

National Quality Infrastructures in the COVID-19 Pandemic: Insights from a Multinational Study on Impacts and Institutional Responses of Conformity Assessment Bodies

Authors: Claudia Koch¹, Parsa Asna-Ashari¹, Knut Blind², Pavel Castka³, Mona Mirtsch¹

¹Bundesanstalt für Materialforschung und -prüfung (BAM), ²Technische Universität Berlin, ³University of Canterbury
corresponding author: claudia.koch@bam.de

Introduction

The COVID-19 pandemic has posed new and manifold challenges to organizations and their operations worldwide (Kraus et al., 2020; Pinzaru, Zbucnea, & Anghel, 2020; Queiroz, Ivanov, Dolgui, & Fosso Wamba, 2020). Conformity assessment bodies (CABs), such as testing or medical laboratories, certification, and inspection bodies, are also affected by the associated disruptions.

Their situation in this crisis is highly relevant, as CABs are essential pillars of the quality infrastructure: Their activities ensure that products and services meet defined requirements, thereby contributing to their safety and reliability. They are a cornerstone of trade by establishing trust and transparency (Blind, Mangelsdorf, & Pohlisch, 2018; Ferro, 2011; King, Lenox, & Terlaak, 2005; Potoski & Prakash, 2009; Terlaak & King, 2006). CABs provide the link between regulators, industry, and markets (UNIDO, 2020a). Moreover, they play a fundamental role in innovation, both during the R&D process and in paving the way for innovations to enter markets, as their services provide trust in new technologies and applications (Gonçalves & Peuckert, 2011).

Considering these roles and functions of CABs in economy, health, and innovation, the question arises how CABs and their operations were affected by the pandemic and how they responded. It is important to understand the issues CABs are facing, recognize patterns of vulnerability in the context of crisis, and identify potential support measures. To this end, we present the results of an international survey of 986 CABs of all types in Germany, the UK, Italy, and New Zealand.

Current situation of CABs and research questions

With stagnating industries worldwide, CABs experienced a decline in demand for their services with the onset of the pandemic (UNIDO, 2020b). On the other hand, they had to respond quickly to the increasing demand for specific services, e.g., to ensure the provision of medical devices and pharmaceuticals, or the supply of protective equipment. Specifically, medical laboratories play a crucial role not only in diagnostics but also in the development of vaccines and treatments needed to overcome the pandemic (Ibeh, Enitan, Akele, & Isitua, 2020). However, the ability of CABs to provide such services has been constrained, e.g., due to staff or materials shortages, or travel bans. While some CABs have faced serious threats to their economic viability, others have been able to respond and adapt, e.g. by implementing new

digital solutions (Nowicki & Kafel, 2021; Summers & Charrington, 2020). However, until now, there have been no differentiated data covering the situation of a broad variety of CABs in different countries. The findings of our international comparative study now fill this gap and shed light on the actual situation of CABs in the pandemic.

The study provides interesting insights for two reasons: First, it covers a sector that provides services essential to the innovation system and that is of ever greater importance in the current crisis. Second, it provides data on how the pandemic affects organizations, especially smaller ones, and how they are responding. More than ever, the pandemic has demonstrated the importance of resilience for organizations to master crises. We investigate the short-term impact of the pandemic on CABs, analyzing the resilience of this industry in different countries and their ability to deliver their services to industry and the innovation system. Previous research has found that more digital companies are more agile and resilient in uncertain and dynamic environments (Cobo-Benita, Amo, & Santiuste, 2020; Papadopoulos, Baltas, & Balta, 2020; Pinzaru et al., 2020; Soto-Acosta, 2020). On the other hand, digitalization in organizations has been found to accelerate during the pandemic (Guo, Yang, Huang, & Guo, 2020; Kraus et al., 2020). Therefore, our study specifically addresses digitalization in CABs from these two perspectives.

Methodology and data

To get an overview of the situation of CABs in the pandemic, we set up an online-questionnaire covering key aspects identified in the literature: their economic situation (demand for their services, constraints on their operations, etc.), their resilience, thus maintaining positive adaptation under challenging conditions (Vogus & Sutcliffe, 2007), and digitalization from the perspectives mentioned above. Questions were designed with either yes/no responses or 5-point Likert scales, e.g., with 1 for "not important" and 5 for "very important", or -2 for "strong decrease" and +2 for "strong increase" respectively. We also included multiple-choice questions.

To gather the data, we directly contacted all accredited CABs in Germany listed in the official register of the German accreditation body (a total of 3,204 CABs) in June 2020. In Italy, the UK, and New Zealand, we cooperated with the local accreditation bodies, which sent invitations to their accredited CABs between July and November 2020. In total, we received 986 valid responses from Germany (555), Italy (240), New Zealand (120), and the UK (71).

The questionnaire was designed to account for the differences of the various types of CABs, such as testing laboratories or certification bodies. Some organizations offer more than one service (e.g., a testing laboratory and a product certification body). In fact, 26% of CABs in our sample are testing laboratories, followed by certification bodies (26%), calibration laboratories (18%), inspection bodies (12%), medical laboratories (5%), and 5% of other services. One in five respondents is an internal CAB, i.e., one that belongs to a larger company, e.g., for which it provides its services internally.

The majority of CABs in our sample are small and medium-sized enterprises with fewer than 250 employees (ranging from 61% in the UK to 89% in Italy). The main customers of CABs are from industry (dominant in Germany) and the primary sector/food/water/energy (dominant in the other countries). The international orientation of the CABs varies widely, with German

CABs being much more internationally active than Italian CABs, which are mainly active only in their domestic market.

Our empirical analysis comprises two steps: first, we present descriptive statistics for each country and perform a comparative analysis of the four countries in our sample. Significance tests were performed using Stata and QResearch software. Second, to capture relationships among the data, we further assess different variables using structural equation modeling (SEM) for exploratory path analyses employing SmartPLS (Hair, Risher, Sarstedt, & Ringle, 2019).

Results

Economic impact of the pandemic

Comparing the current demand for their services (at the time of the survey) with the pre-pandemic period, CABs reported on average a negative development, both domestically and in their international markets. Most heavily affected were inspection bodies, while medical laboratories were less negatively affected. Internal CABs were also generally less affected by the pandemic. The different timing of the survey in the different countries might explain the different expectations of CABs in the four countries regarding a recovery in their order situation: The countries surveyed later (New Zealand and Italy) were less optimistic than CABs from Germany and the UK, which were surveyed first.

Restricted access to customers and travel restrictions were the dominant constraints faced by CABs in all countries. However, although almost no CAB in Germany had to completely shut down its operations during the (first) peak of the pandemic, one in five CABs in New Zealand did. 2% of all CABs surveyed saw their business viability immediately threatened (as many as 5% in Italy), and 45% reported having applied for some kind of government support measures, with this being least the case in Germany and most in the UK.

The pandemic had an impact on the CABs' investment and innovation activities: 43% of the laboratories and bodies surveyed postponed planned investments, while only 9% increased them – specifically for new devices and equipment, but also for necessary health and safety measures. Investments in digital infrastructure were particularly common in Germany and New Zealand. One in five CABs said they had introduced new services or strengthened existing ones.

Resilience

The survey data show that CABs in the four countries are differently prepared for this pandemic. While contingency plans were in place in around 60% of CABs in the UK and New Zealand, these figures were significantly lower in Germany (38%) and Italy (29%). CABs in New Zealand were also better equipped than those in the other countries at the beginning of the pandemic, in terms of other resources such as personnel, IT, and crisis-related knowledge. CABs in Germany were most likely to report a lack of IT resources (19%). According to their self-assessment, CABs from the UK and New Zealand responded significantly faster to the challenges of the pandemic than those in Germany and Italy, and they also rated their ability to learn from the pandemic more positively than the others.

Digitalization

Given the constraints associated with the pandemic, 70% of the laboratories and bodies reported an increased need for digitalization, especially more so in Germany and Italy. Here, the pandemic has driven digitalization in significantly more CABs than in the other countries (52% on average). This corresponds with the state of digitalization at the beginning of the pandemic: respondents from the UK and New Zealand were already more digitalized and thus obviously experienced less pressure to adapt. The assertion is supported by the availability of IT-resources mentioned above, but also by respondents' assessments of the need for further adaption of IT and personnel to digital environments (or lack thereof). Overall, CABs in Germany reported a lower level of digitalization at the time of the survey. As the on-site delivery of their services was severely impacted by the pandemic (Castka, Searcy, & Fischer, 2020), 70% of certification and inspection bodies reported offering remote services, with as many as 50% of CABs doing so for the first time due to the pandemic.

Further expected results

Beyond these descriptive results, we expect to unravel further important lessons from the COVID-19 pandemic by conducting an exploratory path analysis applying SEM. Constructing paths with different layers of variables will reveal important relationships and how digitalization eventually affects CAB performance over the course of the pandemic. We expect to draw insights from our analysis about the nature of digitalization shift, as well as its context and impact. In analyzing digitalization and other aspects related to resilience, we address and relate two fundamental issues.

In particular, we expect that the constraints imposed by the Covid-19 pandemic have positively impacted digitalization (Soto-Acosta, 2020). Similarly, organizational resources, investment activities, and contingency plans are likely to be positively associated with digitalization. We further expect a positive correlation between digitalization and resilience, i.e., between the initial level of digitalization, the transformation in the pandemic, further the response time to the challenges of the pandemic on the one hand, and the actual and expected order development on the other hand. It is therefore to be expected that being equipped with sufficient organizational resources has a positive impact on digitalization, which in turn is likely to confirm a positive correlation with the performance of the CABs.

Conclusions and implications

The initial descriptive results of our study show how severely CABs were affected by the challenges of the pandemic. The crisis exposed CABs' overreliance on traditional approaches (e.g., on-site auditing and inspections), which were severely impacted during the pandemic and made it difficult to provide assessment services. The crisis did indeed accelerate the uptake of digitalization of the industry, as our data show, but also reveal significant differences across countries in our sample. Learning lessons about the digitalization and provision of remote service delivery of CABs and how this relates to their resilience and ability to continue to provide their services is critical for the economy and innovation system, which rely heavily on CABs. Exposing their vulnerability in this crisis will allow policymakers and industry to draw conclusions for the post-pandemic world, which will likely depend even more than before on a functioning conformity assessment system. Continuing to improve their resilience to cope with

future crises is an important challenge for CABs, their stakeholders, and policymakers. Governments in all countries have acted quickly and implemented measures to ensure the survival of the organizations. Nevertheless, their focus in the renewal and growth phase should shift to structural and more targeted measures aimed at improving resilience, e.g., through digital transformation (Juergensen, Guimón, & Narula, 2020).

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The adoption of digital technologies in Brazilian industrial firms: patterns of path dependence and determinant factors

Ana Urraca-Ruiz, Julia Torracca, João Carlos Ferraz, Euler Daltro, Jorge N.P. Britto

Introduction

This is an original longitudinal study about the adoption of digital technologies by 299 Brazilian industrial firms, from different sectors and sizes, based on two direct surveys carried out in 2017 and 2019/2020. Firms were questioned about which digital technologies were currently in use and which ones were expected to be adopted in the future (5 to 10 years ahead)¹. This paper has two objectives: (i) to analyse the evolution in the adoption of different generations of digital technologies in time, searching for patterns of path dependence and, (ii) to relate the patterns of path dependence to structural and conduct features of firms.

For that, after a review of the relevant literature, firstly, from the questions posed to firms, a methodological effort was made to develop appropriate indicators to observe current and prospective adoption patterns in each survey, and to proceed to the longitudinal analysis in search of patterns of path dependence.

Secondly, and departing from the descriptive exercise of movements of firms in time, a quantitative exercise will be made to associate patterns of adoption of digital technologies to the different profiles of firms (size, sector, export, capabilities and mobilisation efforts towards digitalisation).

Thirdly, departing from the assumption that digitalisation is positive related to competitiveness, the paper will discuss the results (different patterns of evolution related to different firms' profile) in terms of possible market-structure outcomes.

The empirical approach

The research programme from which this paper is derived, explicitly recognises five characteristics of the rapid rate of progress of digital technologies and the related adoption process by firms which constitute the backbones of the surveys carried out in Brazil in 2017 and 2019-2020²:

- (i) Digital technologies are, at the same time, transversal to all but specific to each firm; questions must be designed to be answered by any industrial firm, regardless the nature of its activities.
- (ii) Digital technologies are adopted across all business functions, from design to production to relations with clients. What matters then is to raise which digital solutions are adopted to carry out different business functions; not the specific technology in itself, such as painting robots or generic ones such as artificial intelligence.

¹ This paper is the by-product of a research programme (I-2027 and I-2030) in progress since 2017 by a group of researchers from the Federal University of Rio de Janeiro, the Campinas State University, and the Fluminense Federal University. See IEL 2018 and Ferraz et al 2019 for outputs of such research programme.

² A similar approach to question firms about the adoption of digital technologies was adopted in Argentina (Albrieu et al 2019) and in Ghana, Vietnam, and Thailand (Kupfer et al 2019)

- (iii) Digital technologies have been around for a while; it is important to consider that firms may adopt state of the arts solutions and/or older technologies and coexist with different solutions; it is necessary to specify “generations” of digital solutions, naturally having as the ultimate reference the most advanced ones.
- (iv) Four generations were specified: stand-alone solutions; solutions that partially integrate business functions; integrated and connected solutions and, a system that intelligently integrates and interconnects a firm in a digital platform. Such very brief description indicates that the evolution along such digital generation ladder is not linear.
- (v) As present and future adoption prospects matter, direct research must rely on perceptions and expectations of qualified representative of firms.

Thus, in both surveys similar questions were posed to firms about the **current** and the **prospective** (5 to 10 years ahead) generations of digital technologies used or to be used in three different business functions (relations with suppliers and clients and in the management of production processes). Four different generations were specified: stand-alone; partial integration; complete and connected integration and, intelligent connected and integrated solutions. Firms were also asked about the type of efforts (*readiness*) they were currently implementing to achieve the digital solutions expected to be adopted in the future (no actions, studying, planning, implementing plans).

In short, both surveys supplied information about four generations of digital technologies being or expected to be in use in three business functions, in two moments of time.

Searching for patterns of path dependence

In search for possible patterns of path dependence in the adoption of digital technologies, in time, three methodological steps were taken:

- To take up the non-linearity of the digital evolution ladder, values for each generation, using a Fibonacci-like sequence, were defined as follows: first generation = 3, second generation = 5, third generation = 8 and, fourth generation = 13.
- In order to collapse the three business functions, mean values were estimated to obtain the level of digitalisation of a firm, for the present and future.
- Firms declaring to have moved forward (advance) and not having moved forward (stagnating) in the current adoption of digital technologies between the first and second survey were then associated with those expecting to move forward (advance) and not to move forward (stagnating) between 2020 and 2030 (second survey).

The emerging patterns of path dependence in the adoption of digital technologies in Brazil reveals (Table 1):

1. A **sustained and positive path dependence** for 20,4% of firms. Firms demonstrated evolution in current adoption between both surveys and expect further advances between 2020 and 2030.
2. A **discontinuous optimist path dependence** for 23,7% of the firms. Firms stagnate in the current adoption of digitalisation between the two surveys, but the group expect to jump ahead in digitalisation in the future to come (2030 vs 2020)
3. A **discontinuous pessimistic path dependence** for 25,4% of firms. This group moved forward in current adoption between 2017 and 2020 but they demonstrate

a negative perspective between current digitalisation levels (2020) and future prospects (2030).

4. A **sustained and negative path dependence** for 30,4% of firms. This group do not demonstrate progress in current adoption of digitalisation between both surveys (2017 vs 2020) and do not expect to move forward in the future (2020 vs 2030).

Table 1 –Patterns of path dependence

		Projected change: current generation in 2020 and prospective generation in 2030		
		Advance	Stagnation	Total
Actual change in current generation (2017/2020)	Advance	20,4%	25,4%	45,8%
	Stagnation	23,7%	30,4%	54,2%
	Total	44,1%	55,9%	100,0%

Source: own elaboration based on I-2027 and I-2030 database

The nexus exercise (to be developed)

These preliminary findings provide the empirical base to categorise firms according to their style of path dependence.

The next step will be to relate these patterns of path dependence to the different profiles of firms. To do so, the paper relies on an ordered logistic regression. These methods are consensually accepted for survey-based data that has ordinal categorical variables. In these models, there is a relative ordering of response values that are known, but the exact distance between them is not. This feature is essential for the present analysis as efforts were made to identify the profile of firms.

For this paper, the dependent variable will be the patterns of path dependence and the independent variables will be: 8 different sectors of origin; size of firms in four ranges, R&D (yes or no), Export (yes or no), a proxy of capabilities (STEM workers to total workers in 4 ranges) and mobilisation efforts to prepare for the future (no actions, studying, planning, implementing plans).

The standard interpretation of an ordered logit coefficient is that for one unit increase in the predictor, the response variable level is expected to change by its respective regression coefficient, in the ordered log-odds scale, while other variables of the model are held constant. Positive coefficients indicate that higher values of the explanatory variable improve the likelihood of a firm being at a higher category of the dependent variable than the current one, whereas negative coefficients indicate that higher values of the explanatory variable increase the likelihood of a firm being in the current or lower category.

Open questions

Current and prospective adoption of digital technologies really follow a path-dependent trend in which the past strongly conditions the expected future?

What determines the firm to be in one of the four possible dependence paths (sustained and positive; discontinuous optimist; discontinuous pessimistic; sustained and negative)?

How to explain advances, paralysis and/or retrocession processes of adopting digital technologies beyond a firms structural feature?

Does path dependency imply irreversibility in the adoption process? What are the analytical and policy implications in terms of market structure and competition?

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Purpose-driven innovation in response to COVID-19: exploring the emergency window of opportunity

Authors: Amber Geurts¹, Tara Geerdink¹ & Marit Sprenkeling¹.

¹TNO.

This article discusses the need for accelerated innovation processes in response to the 'emergency situation' created by COVID-19 and aims to characterize the innovation landscape by looking at the development of alternative ventilators in the Netherlands: how can we characterize and understand accelerated innovation efforts during 'emergency situations', and what role do collaborative efforts play? We draw our implications from an phenomenon-driven, in-depth qualitative case study focused on the innovation landscape for alternative ventilators in the Netherlands. Our results highlight the role of 1) purpose, 2) time, and 3) collaboration during accelerated innovation processes. We conclude by discussing the lessons we can draw from this experience of innovation during an 'emergency situation', and the implications for managing accelerated innovation processes.

Rethinking resilience: the role of gatekeepers in fostering adaptability

Authors: Dima Yankova¹.

¹INGENIO (UPV-CSIC)

The concept of resilience often comes to the forefront following major disruptions or crises, not unlike the global pandemic. Despite its relative “fuzziness” (Hassink, 2010), resilience has merit as a way of conceptualizing and consequently analyzing the capacity of regional innovation systems to cope with the aftermath of exogenous shocks. Traditionally, the literature on regional resilience has been fundamentally preoccupied with the capacity of regions to first resist or dampen the shock – reflective of regional vulnerability (Hill et al., 2008), and then to recover or bounce back from it, focusing on how quickly or how effectively regions can return to previous levels of output or employment (Pike et al., 2010; Pendall et al., 2008). Within this framework, however, the critical question of how regions undergo the process of recovery is consistently overlooked. In other words, the mere return to pre-crisis levels of employment and overall prosperity does not always signal resilience if the entire system remains fragile and overly reliant on decaying industries.

Recent attempts to integrate the concept of resilience in evolutionary economic geography have rejected this equilibrium-based narrative which views resilience as a return to some optimal status quo (Simmie and Martin, 2010), in favor of a more dynamic conceptualization, that is: the long-term capacity of regions “to reconfigure their socio-economic and institutional structures to develop new growth paths” (Boschma, 2015). Here the emphasis shifts from short-term adaptation or adjustment along a pre-conceived trajectory, towards long-term renewal or adaptability, implying new path creation or path renewal, as long as it is distinct from existing regional paths. Yet, the underlying mechanisms which allow regions to branch out and dynamically reconfigure their socio-economic structures, that is the question of “how”, remain an open area of continuous research and debate.

In this paper we seek to address this question by adopting a network perspective. More specifically, we use existing literature on gatekeeper organizations to examine the micro-level processes of new path formation. Gatekeepers have the unique capacity to serve as brokers between otherwise disconnected communities, by virtue of their diverse inter and intra-regional linkages (Graf, 2011). Most empirical studies thus far have analyzed their role in sourcing, translating, and disseminating external knowledge into their local cluster as a way of stimulating innovation and preventing cognitive lock-in (Morrison, 2008; Giuliani and Bell, 2005). Yet, the scope of gatekeepers’ contribution is far from exhausted. We hypothesize that these key network agents may also play a critical role in fostering regional adaptability by directly or indirectly facilitating new path formation through the recombination of different knowledge domains.

Understanding the role of gatekeeper organizations for fostering regional resilience may be particularly relevant in the context of Europe’s smart specialization policies. This influential strategy encourages regions to generate “new specialties” by discovering unexplored domains of opportunity and concentrating resources and competences in these domains (Foray, 2015). Separating the identified specialization priorities in silos may hinder a region’s adaptability potential if network connections between them are not sufficiently well-developed. This is why the role of gatekeeper organizations merits greater attention as a conduit for new path formation, especially during crisis.

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Innovation pattern heterogeneity and crisis resilience

Supported by a strong and diverse theoretical framework (Dosi, Marsili, Orsenigo, & Salvatore, 1995; Nelson & Winter, 1982), innovation is one of the usual suspects in defining differences in performance (and especially, in sustained performance) among firms. But firms are heterogeneous in their ability to innovate. Even among successful innovators, heterogeneity persists while innovators are likely to enjoy superior employment growth with respect to non-innovators. Indeed, innovation facilitates the high growth of “superstars”, as well as the establishment and continued existence of profitable companies that do not seek to become large enterprises (Tether, 1997); understanding this mechanism is often essential to elaborate appropriate innovation policies.

The Covid-19 disease has affected economic activities of a vast majority of the firms, all of which need some degree of innovation to survive. However, both the degree and type of innovation needed varies across different activities, since the effects of the disease (and of the related containment measures) are not constant throughout the economy. The pandemic translates into both supply and demand shocks, and the heterogeneity of shocks is mirrored by a heterogeneity of responses across firms. We assume that the traditional *innovators/non-innovators* dichotomy is insufficient to describe firm heterogeneity in times of crises and open instead for an empirically-driven and micro-founded taxonomy of firms.

A typical way to group firms, also to the purpose of elaborating innovation policies, is by the type of products and processes they deal with, which in turn defines roughly the economic sector to which the firms belong. At high levels of aggregation, product-based classifications of sectors like ISIC have often been considered impractical for understanding the sectoral dynamics of innovation. Therefore, other classifications have been suggested: Pavitt (1984) proposed a four-sector taxonomy based on size, innovation patterns and sources of innovation: scale-intensive, supplier-dominated, science-based and specialised supplier. Miozzo and Soete (2001) proposed to take out services from the supplier-dominated category in Pavitt’s original classification and suggested four additional categories: supplier-dominated services, physical network services, information network services and knowledge-intensive business services; the taxonomy was later used by other studies (see, e.g., Castaldi, 2009) and was subject to further aggregation by Castellacci (2008). However, the mentioned taxonomies have still grouped data at the level of industries rather than of firms. Such choice ignores the fact that firms in the same industry may have a very different technological base. A notable exception is given by De Jong and Marsili (2006), who have built an alternative firm taxonomy using micro-data from a firm-level innovation survey.

We acknowledge that many roads to innovation exist, and we are willing to check which of these roads are best suited for driving the economy out of the crisis. Following Archibugi (2001) and De Jong and Marsili (2006), we taxonomize the Norwegian innovation landscape to summarize the different roads taken by firms to pursue innovation before the crisis. In particular, we apply a factor analysis to data from the Innovation Survey 2018, in order to disentangle the different paths to innovation experienced by Norwegian firms. Then, following Archibugi, Filippetti and Frenz (2013), we check which types of innovation characteristics prove to be best suited to face the pandemic crisis. To this purpose, our data-driven taxonomy is coupled with a wide array of micro-data, and in particular with real-time data on lay-offs, bankruptcies and public support to firms.

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