplus	Expenditure	Surplus

Source: Compiled by the authors based on information from economic censuses and KLEMS from the INEGI.

For the surplus strategy, the gross operating surplus (EBP) of the industries generating intangible assets was considered and the technical coefficients ($\alpha_{i,j}$) of the input-output (I-O) matrix were used to distribute this "investment" among all sectors of the economy ($X_i = EBP_j \cdot \alpha_{i,j}$). In particular, the distribution structure that the $\alpha_{i,j}$ provide in the purchase/sale of inputs is used to distribute the intangible generated by their production sectors across the economy as a whole.[7]

Concerning the expenditure strategy, the economic censuses contain information regarding spending on professional, scientific and technical services, R&D, assumed to be an investment in ownership of innovation, and spending by companies on advertising, which is considered to be an investment in economic competencies associated with marketing (see table 2). Likewise, considering various international studies, the via expenditure estimates assume that all spending carried out by companies on R&D is an intangible investment, while 60% of expenditure on advertising is considered an investment. Similarly, to come closer to the so-called economic competencies, 25% of the remuneration of managers and administrative personnel (in censuses) or of employed personnel with a high level of schooling (in KLEMS) was considered an intangible investment.

Once the series of intangible investment flows by sector have been estimated, the national input-output (I-O) matrix is scaled up to the state, municipal and MZ levels. For this purpose, the Flegg-type location coefficients (Flegg and Webber, 1997 and 2000) were used with the gross value-added variable. The scaled matrices are used following the same procedure described initially in the sectoral distribution of the estimated intangible flows.

4. RESULTS

Added

Using estimates, table 3 reproduces what is schematically plotted in table 2 to illustrate the shares of intangible investment flows with respect to the expanded Gross Censal Value Added (GCVA) (2018), with the latter including the estimate of intangible investment. The last column of table 3 shows the total intangible flows in order to be able to compare the estimates originating from information obtained from Economic Censuses and KLEMS for 2018. The "Criterion A" estimates in both sources of information are very similar at around 2%. In other words, based on the most conservative estimation criterion that only considers the surplus without the financial sector, GCVA in Mexico could increase to just over 2% if investment flows in intangible assets were included. This increase could be as much as 5 or 4% in "C and Ck Criteria", respectively, which include spending on qualified human resources as a proxy for the category of economic competencies, and even reaches nearly 7% with the "Fk Criterion", when the financial sector is taken into consideration. The latter figure is very similar to that estimated in the United States.

Table 3. Share of intangible investment with respect to expanded GCVA or expanded GVA in 2018 (percentage)

CHS Classification	Ownership of Innovation					Economic competencies		Digitized information	Total
Creative sector	R&D	Artistic and entertainment			Financial	Advertising	Human Resources	Software	
		Media	Edition	Art					
Economic Censuses									
Criterion A	0.87	0.47	0.08	0.35		0.17		0.22	2.16
Criterion B	2.28	0.46	0.08	0.34		0.69		0.22	4.07
Criterion C	2.25	0.46	0.08	0.34		0.68	1.14	0.22	5.16
Criterion D	0.84	0.45	0.08	0.33	3.71	0.16		0.21	5.79
Criterion E	2.20	0.45	0.08	0.33	3.64	0.67		0.21	7.56
Criterion F	2.17	0.44	0.08	0.32	3.60	0.66	1.10	0.21	8.58
KLEMS									
Criterion A	0.91	0.27	0.06	0.30		0.17		0.24	1.95
Criterion Ck	0.89	0.27	0.06	0.29		0.16	1.88	0.23	3.79
Criterion D	0.88	0.27	0.06	0.29	3.01	0.16		0.23	4.90
Criterion Fk	0.86	0.26	0.06	0.28	2.95	0.16	1.82	0.23	6.63

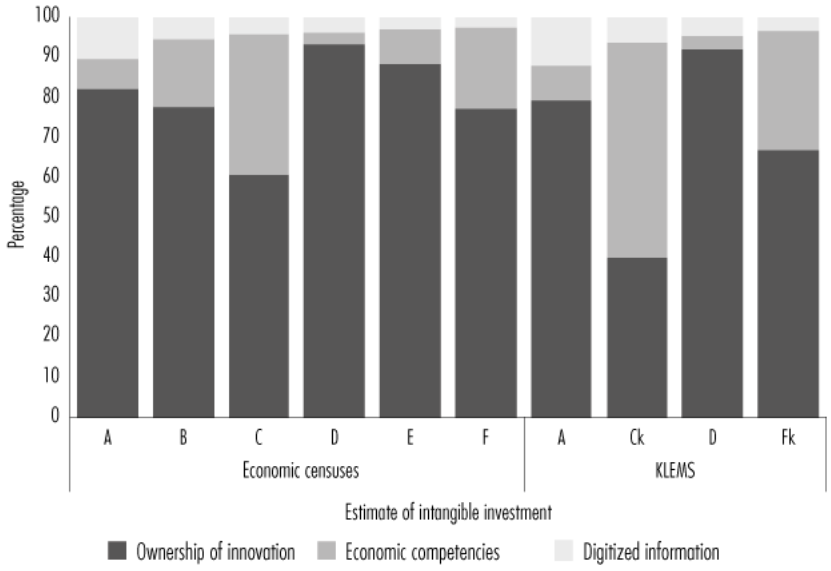
Source: Compiled by the authors based on information from economic censuses and KLEMS from the INEGI.

Table 3 also shows the breakdown of the share of intangible investment according to the CHS categories and creative sectors. In general, R&D has a dominant presence if the financial sector is not included; otherwise, the latter tends to significantly consolidate the investment flows, explaining up to 60% of the flows in the "D Criteria" of both data sources. Software, Publishing and Art have very similar participation in both sources of information, with around 0.22, 0.07 and 0.30%, respectively. In contrast, Media displays a marked discrepancy between economic censuses and KLEMS since the former has an overrepresentation in participation (an average of 0.45%), while the latter is about 0.27%.

One of the results highlighted in table 3 is that the hybrid estimates -which include surplus and expenditure- increase the flows of intangible assets. For example, if R&D expenditures are considered, the share of this sector increases from 0.87 to 2.28 in economic censuses. The same is true for the Advertising sector, which increases its share from 0.17 to 0.69 if expenditure is considered instead of surplus. This indicates the sensitivity of including or not including certain types of expenditure in the estimates. Based on information from the economic censuses, it is possible to analyze these situations since expenditure information is available, at least for the R&D and Advertising sectors. Likewise, including human resources as part of investment flows in intangible assets can increase the expanded Gross Value Added (GVA) by up to 2%.

Figure 1 shows the structure of intangible investment flows according to the CHS classification. In general, the estimation via surplus significantly overestimates the share of ownership of innovation and the hybrid estimation increases the economic competencies sector. Since hybrid estimations predominate in the literature, they will be addressed in the remainder of the text, particularly in the Ck KLEMS estimation that does not include the financial sector. In the latter, economic competencies (EC), Ownership of Innovation (OI) and digitized information (DI) explain 54, 40 and 6% of the intangible flows.

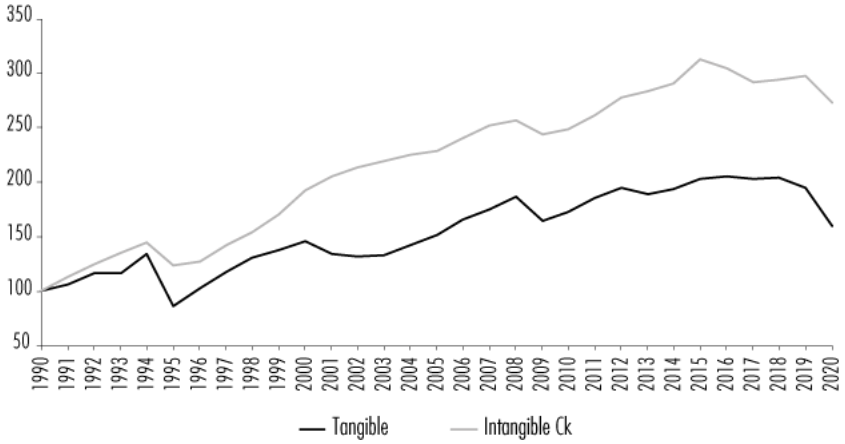
Figure 1. Distribution of intangible investment by CHS categories for each of the criteria



Source: Compiled by the authors based on information from the Klems model KLEMS 2020 (INEGI, 2020).

To present the evolution of intangible investment, figure 2 shows the volume index of the Ck estimate of the TFP-KLEMS series of intangible investment flows from 1990-2020 and includes the series of tangible investment flows (FBKF). The intangible investment series is systematically above the tangible series, reflecting the greater dynamism of intangible investment in the Mexican economy since 1990. An additional observation in figure 2, discussed below, is the slowdown in all series since the 2008 financial crisis, a stylized fact also observed in other countries for the same period.

Figure 2. Investment Index Volume (1990=100)

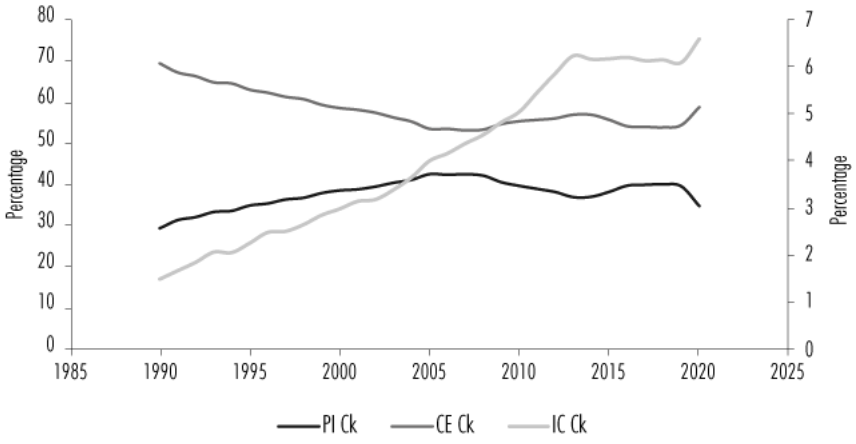


Note: the KLEMS services index is the deflator used for intangible investment, except for the software sector, which uses the TIC index. The FBKF index is used for tangible investment.

Source: Compiled by the authors based on information from the 2020 KLEMS model (INEGI, 2020).

Figure 3 shows the evolution of the CHS structure of intangible investment for the Ck estimate from 1990-2020. The first result to highlight is that despite its size, the DI series shows very significant growth between 1990 and 2013, with its share increasing from just under 2% at the beginning of the 1990s to close to 6% during the second decade of the last century. It subsequently stagnated and rebounded after the Covid-19 health crisis. The significant growth of DI and its gradually increased presence in intangible investment is another stylized fact to highlight in the Mexican case.

Figure 3. Participation series by CHS in Ck



Source: Compiled by the authors based on information from the 2020 KLEMS model (INEGI, 2020).

According to Figure 3, OI shows growth, although not accelerated, between 1990 and 2005, reaching nearly 40% and stagnating until now. Like a mirror, EC follows a decreasing trend until 2005 and stabilizes at around 50%. In general, the behavior of the series is in line with that observed in other regions: OI begins to catch up with EC, but this equalization stagnates in the middle of the first decade of the 21st century, and DI maintains its gradual growth of increased presence, with a possible turning point from the pandemic onwards.

Table 4 shows the average annual growth rates (AAGR) by relevant periods of intangible investment in each of the sectors analyzed pursuant to the Ck criterion. The calculations are performed on a KLEMS basis and the AAGR of intangible investment is also included. Likewise, the AAGR of total intangible investment is calculated with and without the financial sector. In the long run (1991-2020), the AAGR is 2.1 and 2.3 times higher than its tangible counterpart with and without the financial sector, respectively. This confirms that intangible investment has been more dynamic than tangible investment over the analyzed 30-year period. Growth of tangible investment was only considered

to be greater than intangible investment in two of the periods considered: during the 2002-2009 period with a tangible AAGR of 2.5% and an intangible AAGR without the financial sector of 2.14%, and during the 1996-2001 period where the tangible AAGR was 7.46%. The intangible AAGR without the financial sector was 3.93%.

Table 4. Average annual growth rate by periods of intangible flows based on KLEMS information (percentage)

Corrado Classification	Ownership of Innovation (OI)							Economic competencies (CE)			Digitized information	Total intangible without financial	Total intangible with financial	Tangible
Creative sector	R&D	Artistic and entertainment			Financial	Total OI without financial	Total OI with financial	Advertising	Human Resources	Total EC	Software			
		Media	Edition	Art										
Estimation via	Surplus	Surplus	Surplus	Surplus	Surplus			Surplus	Expenditure (25%)		Surplus			
1991-1995	12.95	7.60	6.12	2.80	4.90	7.82	5.80	12.95	1.90	2.39	11.15	4.23	4.51	-3.00
1996-2001	15.22	11.36	0.83	2.37	-5.26	10.24	1.44	15.22	6.44	7.09	20.50	8.48	3.93	7.46
2002-2009	2.55	5.38	-0.44	2.02	9.34	2.64	6.12	3.93	1.02	1.33	10.22	2.14	4.32	2.52
2009-2018	0.17	4.15	-0.11	0.99	5.28	0.92	3.61	-2.32	1.95	1.53	3.38	1.37	2.93	0.91
1991-2007	10.94	8.70	2.39	3.08	3.92	7.61	5.25	11.16	3.30	3.84	15.28	5.43	4.85	3.29
2002-2018	1.93	5.09	0.29	1.91	7.48	2.29	5.21	0.75	1.75	1.66	7.19	2.12	3.95	2.45
2019-2020	0.02	-32.72	-6.18	-37.93	0.02	-10.69	-3.30	0.02	0.89	0.82	-3.40	-3.75	-2.03	-12.24
1991-2020	6.30	4.24	0.94	-0.51	4.01	3.94	3.99	5.63	2.66	2.81	9.81	3.35	3.64	1.57

Note: Calculated AAGR with FBKF deflator for FBKF, tic deflator for software, services deflator for the rest, growth rate by difference of logarithms.

Source: Compiled by the authors based on information from INEGI's KLEMS database.

According to table 4, a "golden" period of intangible investment growth can be observed in 1991-1995 and 1996-2001, where the AAGR of intangible investment without the financial sector was 4.2% and 8.5%, respectively. Since 2002, there has been a slowdown in intangible investment without the financial sector, with an AAGR of 2.1 and 1.4% during 2002-2009 and 2009-2018, respectively. Even in the latter period, the AAGR of tangible investment was higher at 2.5%. Only including the financial sector raised the growth dynamics during these last two periods. In this respect, the 2008 financial crisis accentuated a process of stagnation in the growth of intangible investment. During the pre- and Covid crisis period (2019-2020), the drop in intangible investment (excluding the financial sector) was -3.75%, which is much lower than the registered fall in tangible investment (-12.24%), indicating a higher resilience of intangible investment to the impact of the pandemic.

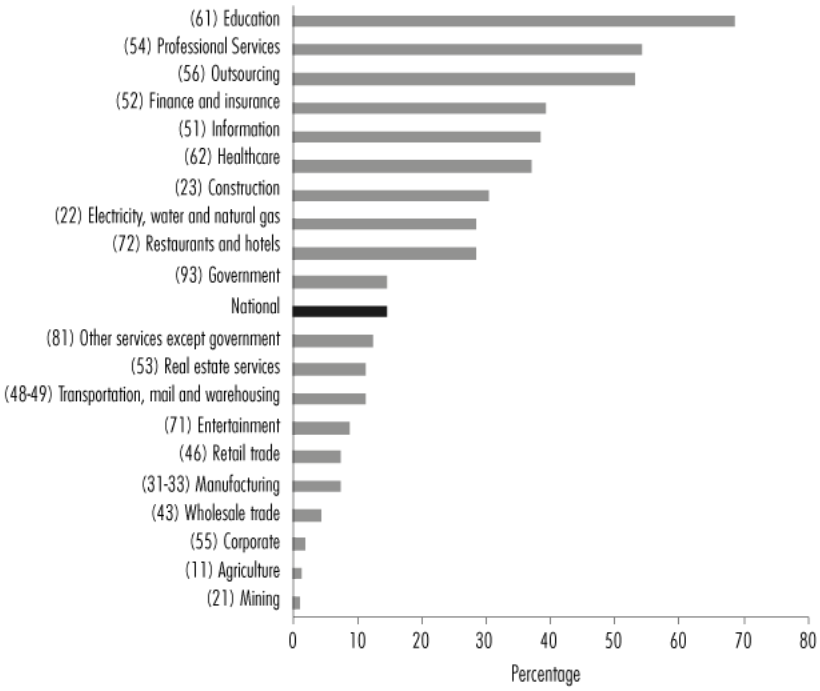
In the 30 years (1991-2020), the creative sectors with the highest AAGR were software (9.8%), R&D (6.3%) and Advertising (5.6%); in clear contrast with the sectors of Publishing (0.94%) and, above all, Art (-0.51%), which had lower AAGR than that observed in tangible investment (1.6%). In this respect, it is essential to highlight that the Art sector shows the most significant delay in using intangible investment.

The slowdown in intangible investment after 2002 does not apply to all sectors. The sectors that performed poorly during the 2002-2018 period were R&D (1.93%), Publishing (0.29%), Art (1.91%), Advertising (0.75%) and Human Capital (1.66%). In contrast, the Media (5.09%), and especially the Financial (7.48%) and Software (7.19%) sectors recorded an AAGR higher than that of tangible non-financial investment (2.12%). Pursuant to the CHS classification, the EC sector experienced the lowest dynamism with an AAGR of 1.66%, while in OI without the financial sector, the rate was 2.3%. However, above all, DI was a long way from global behavior, with an AAGR of 7.2%. Similarly, the resilience of intangible investment in the aggregate in the face of crises and shocks, such as the Covid-19 pandemic, only occurred in R&D, Finance, Advertising, Human Capital and, to a lesser extent, Software since the Media and Art sectors experienced dramatic negative AAGR of -32.7% and -37.93%, mainly because the latter sectors depend to a large extent on face-to-face activities.

Sectorial

An important aspect to identify is which sectors invest more in intangible than tangible assets. At the outset, it is worth noting that 15% of the total expanded investment (Ck estimate) corresponds to intangible assets in 2018. The sectors of the economy that invest more in intangible assets in order of importance are Education (69%), Professional Services (54%) and Outsourcing (53%) (see figure 4). These are followed by the Information and Finance-Insurance sectors with close to 40% and then the Energy-Water-Gas, Construction and Restaurants-Hotels sectors with a share of intangible assets close to 30%. All these sectors are the most intangibilized sectors.

Figure 4. Intangible assets as a percentage of total expanded investment by sector



Source: Compiled by the authors based on information from the 2020 KLEMS model (INEGI, 2020).

Table 5 presents the distribution of tangible and intangible investment (Ck estimate) in 2018 by sector and each CHS category. The main sectors concentrating tangible investment are Manufacturing (22%), Corporate (13%), Real Estate Services (13%) and Wholesale Trade (12%). In comparison, the primary concentrators in intangible assets are Business Support-Outsourcing (16%), Manufacturing (10%), Education (10%) and Real Estate Services (10%). In this respect, it is essential to underline the central role played by the business support sector and, above all, by the manufacturing sector as the main demanders of intangible investment. This expresses how intangible assets permeate the economy as a whole and include the secondary sector. Likewise, when comparing tangible and intangible distributions between sectors, the fact that sectors such as business support and education differ stands out since more than 50% of their investment is intangible.

Table 5. Intangible investment by CHS category: Ck estimate, 2018 (percentage)

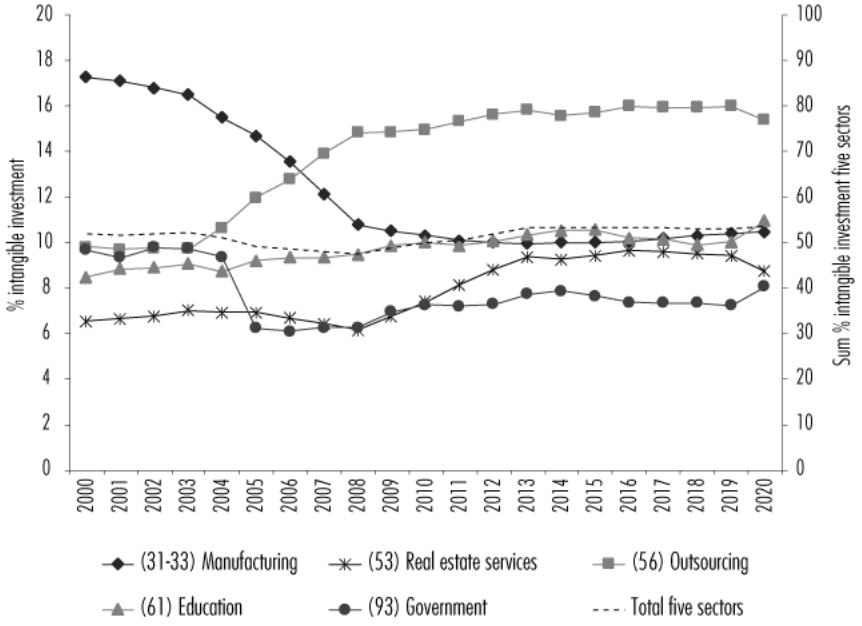
Sector	*Ownership of Innovation*	*Economic competences*	*Digitized information*	*Total intangible*	*Tangible*
(11) Agriculture	0	0	0	0	1
(21) Mining	0	1	0	0	6
(22) Electric power, water and natural gas	5	2	4	3	1
(23) Construction	1	9	1	5	2
(31-33) Manufacturing	10	10	10	10	22
(43) Wholesale trade	4	3	3	3	12
(46) Retail trade	1	2	1	2	3
(48-49) Transportation, mail and storage	5	7	5	6	8
(51) Information	11	2	12	6	2
(52) Finance and insurance	4	4	4	4	1
(53) Real estate services	18	2	19	10	13
(54) Professional services	9	2	9	5	1
(55) Corporate	2	1	2	1	13
(56) Outsourcing	23	10	22	16	2
(61) Education	0	18	0	10	1
(62) Healthcare	0	11	0	6	2
(71) Entertainment	1	0	0	0	1
(72) Restaurants and hotels	3	1	4	2	1
(81) Other services except government	3	1	3	2	2
(93) Government	0	14	0	7	7

Source: Compiled by the authors based on information from INEGI's KLEMS database.

When comparing distribution in OI, EC and DI with that of total intangible assets in Table 5, the following are highlighted: 1) Outsourcing has a higher concentration in OI (23%) and DI (21.6%) and lower EC (10.1%); 2) Information and mass media has low participation in EC (1.7%), but high participation in OI (10.7%) and DI (12.4%); Real estate services have a low concentration in EC (1.7%), but a high concentration in OI (18.5%) and DI (18.6%). The other sectors behave similarly.

An important aspect is to evaluate the concentration of intangible investment at the sectoral level over time. Figure 5 shows the share of intangible investment in the five most concentrated sectors during the 2000-2020 period based on the Ck estimation. First, the concentration level of the top 5 in Table 5 remained stable throughout the analyzed period at around 50%. However, the structure of their share changed significantly. Firstly, the loss in weight of intangible investment in the manufacturing sector can be observed, going from being the primary concentrator at the beginning of the 21st century (17%) to second place with levels close to 10% during the last few years. Regarding the loss of concentration in the manufacturing sector, it is conjectured that its decline is due to an increase in intangible import supply, which could hurt the interactions between the creative economy and manufacturing. There could be a national "de-intangibilization" of Mexican manufacturing.

Figure 5. Sectoral evolution of the concentration of intangible investment, Ck Estimate, 2000-2020

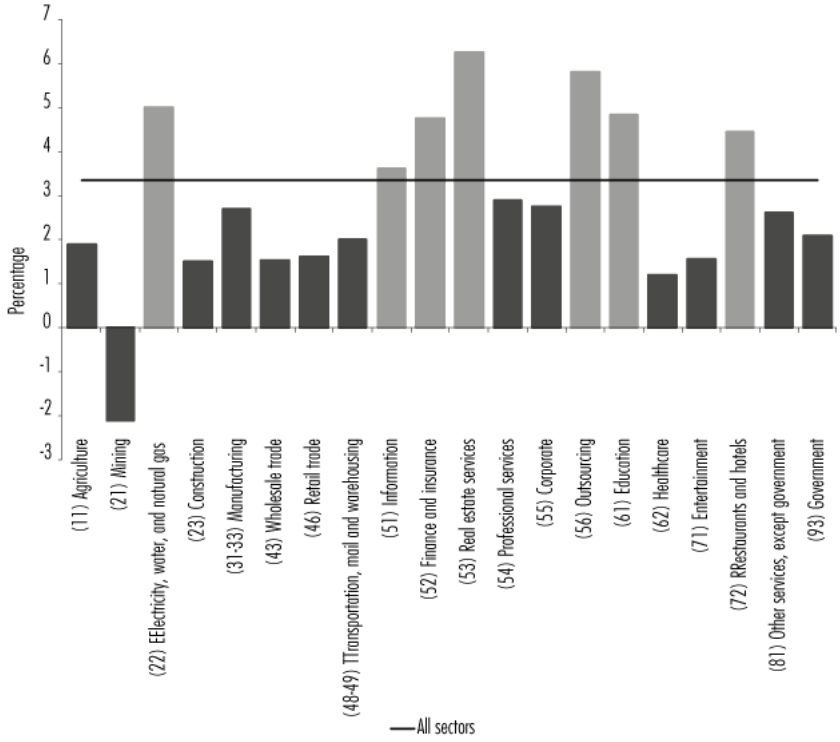


Source: Compiled by the authors based on information from the 2020 KLEMS model (INEGI, 2020).

The new concentrator of intangible investment is business support or outsourcing (56). At the beginning of the century, it represented 10%, and as of 2008, it occupies first place with just over 15%. Similarly, real estate services increased significantly from 2008 onwards and reached levels close to 10% in recent years.

The AAGR of intangible investment (excluding the financial sector) was 3.35% during 1991-2020; however, growth varied at the sectoral level (see Figure 6). The sectors with an AAGR above the aggregate performance were the following, in order of importance: Real estate services (6.3%), Business support (5.8%), Energy-electricity-gas (5%), Education (4.8%), Finance-insurance (4.8%), Restaurants-hotels (4.7%) and Information (3.6%). It should be noted that the significant AAGR of Business support (5.8%) explains why it became the dominant sector for the concentration of intangible investment flows (see figure 6).

Figure 6. Average investment growth by sector. Estimated Ck. Total intangible
Period 1991-2020

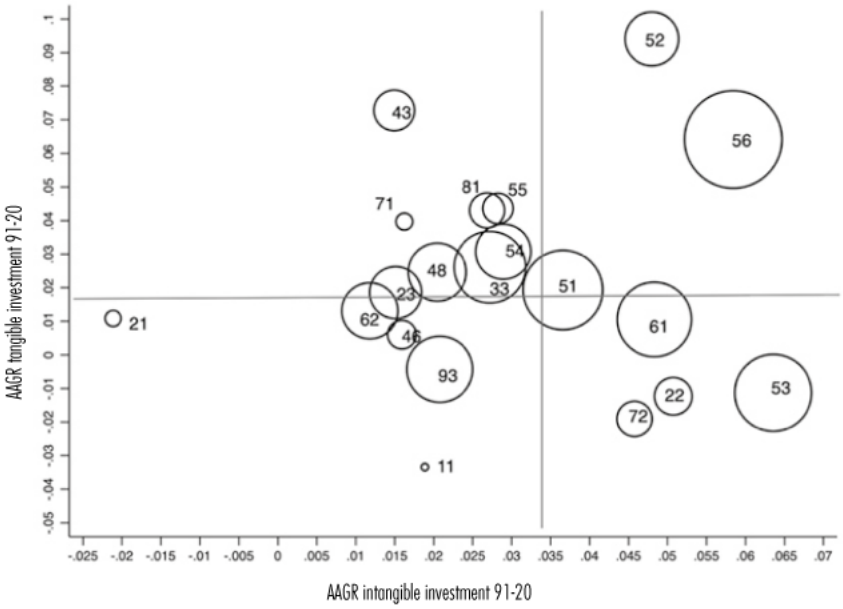


Note: deflator used, services and ICT.

Source: Compiled by the authors based on information from the 2020 KLEMS model (INEGI, 2020).

An important aspect to discuss is the complementarity and/or synergies that may exist between tangible and intangible investment. Figure 7 presents a scatter plot between the log of the AAGR of tangible investment (vertical axis) versus the log of the AAGR of intangible investment (horizontal axis) over the period 1991-2020, with each observation being represented by a circle weighted by the flow of intangible investment in 2018. The diagram is divided into four quadrants where the sectors of the economy are located according to whether they are above or below the overall values of the variables represented. The upper right quadrant shows the sectors for which the AAGRs were above global behavior: Finance-Insurance (52), Business Support (56) and Information and Media (51). In other words, these sectors suggest a possible complementarity between tangible and intangible investment in the long term. In the lower right quadrant are Real Estate (53), Education (61), which also have large circles, and Hotels-Restaurants (72), with high rates of intangible investment but low rates of tangibles.

Figure 7. Scatter plot between the AAGRs of intangible and tangible investment during 1991-2020



Source: Compiled by the authors based on information from the 2020 KLEMS model (INEGI, 2020).

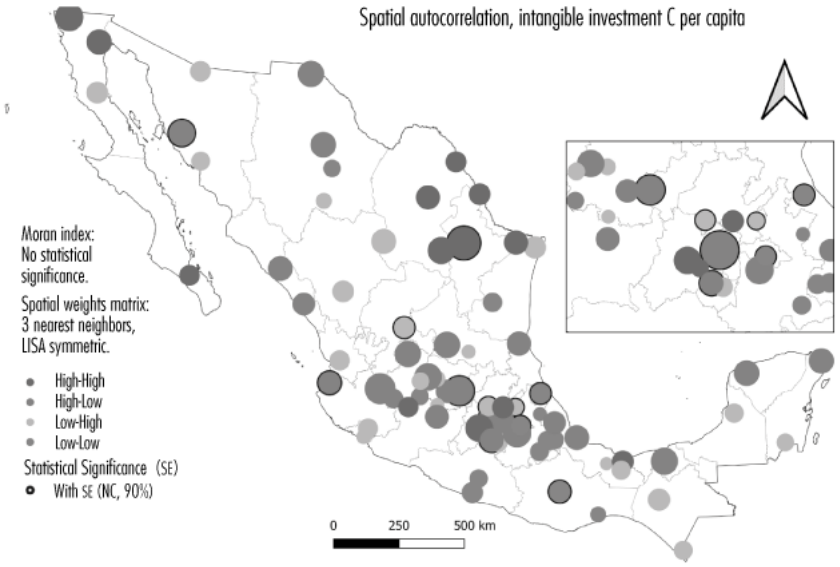
The upper left quadrant displays the sectors for which the tangible investment rates are above global performance but for which intangible investment rates are below. They include Manufacturing (33) and Professional Services (54), which stand out in particular due to their size. The former denotes a possible substitution of national for international intangible investment, and the latter exhibits a poor performance of intangible investment in a sector that, by definition, is a leader in the production of intangible assets. Likewise, the Art sector (71) is located in this same quadrant with a mediocre performance of intangible investment and a negligible concentration of flows. Despite this, this sector should be seen as a potential source of intangible investment growth.

Regional

The behavior of intangible investment flows at the Metropolitan Zone (ZM) level is described below. Estimates were based on information from economic censuses since this is the only source containing representative regional data. In particular, criterion C of table 2 was considered and the methodological details for its estimation are described at the end of the third section.

Table 6 summarizes the distribution of tangible and intangible investment flows in 2018 among the first 11 metropolitan zones with the highest concentration and includes the distribution of intangible flows for each CHS category. These metropolitan zones concentrate 70 and 60% of the entire country's intangible and tangible investment, with the Metropolitan Zone of the Valle de México (ZMVM) representing 41 and 38% of such investments. The second and third largest concentrations of intangible investment are in the metropolitan zones of Monterrey and Guadalajara, with 9% and 5%, respectively. The metropolitan zones of Querétaro and Puebla-Tlaxcala are in fourth and fifth place with 2.5% and 2.3%, respectively. The last column of the table shows the intangible investment/tangible investment ratio as an indicator of intangible asset intensity. The country's largest metropolitan zones have a ratio greater than 1, thus showing greater intangibilization; however, the ZMVM has the lowest value. The metropolitan zones with the highest presence of intangible assets are Villahermosa (5.7) and Tijuana (2.6). The metropolitan zones of Puebla, León, Saltillo and San Luis Potosí are the most tangibliized, which aligns with their solid industrial vocation.

Figure 8. Moran index values of intangible investment per capita (scenario C) in metropolitan zones (2018)



Source: Compiled by the authors based on information from economic censuses (INEGI, 2019).

Table 6 also shows the distribution of intangible investment by CHS categories. In the DI sector, only ZMVM, Monterrey and Querétaro show a positive concentration bias, although the rest of the metropolitan zones demonstrate deficiencies in this sector. The ZMVM and Monterrey show a negative bias in EC and OI, respectively, and Querétaro in EC. [8]

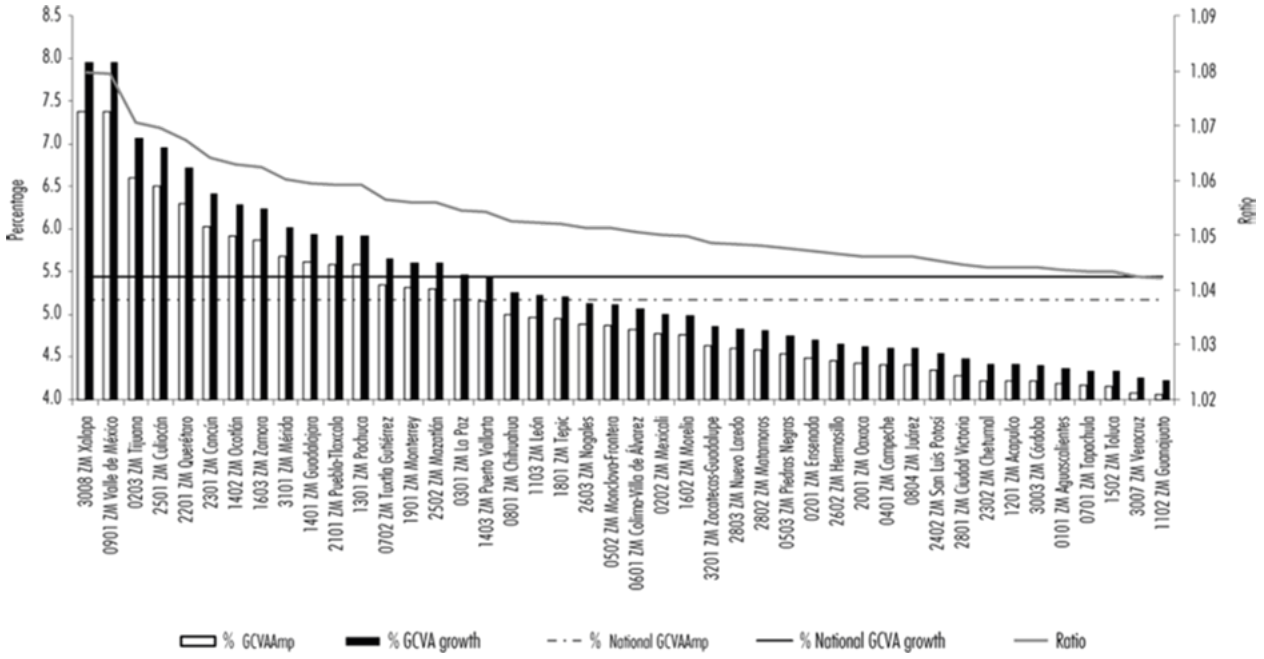
Table 6. Structure of intangible investment in estimate C, CHS classification (2018)

Metropolitan Zone	*Ownership of innovation (%)*	*Economic competencies (%)*	*Digitized information (%)*	*Total intangible (%)*	*Tangible (%)*	*Ratio*
ZM Valle de México	41.5	37.9	56.2	40.85	37.89	1.08
ZM Monterrey	8.6	8.8	10.9	8.80	6.75	1.30
ZM Guadalajara	5.6	4.9	4.1	5.31	3.22	1.65
ZM Querétaro	2.5	2.4	2.6	2.50	1.90	1.31
ZM Puebla-Tlaxcala	2.3	2.6	1.3	2.33	2.93	0.80
ZM Tijuana	2.7	1.8	0.8	2.31	0.88	2.61
ZM Toluca	1.9	1.7	1.0	1.77	1.18	1.50
ZM León	1.5	1.9	0.9	1.64	1.70	0.97
ZM Villahermosa	0.5	3.6	0.1	1.55	0.27	5.65
ZM Saltillo	1.3	1.9	0.0	1.48	1.57	0.94
ZM San Luis Potosí	1.2	1.3	0.1	1.19	1.44	0.82
Total	69.75	68.74	77.85	69.73	59.75	1.17

Source: Compiled by the authors based on information from INEGI economic censuses.

The share of intangible investment, in relation to expanded GCVA, of 5.2% in 2018 indicates that GCVA could increase by about 5.5% if intangible investment were included. Figure 9 displays the share of intangible investment with respect to the expanded GCVA of the metropolitan zones with a value greater than 4% in descending order. It also indicates the percentage of growth of GCVA if estimated intangible investment were included -dark column-, as well as the national series of the previous variables -horizontal series-. 18 metropolitan zones are above or equal to the aggregate behavior,[9] with the top three being the metropolitan zones of Xalapa, Valle de Mexico and Tijuana, with shares of 7.4, 7.4 and 6.6%, respectively, which in turn imply an increase in GCVA of 8, 8 and 7%, respectively, if these investment flows were included. It is important to note that the impact of the inclusion of intangible assets on the increase in GCVA (dark column) is not linear with respect to their share (white column); in other words, the greater the share of intangible assets, the greater the impact on the increase in GCVA. This can be observed in the series with a double line labeled as a ratio that displays the quotient of the percentage increase in GCVA between the percentage of intangible assets with respect to the expanded GCVA (referenced on the right axis).

Figure 9. Share of intangible assets with respect to the GCVAAmp



Source: Compiled by the authors based on information from economic censuses (INEGI, 2019).

In general, metropolitan zones with high shares of intangible assets have these three characteristics: *a)* increased urban hierarchy (Valle de México, Guadalajara, Monterrey, Puebla), *b)* tourism (Cancún, La Paz, Puerto Vallarta, Mazatlán), and *c)* an industrial base focused on the external market (Querétaro, Tijuana). In other words, amenities and industrial base are essential elements in the attraction of intangible assets in line with the discussions of Valdivia *et al.* (2023) for the case of CCIs.

To obtain an approximation of the regionalization of intangible investment in metropolitan zones, figure 9 presents the values of the Moran scatter plot for intangible investment flows per employed personnel for criterion C in 2018. The circle reflects the size of the variable value in logarithms. Four spatial agglomeration patterns of intangible investment flows are identified: 1) The northeast and northwest border metropolitan zones led by Monterrey and Tijuana, respectively, form a High-High cluster; 2) A central corridor of the MZ connecting Guadalajara and the port of Veracruz, which is mostly High-Low and, in particular, in the central region of the country and the Bajío region (see box), the ZMs of Cuernavaca, Puebla, Querétaro, León and Morelos stand out, with a High-Low index, in addition to Pachuca and Toluca with High-High; *3)* the metropolitan zones integrated into tourist corridors denote High-Low autocorrelation, and include Merida, Cancun, Puerto Vallarta, Mazatlan and La Paz with High-High (the exception of Acapulco with Low-Low is notable). Finally, *4)* metropolitan zones in the country's south with states bordering the Pacific denote Low-Low and Low-High agglomerations.

5. CONCLUSIONS

This paper provides a national, sectoral and regional overview of intangible investment flows estimated for the Mexican economy over the last 30 years with their respective time series. There is a consensus in the specialized literature on the importance of taking intangible assets into account in measuring productivity and economic growth (see the second section of this paper). However, for the Mexican case only, Hernandez Laos (2022) makes a marginal comment in his most recent book in this respect. The rest of the studies reviewed for the case of Mexico, but not documented in the references, address the issue of intangible assets generically, with approaches different from that of this research. As far as the authors know, this is the first time that estimates of intangible assets have been made for Mexico.

The estimates carried out in this research allow us to conclude that Mexico generally reproduces some of the stylized facts that characterize intangible investment in developed regions/countries and simultaneously identify the particular features of this phenomenon for the Mexican economy. First, intangible investment has shown average growth in the long term (1990-2020), which is slightly more than twice as high as that observed in tangible investment. This has important implications for the calculation of the GDP in Mexico because it indicates that if intangible investment were incorporated into the NAS, the total value added could increase by up to 5.5% - according to one of the criteria used. Intangible investment permeates the entire economy and is not exclusive to the service sectors. The secondary sector accounts for close to 20% of intangible investment. Manufacturing alone is the second most concentrated sector, with close to 10%, but it has been losing share, most likely due to an increase in the importation of intangible investment assets. Software is the intangible investment sector that has grown the most over the last 30 years. However, it is still a sector with a low share of total intangible assets (6%) compared to other countries, and it is also heavily concentrated in the metropolitan zones of the Valle de México, Monterrey and Guadalajara.

A pattern of spatial concentration was identified that is characterized by a corridor of MZs in the central region of the country, with the ZMVM being dominant, together with a strong presence of metropolitan zones close to the eastern and western border region with the United States, where Monterrey and Tijuana are relevant. Finally, a group of metropolitan zones associated with tourist centers, including Cancún, Mérida, Puerto Vallarta and La Paz, is identified. This spatial pattern coincides with that determined by Valdivia *et al.* (2023) when analyzing the CCI, which shows how industrial base and amenities are two mechanisms for attracting creative forces.

The transversal nature of intangible assets in the economy occurs with domestic and foreign investment, but it is impossible to identify them separately due to the lack of information. It is important to note that intangible capital is crucial in capturing value in global value chains. Large multinational companies (LMC) establish partnerships through foreign direct investment to build their value chains in different countries where intangible capital is an integral part of their strategy and expand their competitive advantages by acquiring or merging local firms with domestic capital (Cadestin *et al.*, 2021). The dynamics of intangible capital investment in Mexico, especially in LMC companies, is no stranger to these dynamics and future research should focus on analyzing this type of process.

The results presented in this paper are only an initial estimation and characterization of intangible investment flows in Mexico at the sectoral and urban levels. The next step would be to analyze the contribution of this investment to output growth and its impact on the TFP in the growth accounting framework.

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[1] Recent revisions relating to intangible assets can be consulted in Roth and Thum (2013), Roth and Sen (2021) and Van Criekingen *et al.* (2021).

[2] Available at www.intaninvest.net and www.spintan.net.

[3] From an accounting point of view, an asset is recorded as the value of all those assets owned by a company, whose useful life is more than one year and which, together with labor, make up the necessary conditions for the generation of assets and services in an economy.

[4] These authors define this form of capital as an "agglomeration" of technologies (business practices, processes and designs, as well as incentive and reward systems), which, when combined, allow companies to extract greater value systematically and efficiently from the product.

[5] A production function can be represented for each sector. If it is also assumed that factors are paid at their marginal product (1st degree homogeneous function), we have the monetary flows by sector and the associated accounting identities.

[6] This refers to the KLEMS model, which is an international project in which INEGI participates, permitting comparability of growth accounting statistics between countries and the determining of contributions due to production factors: Capital (K), Labor (L), Energy (E), Materials (M) and Services (S). https://www.inegi.org.mx/programas/ptf/2013/

[7] When using the EBP_j, not only the intermediate consumption expenditure but also the payment or cost of factor use is deducted. In other words, it reflects the profits of industry j and it is assumed that only a fraction ($\alpha_{i,j}$) of the EBP is converted into intangible investment in sector *i*.

[8] Despite the leadership of the ZMVM in the concentration of intangible assets, it has gradual lost importance over time, resulting in a process of the decentralization of intangible assets towards the rest of the metropolitan zones.

[9] The two extreme cases of the metropolitan zones of Coatzacoalcos and Villahermosa, which report atypical shares of 30% and 23%, respectively, are not considered.