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PARALLEL 3B: DIGITAL ECONOMY AND COMPETITION

An innovative approach to the regulation of equipment authorisation in developing countries

Praneel Haricharan Ruplal, LINK Centre, Wits University
Luci Abrahams, LINK Centre, Wits University

Abstract
The current theoretical approach to equipment authorisation (EA) regulation has proven problematic to resource-poor countries, yet it is relevant to building competitive markets in digital infrastructure and services. EA involves checking the technical characteristics of equipment, conducted by dedicated test facilities, against national or international standards, which are enforced by the regulatory authority. Initial research on EA in South Africa reveals several limitations when faced with a rapidly changing electronic communications landscape. Using grounded theory methodology, the research finds that the EA framework, applicable in an efficiency-driven, transitional economy with a relatively rich EA testing infrastructure, is predicated on a calculated concept of trust. The regulatory authority employs a tacit computational mechanism to determine the level of trust when dealing with EA applications. The rationale for such an approach is largely driven by sub-optimal decision heuristics available to the regulator, as a result of an inability to corroborate technical data associated with the EA process. The regulator thus applies a differential trust paradigm based on determining factors, such as salience. A future knowledge-based regulatory approach to EA is theorised, in which technology innovation assimilated from other EA environments, is applied to the EA process to improve institutional efficiency. The goal of applying technology and innovation to the EA process is centred around increasing the trust value proposition and contributing to a competitive digitally-enabled economy.

Keywords equipment authorisation, competitive markets, digital infrastructure, digital services, differential trust, deterrence-based trust, knowledge-based trust

Trends and context for a review of the equipment authorisation (EA) regime

Equipment authorisation (EA) regulatory frameworks have a significant impact on the digital economy, as they control the supply of electronic communications equipment into markets. Classically defined regulatory approaches to EA follow either a social or an economic policy approach. While there are many compelling reasons for using one or the other approach, the socio-economic factors uniquely prevalent in developing countries underlies the importance of finding an approach to EA that is appropriate to the regulatory context and realities. The evolving electronic communications landscape discussed here broadly includes the emission, transmission or reception of information using magnetism, radio or other electromagnetic waves (RSA, 2005:9).

A changing electronic communications landscape needs to be complemented with an effective regulatory environment to support and attract investment (Bourreau & Dogan, 2001; Mahan & Melody; 2005; Wright & Head, 2009; Coulter, Negishi & Foskett, 2010). As a developing country, South Africa needs to ensure that its regulatory approach is conducive to investment and economic growth. The ICT sector as a whole contributes around 3% or ZAR114bn to GDP, more than agriculture, but less than tourism, while household financial consumption expenditure (HFCE) on ICT products is 4.6% of total household expenditure, or ZAR105bn (StatsSA, 2017, p.2)[1]. The rapid growth of the Internet of Things (IoT) is likely to see 50 billion devices connected to the Internet worldwide by 2020 (CompTIA, 2015), with at least 50 million of these devices in South Africa. The EA process would have to be applied to each device type to ensure that the cumulative impact of these devices does not degrade network interoperability and quality of service.

The EA process is key to the provision of telecommunications infrastructure and services, as no equipment may be legally used in a telecommunications network in South Africa, without first being approved by the regulator (ICASA, 2013). EA is important to manufacturers, importers and distributors. There are three distinct regulatory approaches to EA, namely certification, verification and declaration of conformity (Magallanes, 2011:1). In essence, these EA regulatory approaches are either a command and control regulatory approach, or a self-regulation approach. These approaches are detailed by the administrative procedures that dictate the EA process. EA, or type approval, details the minimum set of regulatory, technical and safety requirements that a product would need to meet before it can be certified for use in a particular country (ITU, 2012: 9). The argument can be made that regulations applicable to EA should be technology agnostic to ensure that technological change does not render them obsolete. However, Carterfone-esque regulations may either foster or harm competition (Ford, *et al*, 2008) with respect to the market for customer-premises equipment and wireless services.

It would seem simple to adopt the successful deregulation approach to EA of countries in the European Union (EU) (Salisbury, 2000) and the United States of America (USA) (FCC, 2012), however the regulatory frameworks of these countries are underpinned by the applicable theoretical approaches to regulation that have evolved there. The regulatory approaches in

[1] Data is for the 2014 financial year.

developing countries face specific challenges as they are influenced by "poor infrastructure, weak economic conditions and inefficient institutions inherited from pre-reform eras" (Gasmi & Virto, 2010:275) as well as poor administrative resources (Ogus & Zang, 2005:131).

In South Africa, the Independent Communications Authority of South Africa (ICASA) has the overall responsibility for setting standards, certifying that EC equipment meets these standards and enforcing policy and regulation in South Africa (RSA, 2005). It is important to note that ICASA does not conduct conformance testing (i.e. the physical testing of EC equipment to a specified standard), but only specifies the standard to which the equipment should prove conformance. ICASA will accept a test report from any accredited test laboratories that show conformance to the specified standard, but the testing process is costly and places an economic burden on the equipment supplier.

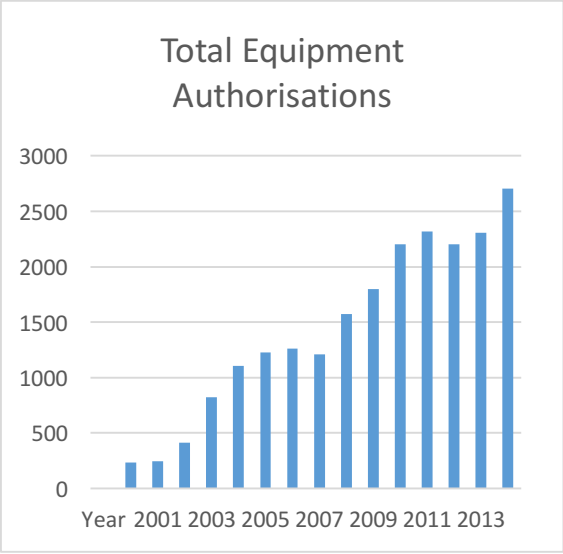
Four observable trends in EA in South Africa

The high growth in telecom markets have proven challenging to ICASA's mandate and the current EA regime. Four trends in EA have been observed (ICASA, 2015):

i) Total EA applications received increased ten-fold over the period 2000-2014.
ii) The total processing time per EA application grew three-fold over the same period.
iii) The amount of harmful interference by approved equipment reported during the period 2004-2011 increased significantly.
iv) An increase in the number of non-type approved equipment confiscated during the period 2006-2009 increased substantially.

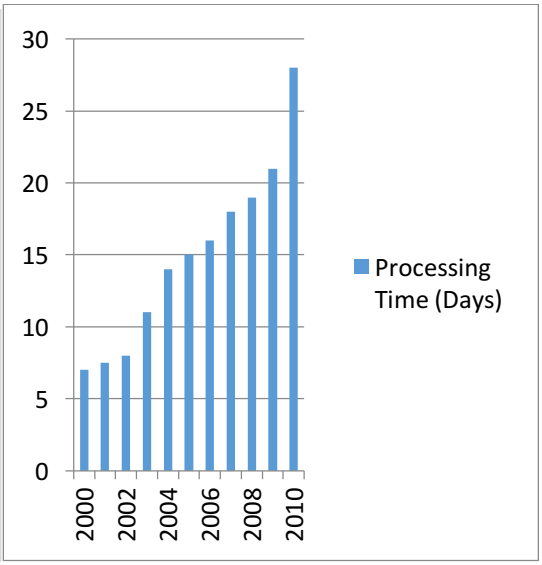
Despite these increases challenging the capacity of the regulator, the regulatory approach did not change and real problems can be observed. Two of the four trends are highlighted below.

Figure 1: Total EA applications 2000-2014 authorisation applications



Source: ICASA Type Approval unit, June 30, 2015

Figure 2: Processing Time of Equipment



Source: ICASA Type Approval unit, July 13, 2015

The primary cause cited by the Type Approval Department of ICASA for the increase in processing time, was not the increase in the number of applications, but problems with the regulatory approach that guides the type approval process. The increase in processing time

per application, coupled with the increase in the total number of applications, gives a more precise indication of the challenges that the current approach to regulation has on EA. The current command and control approach to regulation creates a substantial administrative burden for the regulator, which has to scrutinise and evaluate each application (Ogus & Zhang, 2005:132). The increased processing time for these applications imposes a cost on the applicant and therefore on the consumer (Ogus & Zhang, 2005:132). This is an example of the challenges arising from the command and control regulatory approach to EA, noting that regulation should not add undue cost in the approval process.

Problem statement: The discourse of EA regimes and the gap in knowledge

Studies by Knapp and Wall (1997:28) reviewing the FCC regulatory approach to EA by Pelkmans (1987) on technical harmonisation and standardisation relevant to removing the barriers to trade within the EU, by Veenstra and Leonhard (2008) on the impact of new technologies on regulatory regimes, and by Howard and Mazaheri (2009) on telecommunications reform in developing countries do not address the differences in influencing factors in developed and emerging markets.

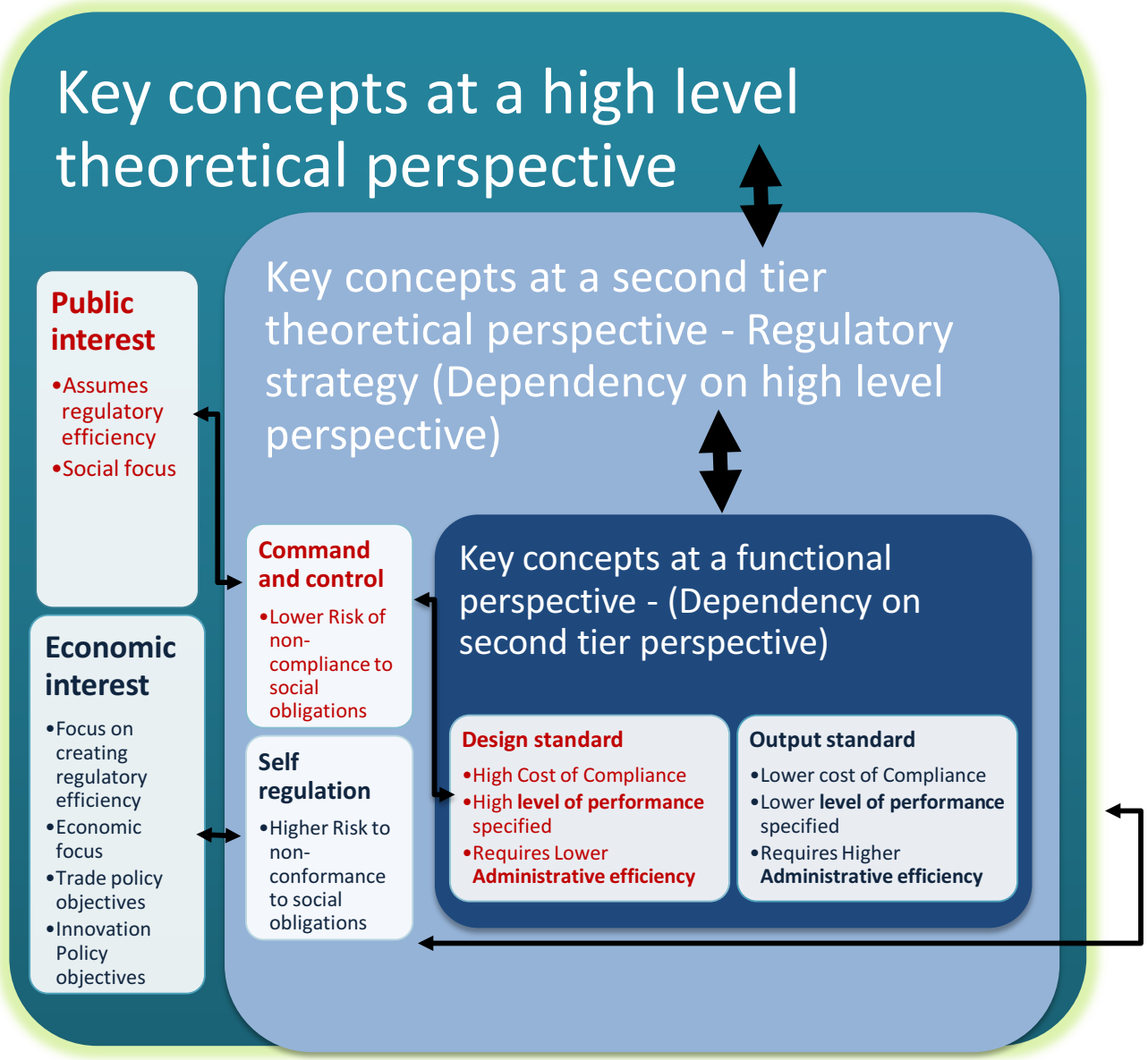
The popular deregulation approach to EA that has proven successful in many first world countries, may not apply to developing countries given their unique challenges. These challenges, such as a lack of administrative resources, poor infrastructure and a lack of ex-post regulatory monitoring add to the complexity of designing an appropriate theoretical approach to EA. The primary focus of the current public interest EA regulatory approach in South Africa ensures that social obligations are met, possibly to the detriment of economic imperatives. A predominantly economic-focused approach, however (such as a deregulated model of EA), does little to ensure that social obligations are met. Research has shown that even deregulated markets require some form of regulatory intervention to preserve competitive economic and social effects (OECD, 2012). This summary represents a naïve picture of the research problem. There is therefore a need to develop deeper insight for an innovative theoretical approach to EA that is grounded in empirical data generated in a developing country, in order to develop a rich picture of future equipment authorisation to promote competition and economic development.

In formulating a country competitiveness index, Porter, Sachs and McArthur (2002) defined three specific economic development modes and two transitionary stages, namely factor-driven, efficiency-driven, innovation-driven and the transitions from one stage to the next. In terms of this categorisation (WEF, 2015:13), South Africa is at the efficiency-driven stage, with thirty other developing countries at the same stage. As this study is grounded by data obtained in South Africa, the generalisability and applicability of the theory developed in this study would be best suited to countries within the same developmental stage.

The main research question is: In which ways can innovative theoretical approaches to regulation be applied to the EA regime of a developing country, in order to address possible limitations presented by the current theoretical approaches?

Theoretical and conceptual framework: Insufficiency of existing theory

Figure 3: Theoretical perspectives and key concepts



Based on interpretation of the existing literature, it is argued that there is no explicit research addressing specific EA approaches designed for developing country contexts.

Rationale for grounded theory methodology

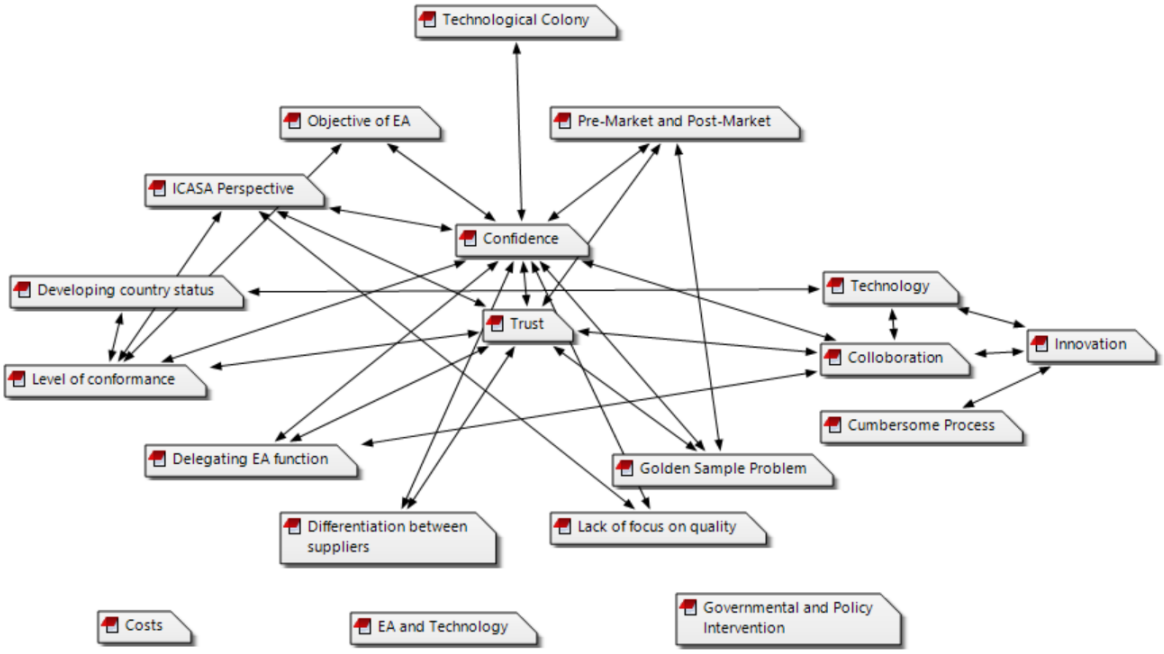
The premise of formulating theory directly from data, grounded through a logical process of deduction is applicable to this study, as our assertion is that the current theoretical regulatory approaches to EA are not grounded in the reality of developing countries. The aim is not simply to generate an improved mechanism for EA, but to formulate a theoretical explanation as the foundation for an alternative EA approach. Strauss and Corbin (1998) argue that grounded theory facilitates the move from a description of what is happening, to an understanding of the process by which it is happening, hence the methodology has relevance. The analysis and conclusion offer new theoretical insights, that have practical application.

The data used in the study was obtained predominantly from ICASA documents and from primary data sources, namely interviews with industry and regulatory stakeholders, noting that primary data carries the authority of the real world (Badenhorst, 2007). Twenty-five interviews were conducted and 53 documents were reviewed, though this paper reports only the interview data. This process of gathering rich data opened up other possibilities, including review of the various regulated standards.

Findings: Snapshot of key players and practices in the current regulatory approach

This next section draws only a few highlights from the study, including key players, efficiency issues, effectiveness in relation to EA objectives, and the specific issue of the "golden sample".

Figure 4: Atlas.ti network diagram of EA regulatory issues



Findings 1: Key players in the EA environment

Nearly all respondents held the view that the key player in the EA environment is the regulator. Original equipment manufacturers (OEMs), standards bodies and test laboratories were considered to be of secondary importance. However, one respondent argued that manufacturers are the most important player, alongside importers and service providers. Reference was made to "tier one" suppliers (large company size, high market share, high exposure to reputational damage) and "tier two" suppliers (small company size, typically a reseller, infrequent EA applications, less exposure to reputational damage) and the differential trust applied to each.

Findings 2: Efficiency: Simplified or cumbersome EA process?

ICASA has introduced what it considers to be a simplified process for EA, especially after the equipment has been approved. ICASA does not believe that a self-declaration process would

work as it has concerns about sub-standard equipment coming into the market. It wishes to have test reports as means of verification. The view of other key players is that the current EA process is cumbersome, labour intensive, highly inefficient and ineffective. The processing time has increased from 15 days to 30 days over the past years, attributed to the growing volume of applications. Technology advances have negatively impacted the EA processing time. As the number of different technologies on a single device increases, verification of these technologies is required as part of the process. This verification increases the time to process an EA application as radio-frequency engineers have to evaluate each additional test report. Technology is constantly changing and any delays cause unnecessary burden and unnecessary costs to the equipment supplier. The human resource capacity for EA has not increased, though the workload per EA staff member has. ICASA staff suggest that a new software system is required to ensure quicker processing times.

Simultaneously, the current process, coupled with the lack of human resources, creates the impression that ICASA is a bottleneck in the EA ecosystem. The majority of respondents, including industry suppliers, experts on standards, and some regulatory staff, agreed that a more efficient EA process was required. Quicker turnaround times were identified as a key action point to alleviate time delays in the approval process. Some operator respondents argued that insufficient emphasis is placed on allowing ICASA to exempt certain types of equipment from EA, as allowed in terms of the ECA legislation, particularly since the ICASA EA process is primarily a verification process, not a testing process. Respondents argued in favour of a narrower definition of scope for the equipment that would require approval.

The biggest single drawback listed by the majority of respondents was ICASA's inability to confirm the validity of a test report, through an independent verification mechanism such as retesting the product. Test laboratories in South Africa do not have either the skill or equipment to test the majority of international standards used in South Africa (respondent OB2G), nor is it feasible for ICASA to build their own test facilities. An investment by the Department of Communications (DoC) in building test facilities at the SABS has not met its objectives, given the failure to provide these facilities as a commercial venture and the high cost of testing, which feeds through to the cost of purchase for the end consumer, increasing the cost to communicate (respondent PP1L).

The problem is compounded where the equipment is tested at an internal (in-house) accredited lab, as the equipment supplier is essentially attesting to the validity of their product. ICASA has low confidence in this process, but has no option but to accept reports from "accredited" laboratories. Even if ICASA is not satisfied with the test documentation, they do not have the grounds to decline an application if equipment suppliers follow the rules.

Some respondents noted that (respondent RD3M):

> These devices have already been approved in other countries, so why should these products be approved here again in South Africa? It is very seldom that South Africa will not approve a device. For RF devices, there has never been a case where a device approval has been rejected. It is a waste of time doing the type approval here again. The supplier should just declare that they meet the requirements and we should grant the approval.

The duplication as described above highlights a significant process inefficiency, as equipment approved for use in the EU, for example, would again require approval for use in South Africa.

This requirement does not appear unreasonable, however the fact that ICASA has seemingly never made an executive decision to disallow an EC device, based on technical considerations, raises questions about the necessity for further technical evaluation. Conducting technical evaluations is significant in terms of technical staff allocation and time, as the output of six technical staff are channelled to a single administrative person, creating delays. Other respondents have been even more sceptical, referring to the EA process as a "rubber-stamping" exercise with the primary aim of generating revenue for the regulator (respondents OR1A, OB2G), noting that the quality of the product is verified by the out-of-country test laboratory, where it is physically tested to the appropriate performance and interoperability standards. The regulator merely reviews the test reports from these laboratories without conducting any further testing, meaning that there is scope for the regulator to accept the EA reports from the originating test laboratory, where the equipment has met all the test laboratory requirements.

Radio frequency specialists employed at ICASA involved in the technical evaluation of EA approval disagree with this assessment and note two ways in which additional checks are conducted. Firstly, ICASA conducts an assessment of the test facility issuing a test report, to determine its authenticity. This process lends credibility and confidence in the test results obtained from the test facility as well as confidence that the tested product conforms to the requisite standards. The second check involves a technical evaluation of the test report, checking the actual test parameters in a standard needed for EA approval to the measured result. Only if the device under test passes all technical requirements as stipulated in the standard, will the radio frequency specialist consider the equipment for EA approval.

Respondent SD2M stated that the objective of EA should be based on a business case and not a "government case". EA should support the sale of EA equipment, given the fast-moving pace of technology. Technology has commoditised the EC equipment market, and thus the life cycle of EC equipment can be very short. Delays in the EA process can render an entire model range obsolete and thus the business case objectives of ensuring quicker times to market are of utmost importance.

Trust in the process emerges as a common theme. Some respondents suggested bi-lateral cooperation with international test laboratories to improve the levels of trust and confidence. Another proposed solution is the use of current facilities in South Africa, the consolidation of these facilities, and the upskill of staff to enable them to perform the necessary testing. Both proposed solutions would involve collaboration with test facilities outside South Africa.

Another factor that has led to frustrated suppliers is the response time to technical queries. When dealing with technical reports, many suppliers rely on their principal vendors based abroad. With US and Chinese vendors, two of the major supplier countries, any query sent by the South African supplier results in at least a 24-hour waiting period, owing to the time difference. Thus even simple queries could take at least 48 hours to resolve. A few respondents highlighted language barriers, stating that Chinese and Japanese manufacturers, in particular, had a difficult time understanding EA queries: "We can have a disjointed conversation with no real response, especially when trying to explain ICASA's request to a non-English speaker" (respondent SD2M).

Despite evidence pointing to ICASA being a bottleneck in efficient regulation, staff at the regulator were adamant that there should be no compromise with regards to fulfilling the core objectives of EA. Instead, the suggestion was to drive additional capacity to the sector. It is noted here that accepting the reports of test laboratories outside South Africa, operating to world standards, would not constitute compromise.

Findings 3: Effectiveness: Industry and regulatory perspective on meeting EA objectives

Respondents were in broad agreement that EA is a vital process to ensure the integrity, safety and quality of service of electronic communications equipment sold in South African markets. Promoting consumer confidence was noted as a key theme, both in the EA process itself and in the equipment approved via the EA process. Consumer confidence means that consumers who see the ICASA logo affixed to any EC device understand that the device has been checked by ICASA, who has applied due diligence in assessing the equipment regarding its functionality and safety. Furthermore, a regulatory respondent highlighted the relationship between EA and competitiveness of network operators, as the assessment of efficiency of spectrum utilisation, interference protection and maintenance of equipment can save operators money by minimising network breakdowns caused by sub-standard equipment.

Another regulatory respondent was concerned that, without EA, there would be "chaos in the market". The example was cited, where new market entrants in Nigeria do not want to enter the market using the 2.4 GHz licence free band, as they cannot conduct commercial operations with an appropriate level of comfort that the service would work. On the other hand, a well-regulated 5.8 GHz licence free shared band in South Africa works very well due to coordination, assisted predominantly by the EA process. The band is so well managed that even high power links, which can cause widespread interference, can work in the same band with other lower power devices.

However, the view was expressed that the current EA process achieves only 60-70 percent of the objectives of EA. There are still devices that make it onto the market without type approval. A lack of and inefficiency in post-market surveillance prevents the confidence level from being higher (respondents RM1K and RN2A). The issue of a "golden sample", where the testing of one sample of EC equipment results in authorisation was raised, as the sample may not be representative of the entire production of that particular model of equipment.

Confidence is a recurring theme in the data gathered in all segments of the study. This relates to confidence in the EA process itself, confidence in the testing facilities, confidence in the test reporting and confidence in the post-monitoring abilities of the current EA regime. The issue of confidence raises serious concerns about the effectiveness of the current EA process in terms of achieving its stated objectives.

Findings 4: Effectiveness: The "golden sample" issue

A negative sentiment was expressed around the fact that the EA process is based on a representative sample that does not reflect the actual product. This can lead to counterfeit equipment, amongst other problems. Respondents explained that the current EA process cannot guarantee that the actual product is the same as the tested. ICASA does not confirm from a sample of the mass production run of the equipment that it is the same as the tested sample. Furthermore, no proof of compliance is required in terms of the current regulations.

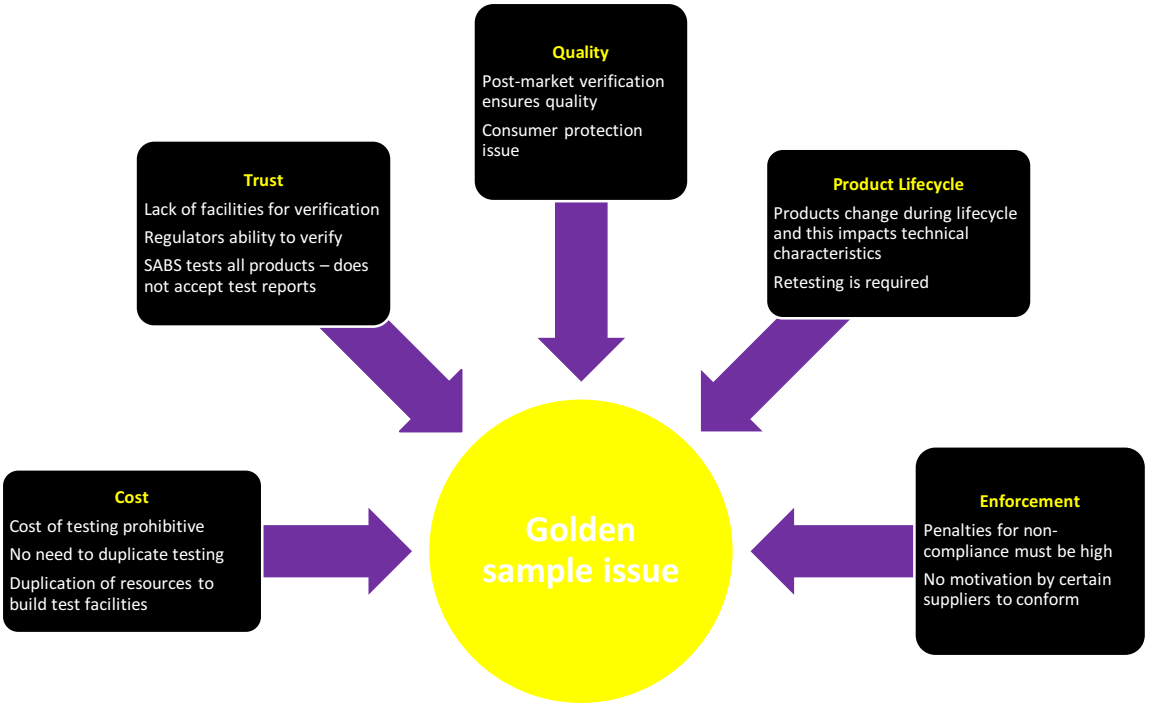
This discussion once again raised the issue of trust. EC equipment suppliers are not motivated to ensure that the retail equipment matches the tested sample as they are aware of the regulator's inability to test such compliance. This has emboldened some suppliers to either focus only on regulatory conformance through a “golden sample” or to submit false test reports (respondent RN6B). These suppliers do not fear reprisals from the regulator for such actions, as the burden of proof lies with the regulator. Should ICASA develop the ability to conduct post-market verifications, the trust between ICASA and the EC equipment suppliers could be strengthened. The equipment supplier would be less likely to sell equipment that did not meet the regulatory requirements, because of sanctions that the regulator could levy due to non-conformance, based on post-market testing. ICASA would also be more likely to trust the information provided by such suppliers.

Solving the golden sample problem will have a direct impact on the quality of the product, as continuous compliance to the approved EA standards through post-market testing would ensure that the manufactured product conforms to the regulated standards. The regulated standards ensure that the equipment meets quality standards, hence the continuous testing of devices will be very advantageous (OH1M). Collaboration with local and international test facilities was suggested as a mechanism to assist with post-market testing (respondents OB2G & RS3R).

The level of fines imposed should serve as a sufficient deterrent to suppliers should they not conform to the EA approval standards. Actual fines levied could be used to fund future post-market surveillance. The EU program of post market testing was suggested as a benchmark (respondent OH1M). An alternative funding mechanism would be to shift proof of compliance to the equipment supplier, thereby passing the cost of testing to the vendor (RM5S), however this could shift the cost of compliance to the end consumer. The penalties for non-compliance could include criminal action against individuals, such as directors of companies, should non-compliance be noted. With such harsh penalties, the likelihood of suppliers providing golden samples should be greatly reduced.

The SABS faced a similar problem and identified the acceptance of third party test reports as a major risk (respondent TLS2L). Hence, the SABS no longer accepts third party test reports and tests a wide range of products submitted for certification, from toasters to motor vehicles. SABS have entered into agreements with test laboratories both locally and internationally to test products that they are unable to test themselves. They negotiate this testing on a case by case basis and determine how much (if any) verification testing they can do. Ultimately, the complete test report is issued only by SABS, irrespective of the where the testing was done. The supplier bears the entire cost of such testing. As SABS can randomly select the sample for testing, this approach eliminates the golden sample problem. The major drawback to this process is the additional time required for testing. Equipment suppliers have expressed frustration with the “new” approach of SABS, citing significant financial loss due to the long lead times (respondents IOW2E, SM1E, SD2M). SABS themselves concede that this approach is challenging regarding the availability of resources. Figure x depicts the golden sample issue as a summation of five key variables.

Figure 4: Golden sample issue



Quick summary: Exploring the positive and negative aspects of the current EA process

The view expressed by numerous respondents was that the fact that a working EA regime exists is considered to be a positive attribute, irrespective of the flaws. ICASA has control and a reasonable level of confidence and control over devices that enter the country and has applied the applicable standards to these devices. The current EA regime has also kept the market vibrant. Operators were more specific, agreeing that the EA process instils confidence that the equipment conforms to the *minimum* mandatory standards required by the EA approval process (respondents OS5J, OB2G).

Figure 5 Positive aspects of current EA approach

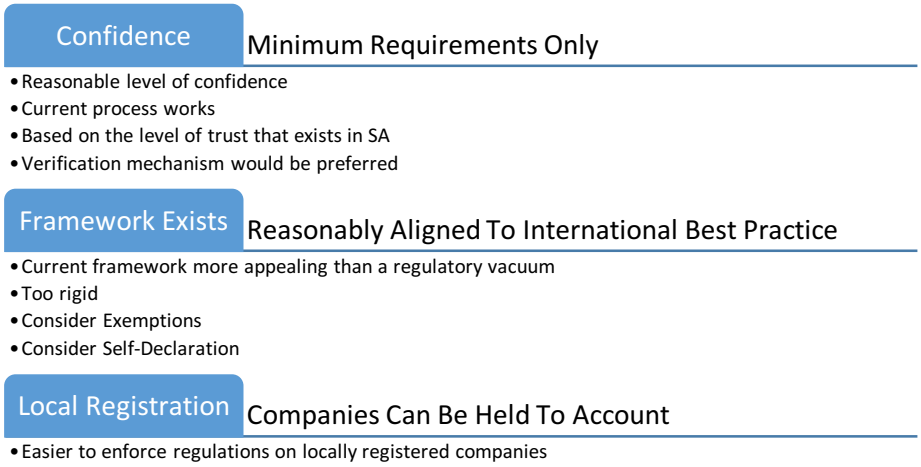
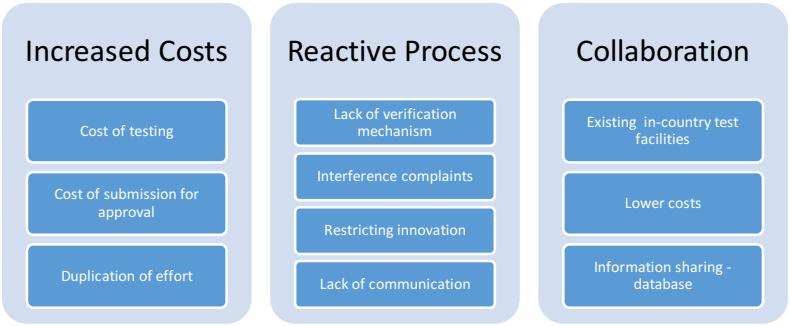


Figure 6 breaks down the problems associated with the current EA process into three key themes.

Figure 6: Problems with the current EA process



Several insightful themes are already evident from the data. One theme posits that all suppliers are not equal. Another emergent theme centres around the validity of data sources made available to the regulator.

Findings 5: Summarising stakeholder perspectives on applying innovation to EA

Respondents were unanimous that the objective of "integrity" of the EA process should remain, however, they argued that the focus should be on what matters in the EA process, namely the conformance of essential technical requirements to international standards. There was limited support for South Africa to move to a fully liberalised EA regime, such as those practiced in EU countries, where self-declaration is the norm. Self-declaration, coupled with the use of a local test facility, as well as allowing exemptions, are all presented by respondents as approaches to reducing the administrative workload and increasing the efficiency of the regulator. Technology advancements, such as the application of cognitive radio using the unlicensed spectrum (Lemstra, 2008), would contribute to a self-regulating environment.

Rapid, disruptive digital product innovation is understood to be a major driving influence for a future-oriented EA framework, offering potential benefits to consumers, with respondents citing the beneficial example of over-the-top (OTT) technologies. Hence, it was argued that the key principle in formulating an alternative EA approach would be that such approach does not inhibit digital product innovation, which can address many governmental public interest objectives without direct regulatory or policy interventions. Any EA regulatory approach should foster innovation and enable trade. Hence, relaxing the command and control approach would be an option, introducing a more relaxed approach, coupled with a strong enforcement regime (respondent RM1K). Such a regime could prescribe severe penalties for non-compliance. Counter-intuitively, a "relaxed" EA regime was thought to provide greater control for the regulator than a command and control regime.

Respondents argued that local and international collaboration should be a key regulatory approach to leveraging the existing resources available at test facilities in country and at international facilities (respondents OB2G, OK3H, OH1M, SD2M, SM1E). The focus should be on improving the EA process, not simply on publishing EA regulations. The EA process must become cheaper and more efficient, since a quicker time to market means more product

availability and greater internal revenue through increased tax collection. Various funding models need to be considered to fund the use of test facilities, an example being public-private partnerships between government and industry (respondent TLS2L).

Other respondents saw testing as a regressive move and advocated a self-managed solution that accepted verified test reports from accredited institutions. Money spent on test facilities could be better devoted to promoting local manufacturing (respondent TLJ1H). Local device manufacturing should be encouraged, as this has proven to be a major driver of growth in a few developing countries, such as India and China. Testing these locally produced devices would increase confidence in the EA process and could further stimulate innovation and competition.

Some respondents argued that ICASA should investigate and initiate a mechanism to allow exemptions of particular types of equipment. For example, where a few operators are the only parties affected by EA, they would be motivated to ensure compliance with standards, giving the regulator a degree of freedom in allowing equipment in specific categories to be declared as competent for use by the network operator (respondent OB2G). The current EA workload could be minimised should ICASA be more selective on what equipment is required to be approved.

A risk-based analysis should be applied to all equipment. The example was cited where the time, costs and process for certifying such a relatively innocuous device as short-range infra-red equipment is the same as that for approving a 100kW radio transmitter that has a range of several kilometres. A risk matrix categorising high-volume, low-risk equipment should be developed, with a view to differentiate or exempt such devices from the current EA process. Careful thought would need to be applied in this area, as the cumulative effect of interference caused by large volumes of low powered devices would also need to be considered (respondent OK3H).

The entire EA value chain is driven by the people active in the process, and upskilling of these EA staff could lead to substantial gains in the efficiency. This upskilling process applies to internal ICASA staff, as well as to staff of external stakeholders. Internal efficiency gains can be realised through training and upskilling, including knowledge of the many different product development processes from prototyping to manufacturing (respondent OR1A). External stakeholders can benefit from clear communication and instructions made available by the regulator. These instructions should be clearly and explicitly articulated to guide people who may be operating at different levels of skill.

In addition, automation of the EA process is considered to be an innovative way to increase efficiency. Increasing administrative efficiency by using an automated system to manage the EA approval process was seen as a quick win, and being the only real requirement to improve the system by many commentators. Efficiency was clearly related to costs, especially by equipment suppliers.

Any approach suggested by the regulator would require a phased-in approach, engaging with stakeholders in the EA process. The digital products sector is of vital importance to the economy of South Africa, and ICASA should ensure that advances in the EA approach are

well understood with as many negative scenarios as possible mitigated before roll out (respondent OK3H). Any new approach should focus on maximising technical and administrative efficiency, as well as effectiveness and quality of the EA process (respondents RN2A, RG5N, RM1K) and heightened confidence in the EA process (ICASA).

Analysis: Towards an innovative EA approach: The calculated concept of trust

In this section, we work towards building the proposed alternative theory for EA in efficiency-driven developing countries. The key category (calculated concept of trust) and its three dimensions discussed here (managing risk, regulator's level of confidence and promoting public trust), all emerge from analysis of the interview data and the documents reviewed.

Figure 7: Properties and dimensions of the key theoretical category "calculated concept of trust"

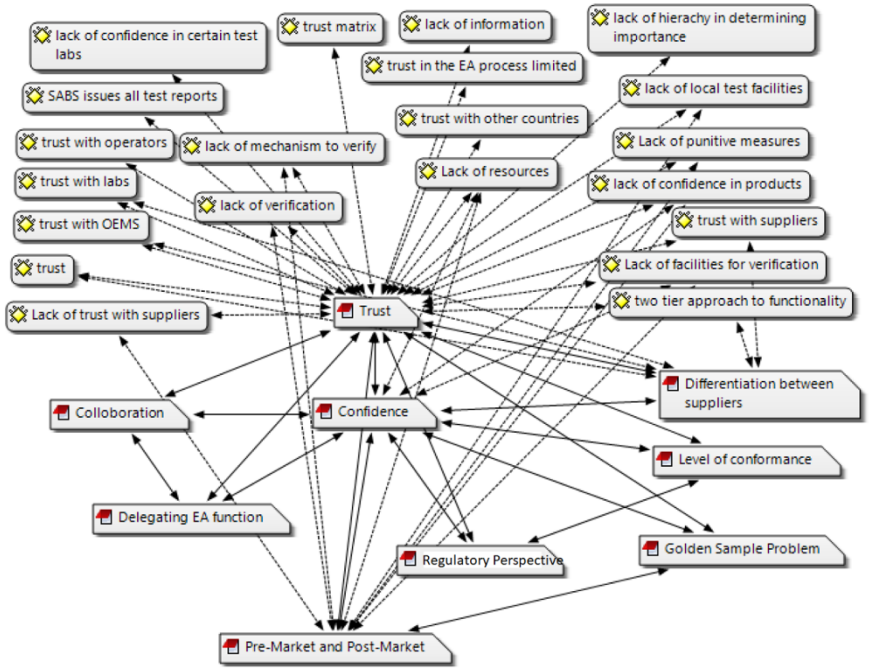


Figure 7 depicts the properties and dimensions of the key category for building the grounded theory, namely the "calculated concept of trust". It is immediately noticeable that the network diagram of the code-family "trust" is integrated with other code-families in complex ways, notably linked to the code-family "differentiation of suppliers", which in turn is related to the key category of "differential trust". Trust facilitates decentralisation and encourages collaboration (Lewicki & Bunker, 1996). There exists a "calculated conception of trust" where "…the assumption that the decision to trust is predicated primarily on the computation of risks" (Lewicki & Bunker, 1996:10). It is noted the Lewicki and Bunker (1996) are referring to trust in work relationships, not to equipment authorisation or regulation.

The network diagram in Figure 7 suggests that trust is largely risk driven, for example, the codes "lack of verification", "lack of facilities" and "lack of resources" are all risks that contribute to the regulator's decision to trust. Other codes that relate directly to trust such as "trust with labs", "trust with OEMS" and "trust with suppliers" relate to organisational trust,

which again is predicated on the regulator's computation of the risk associated with that particular group or organisation. The conception of trust is therefore calculated in the EA environment, with different metrics being applied to gauge the risk associated with a particular organisation or entity.

Another dimension related to calculated trust is confidence. Incremental increases or decreases in confidence impact the associated level of trust. Confidence is, therefore, a further metric, in addition to risk discussed earlier, that forms the calculated computation of trust that ICASA applies to the EA process. In the EA environment, confidence is an issue concerning data obtained by EA suppliers in the form of test reports. ICASA has a lack of confidence and thus a lack of trust in the test reports. ICASA also has a differential level of confidence in EA approval regimes external to South Africa. It is confident in the results from certain approval regimes and hence has a higher level of trust in them. Regional EA approvals are subject to more scrutiny by ICASA, and hence such approvals are assigned a lower level of confidence and trust in the process. This is another dimension of ICASA's calculated concept of trust when examining EA approvals conducted by other approval bodies.

A third dimension to calculated trust relates to the purpose of conducting the EA process. One of ICASA's goals is to ensure that all stakeholders view the EA process as trustworthy. The external perception of trust is important to the regulator, who actively works to promote such a perception. Some of the regulator's actions include consciously adopting inefficient administrative processes, such as duplicating certain approvals, with the purpose of promoting public and industry trust in the EA process and therefore in the electronic equipment market.

The formulation of a substantive grounded theory of EA in developing countries

The discussion in Table 1 below commences with the highest level concept and then briefly presents each of the key concepts used in theory building. Out of the 10 key categories that emerged from the data, analysis pointed to one, the calculated concept of trust as the core category around which theory building should take place.

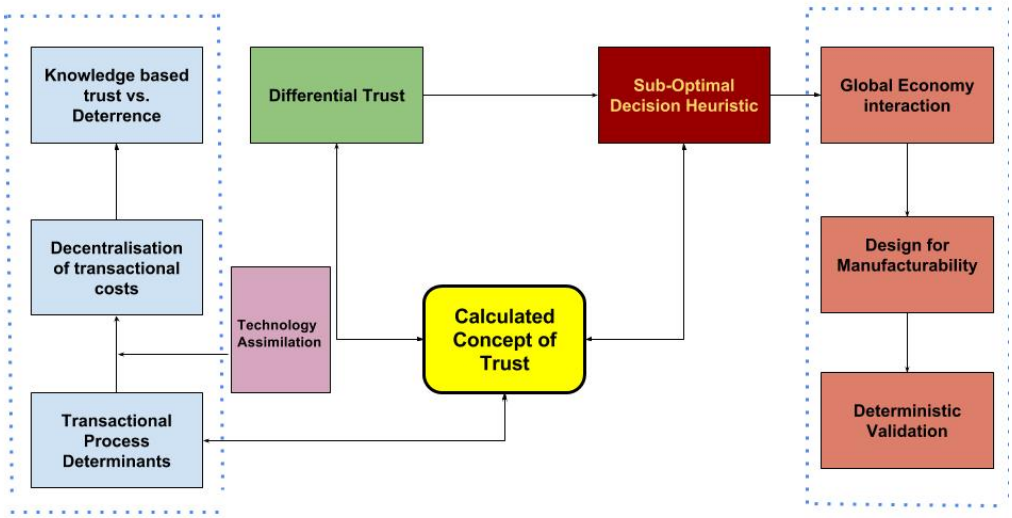
Table 1: Explanation of the formative conceptual categories for the final theory

Category	Explanation of core category and key categories for theory building
1. Calculated concept of trust (core)	The concept of trust in the EA environment is characterised by the risk associated with a particular organisation, with the regulator applying different metrics for a tacit computation of trust. This tacit calculation is the process of mental agility that the regulator goes through and is based on the assumption that the decision to trust is largely risk driven. This risk assessment leads to the differential application of trust.
2. Differential trust (key)	The level of trust assigned by the regulator to an EC equipment supplier is based on the tier status and salience of that supplier, with "tier one" suppliers enjoying a higher level of trust than "tier two" suppliers. The risk associated with a supplier impacts the decision heuristic employed in the EA process. Differential trust is a mechanism that the regulator employs to deal with the reality of sub-optimal decision heuristics.
3. Sub-optimal decision heuristics (key)	The regulator requires data pertinent to the EA process. The source of the data, coupled with an inability to verify the data through re-testing, limits the options available to the regulator, ultimately resulting in the regulator accepting data tested elsewhere. The regulator's confidence level with respect to this data results in a sub-optimal decision heuristic protocol being adopted for current EA approvals.

4. Global economy interaction (key)	The consideration of South Africa as a developing country, when analysing the EA environment, is negligible. The EA market is driven by South Africa's interaction with the global economy. Technology is the key driver of EC equipment standards, and technology adoption is dictated by the global economy. South Africa is obliged to accept global approvals and testing regimes, as the EC market in South Africa is not sufficient to support an indigenous testing capacity.
5. Design for manufacturability (key)	Design for manufacturability refers to the proactive optimisation of EC equipment over the entire equipment value-chain for the global market, prior to sale, to ensure that an appropriate balance between cost and quality is achieved. Safety and regulatory compliance are key determinants of the process, hence EC equipment is designed with EA conformity in mind.
6. Deterministic validation (key)	The current EA regulatory approach is pre-determined, as it validates known technical interoperability and performance standards as most EA equipment are designed for manufacturability. The current EA process is thus deterministic, with a core focus on validation. Technical regulations are usually binary in their outcome, with a technical review process used for validation. Little else can significantly impact the EA outcome.
7. Transactional process determinants (key)	Various exogenous factors impact the EA transaction and are determinants of the overall efficiency of the EA process. At the same time, other key transactional determinants with the ability to introduce institutional process efficiency are ignored. Some of the current processes that determine the current EA process are responsible for significant negative externalities to the EC equipment market.
8. Technology assimilation (key)	EA innovation through technology could be driven using existing software solutions. Automation, coupled with incremental process improvements, would mitigate the transactional process determinants. Applying software intelligence is required in order to formulate a risk rating of the equipment being approved, as well as to assimilate the results of a proven international approval framework. These are further examples of EA innovation. Technology assimilation must incorporate indigenous variations based on the requirements of the implementing country.
9. Decentralisation of transactional costs (key)	An innovative EA approach would aim to shift the burden of proof of EA approvals from the regulator to selected third parties. By collaborating with these third parties, the regulator can decentralise the EA process and thus the associated transactional costs. Decentralisation through public-private partnerships (PPPs) was deemed to be the ideal way forward, as it represents gains for both the regulator and industry.
10. Deterrence versus knowledge-based trust (key)	ICASA applies "deterrence based trust" in relation to the notion that a credible sanction exists, should an actor fail to cooperate. EA provides an appropriate level of deterrence in the form of fines and sanctions, ensuring that the actor can trust the outcome of a regulatory process. An innovative EA approach should incorporate "knowledge-based trust", where the actor's willingness to trust is determined by knowledge of the context/situation, and this knowledge forms a sufficient base from which the actor can reliably predict a rational outcome.

The theme of trust emerged as the golden thread that permeated through all the key categories. Trust as a theme on its own, however, was deemed to be too general did not function at a conceptual level of applicability and was not considered analytical enough to be explicated at a theoretical level. Theoretical saturation showed that the themes of trust and confidence were convergent and ultimately, after multiple iterations, were expressed as a "calculated concept of trust". The "calculated concept of trust" is more nuanced, retains the complexity of the concept of trust and has definitive linkages to all the other nine key categories. Figure 8 below presents a diagrammatic view of the relationship amongst the 10 categories, with the calculated concept of trust as the core category for theory building.

Figure 8: The calculated concept of trust



Explication of the substantive theory: A calculated concept of trust for EA in efficiency-driven economies

The EA framework, applicable to efficiency driven and transitional economies with a relatively rich EA testing infrastructure, is predicated on a calculated concept of trust. The regulatory authority employs a tacit computational mechanism to determine the level of trust when dealing with EA applications. The rationale for such an approach is largely driven by sub-optimal decision heuristics available to the regulator, as a result of the inability to corroborate technical data associated with the EA process. The regulator thus applies a differential trust paradigm, assigning a high level of trust to EA suppliers with a high level of salience.

The global economy has a significant impact on the EA approach. Efficiency-driven and transitional economies are typically net importers of EC equipment and are therefore compelled to adopt international technology trends and standards. EC equipment is designed for manufacturability, including the provision of evidentiary data required for global EA approval. The global EA approval process is thus deterministic, with a binary result either approving equipment for the global market, or not. Developing countries therefore have little control or influence over the global EA process, or over the source of the evidentiary data. The calculated concept of trust is once again applied, grounded in the source of the data provided to the regulator.

Trust in the sources of data is fundamental to the regulatory process for EA. An innovative regulatory approach to EA should be based on mechanisms to validate data integrity, such as collaboration with multiple stakeholders to promote data validation. A consequence of collaboration would be the decentralisation of transactional costs associated with the EA process. Using appropriately vetted stakeholders to validate EA evidentiary data

decentralises the EA transactional costs. Collaboration also has the effect of facilitating knowledge-based trust in the EA process, providing the regulator with a sufficient base to reliably predict a rational outcome to the EA process. When juxtaposed with the current deterrence-based trust approach of the EA process, a knowledge-based trust approach would not require the threat of a credible sanction. Knowledge-based trust is therefore a positive contributor to the calculated concept of trust in the EA environment.

There are numerous exogenous transactional process determinants impacting the overall efficiency of the EA process. Applying technology to the EA process can improve institutional efficiency. Assimilating technology from other EA environments is an example of innovation, although such assimilation must incorporate indigenous variations based on the requirements of the implementing country. The goal of applying technology and innovation to the EA process is ultimately centred around increasing the trust value proposition.

Concluding remarks

South Africa is a net importer of EC equipment and is thus intertwined in the regulatory dynamics of the global economy, as a means to building competitive markets in all economic sectors, including in the EC equipment sector itself. The South African economy relies on access to new generations of EC equipment and new types of devices to remain efficiency-driven. From a regulatory perspective, technological trends have led to a "designed for manufacturability" approach in which evidentiary data required for global EA approval is easily accessible. Deviations from such an approach are a difficult proposition, as the global EA approval process is deterministic. The regulator has adopted the calculated concept of trust in its attempts to verify the authenticity of the evidentiary data provided during the EA application process. However, current EA processes are cumbersome, hence often costly for the supplier and for the end consumer. This theory argues that a future-oriented EA approach should move to a position where knowledge-based trust underpins the calculated concept of trust in the EA environment, shifting beyond the current deterrence-based trust. Knowledge-based trust and automated intelligence can be applied in ways that create positive externalities for competition, both in EC equipment markets and in those markets that rely on EC equipment.

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