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Business policies to foster cloud computing adoption

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Abstract (English)

My research shows that national institutions, both formal and informal, matter when it comes to the adoption of technology such as cloud computing, a technology focused on business benefits and referred to as business-oriented technology. Institutions of power distance, uncertainty avoidance, trade union strength and government effectiveness significantly impact cloud computing adoption in a country. However, none of those national institutions tested impact mobile broadband adoption, technology mainly benefiting consumers and referred to as consumer-oriented technology. The adoption processes of cloud computing and mobile broadband, two very different technologies, possess rather different institutional drivers. Additionally, businesses operating in the EU countries with higher quality of governance are more likely to implement cloud computing in their operations, where the quality of governance (or good governance) also reflects institutions in a county. Noting the importance of national institutions to the success of the implementation of new technological advancements should result in the implementation approaches by businesses and governments being adjusted and fitted to specific situations and environments. Both, businesses and governments, need to take an active role in understanding institutional environments in which their operate in order to foster adoption of technology such as cloud computing. Just copying what is done in other geographies may not be the most effective approach. Additionally, when governments invest in the initiatives, such as Gaia-X, to foster implementation of cloud computing technology, it is necessary that there is an alignment with the businesses' priorities, otherwise it is unlikely that the businesses will adopt the initiative.

Findings of this research could apply for other upcoming technologies such as Artificial Intelligence and Robotics, which are also perceived as mainly business-oriented technologies. However, they were not focus of this research but are interesting next research topics.

Abstract (German)

Meine Forschung zeigt, dass nationale Institutionen, sowohl formelle als auch informelle, eine Rolle spielen, wenn es um die Einführung von Technologien wie Cloud-Computing geht, einer Technologie, die sich auf Geschäftsvorteile konzentriert und als geschäftsorientierte Technologie bezeichnet wird. Institutionen wie Machtdistanz, Unsicherheitsvermeidung, Stärke der Gewerkschaften und Effektivität der Regierung haben einen signifikanten Einfluss auf die Einführung von Cloud-Computing in einem Land. Allerdings hat keine dieser getesteten nationalen Institutionen einen Einfluss auf die Einführung von mobilem Breitband, einer Technologie, die vor allem den Verbrauchern zugutekommt und als verbraucherorientierte Technologie bezeichnet wird. Die Einführungsprozesse von Cloud-Computing und mobilem Breitband, zwei sehr unterschiedlichen Technologien, haben eher unterschiedliche institutionelle Antriebe.

Darüber hinaus sind Unternehmen, die in den EU-Ländern mit einer höheren Qualität der Regierungsführung tätig sind, eher geneigt, Cloud-Computing in ihren Betrieb zu implementieren, wobei die Qualität der Regierungsführung (oder gute Regierungsführung) auch die Institutionen in einem Land widerspiegelt. Die Bedeutung nationaler Institutionen für den Erfolg der Umsetzung neuer technologischer Fortschritte sollte dazu führen, dass die Umsetzungsansätze von Unternehmen und Regierungen an spezifische Situationen und Umgebungen angepasst werden. Sowohl Unternehmen als auch Regierungen müssen eine aktive Rolle dabei spielen, die institutionellen Rahmenbedingungen, in denen sie tätig sind, zu verstehen, um die Annahme von Technologien wie Cloud-Computing zu fördern. Einfach nur zu kopieren, was in anderen Regionen getan wird, könnte nicht der effektivste Ansatz sein. Darüber hinaus ist es erforderlich, dass die Investitionen der Regierungen in Initiativen wie Gaia-X zur Förderung der Implementierung von Cloud-Computing-Technologie mit den Prioritäten der Unternehmen in Einklang stehen; andernfalls ist es unwahrscheinlich, dass die Unternehmen die Initiative übernehmen.

Die Ergebnisse dieser Forschung könnten auch auf andere kommende Technologien wie Künstliche Intelligenz und Robotik anwendbar sein, die ebenfalls als hauptsächlich geschäftsorientierte

Technologien wahrgenommen werden. Allerdings waren sie nicht Gegenstand dieser Forschung, sondern stellen interessante nächste Forschungsthemen dar.

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1. Introductory Chapter

Technology advancement is widely recognized as one the key drivers of growth and development. Caliskan (2015) notes that the difference in technology adoption represents a major difference in the GDP per capita of countries. In recent years, there has been a particular focus on digital technologies such as cloud computing. Cloud computing has a direct impact on growth and development of digital economies, which represent around 5% of global economy and 3% of global employment (Bukht and Heeks, 2017); Williams, 2021). Cloud computing is generally considered a cost efficient and reliable technology that particularly benefits business users, hence is described as business-oriented technology. The cloud computing services are typically offered by large multinational companies, referred to as hyperscalers, with a variety of diverse offerings and competitive pricing that individual businesses could not produce on their own.

Despite clear advantages of using cloud computing services, cloud computing technology is not widely adopted in many countries. This observation has led to this research, firstly to understand why is that the case and secondly to identify what possible measures/actions/policies[1] can businesses and governments in different countries implement to foster the adoption of such an important technology such as cloud computing. The research is constructed as a cumulative dissertation comprising of three separate papers, being: 1. *Impact of national institutions on cloud computing adoption. Comparison to mobile broadband adoption*; 2. *Country's governance quality impact on cloud computing adoption in the EU enterprises,* and 3. *Does Gaia-X foster cloud computing adoption by European (EU) businesses?*

The first paper, *Impact of national institutions on cloud computing adoption. Comparison to mobile broadband adoption,* draws on the neo-institutionalism and investigates the impact of selected national institutions, formal and informal, on cloud computing adoption. According to neo-institutional theory, the adoption of technology is subject to various institutional pressures present in a country and reflected in the country's national institutions. Hence, national institutions may cause

[1] Term business policies in the title of the Thesis refers to the measures, actions and policies that businesses and governments could take to foster cloud computing adoption.

individuals in a certain national (country) setting not to behave in an economically rational way, which would affect the success of implementation and adoption of technology such as cloud computing. The research in this first paper aims to understand national, institutions based, cross-country perspectives on cloud computing adoption, on which there is very limited prior research conducted.

National institutions are ‘humanly devised constraints that structure political, economic and social interactions (North, 1991, pp. 97). The main proposition of this paper is that institutions, which according to North (1991) can be formal or informal, impact cloud computing adoption in a country. Formal institutions are ‘formal rules (constitutions, laws, rights)’ (North, 1991, pp. 97) typically enforceable by the state via official channels. Informal institutions are ‘socially shared rules, usually unwritten, that are created, communicated, and enforced outside officially sanctioned channels’ (Hemke & Lewitsky, 2006, pp. 727). Informal institutions are mostly reflected in national culture that is best described by Hofstede’s national culture parameters (Hofstede, 2001).

The selection of three formal institutions (employee protection legislation, trade union strength and government effectiveness) and three informal institutions (Hofstede’s model’s power distance, individualism and uncertainty avoidance) were tested using one step GMM, Generalized Method of Moments dynamic regression, on a panel of 38 worldwide countries’ cloud computing revenues over a five-year period (2013 to 2017. 2018 and 2019 forecasts also available; however, they are not used in the regression analysis). Cloud computing revenues are considered as a good proxy for cloud computing adoption, since higher the revenues in a country accrued from the cloud computing services, greater adoption of cloud computing in the country assumed. Additionally, cloud computing revenue data is available across a large sample of countries over a longer period in order to perform panel analysis. No similar comparable data sample is found. For example, EU measures cloud computing adoption by enterprises and is used in the second paper; however, that measurement is only available for EU countries.

The selection of institutions is based on various previous research that indicated that those institutions maybe relevant for technology adoption such as cloud computing[2]. The research in this paper centers around the question of which national institutions are significant for cloud computing adoption across countries. As noted in the paper, there were other studies into cloud computing; however, they are also limited in scope and/or focused on few countries or geographies (Low, Chen & Wu, 2011; Sharma, Gupta, Acharya & Jain, 2021; Vu, Hartley & Kankanhalli, 2020; Senyo et al., 2018; and others). In contrast to the previous research, this paper offers a new perspective to cloud computing adoption, and technology adoption in general. It focuses on cross-country analysis of cloud computing using institutional approach and identifies several national institutions as determinants of cloud computing adoption. This kind of approach was applied by Crossland and Hambrick (2011) to analyse the impact of national institutions, both formal and informal, on 'latitude of managerial actions'. It is however not yet applied to analysing technological adoption determinants, and in this study, it is applied to cloud computing adoption and the impact of both formal and informal national institutions as its determinants.

The national institution data is based on public sources, such as OECD Index for employment protection legislation[3]; Collective Labour Force Index index for trade union strength[4]; the World Bank Group for government effectiveness[5], and Hofstede model data to measure informal institutions[6] of power distance, individualism, and uncertainty avoidance. The data on cloud computing revenues as a proxy for cloud computing adoption per country is sourced from GlobalData research[7]. The data is available in a panel format, with the expectation that the past values of dependent variables affect the future values, hence dynamic regression is chosen as the most appropriate statistical method. GMM was selected since it is considered a robust model that accounts for presence of country-fixed effects,

[2] With more details on those available in the actual paper, which attached to this PhD Thesis.
[3] Source: OECD employment protection legislation index. https://www.oecd.org/els/emp/OECDEmploymentProtectionLegislationDatabase.xlsx. Accessed 4th Nov. 2020.
[4] Metten, A. (2021). Rethinking trade union density: A new index for measuring union strength. *Industrial Relations Journal*, 52(6): 528-549.
[5] Source: Worldbank. Worldwide Governance Indicators. https://www.worldbank.org/en/publication/worldwide-governance-indicators. Accessed 25th Feb. 2024.
[6] Source: Geert & Gert Jan Hofstede model data. http://www.geert-hofstede.com/. Accessed 20th Sep. 2020.
[7] Source: GlobalData, Cloud Computing Industry Data using the figures from MarketLine's Industry Profile Series: Cloud Computing, undertaken in July 2018.

heteroscedasticity and serial correlation potentially present in the error term, which could be the case on the data set used. Additionally, one step GMM is used due to the data sample considered to be of a smaller size.

Results of the analysis indicate that four of the six national institutions tested are significantly impacting cloud computing adoption in countries worldwide, those institutions being power distance, uncertainty avoidance, trade union strength, and government effectiveness. Specifically, the following was found: 1. The higher the value of power distance in a country, the higher cloud computing adoption in that country; 2. The higher the uncertainty avoidance in a country, the lower cloud computing adoption in that country. 3. The higher trade union strength in a country, the higher cloud computing adoption in that country. 4. The higher government effectiveness in a country, the lower cloud computing adoption in that country. In countries with higher tolerance to following top-down strategies and unilateral decision making, as well as with lower risk avoidance/aversion, cloud computing is adopted more. Additionally, in countries with lower government effectiveness and higher trade union strength, cloud computing is adopted more. This indicates that national institutions do really matter in case of cloud computing adoption.

To establish whether the institutions that impact cloud computing also impact a different type of technology, a comparison to mobile broadband technology adoption was done. On a panel of 41 worldwide countries' mobile broadband revenues over a three-year period, it was found that none of the institutions tested in this study affect mobile broadband adoption. Cloud computing and mobile broadband, two very different types of technology, have different institutional drivers.

To foster the adoption of a technology such as cloud computing, both businesses and governments need to pay strong attention to the national institutions relevant in each country. Businesses need to consider the level of power distance and uncertainty (risk) avoidance built in the national culture of a country, hence develop approaches that fit to their specific national setting. Similarly, governments and policy makers need to reflect on the laws and the policies in a country, which are typically reflected in formal institutions of a country. It is important to note that national institutions differ in different countries, hence specific measures and actions need to be developed per country. Just copying what is done in other countries may not provide optimal results. As noted in the paper, 'This study should raise the awareness that each technology and each country need to be understood and analysed before embarking on the implementation journey. Without this awareness there are hidden risks to the implementation going above and beyond what is considered rational and is impacted by the national institutions or constraints. This is particularly relevant for managers of multinational organisations, which often do not reside in the countries for which they develop the strategies and policies, hence may not be aware of the specific national constraints operating in those countries. For example, if a multinational company is leading a strategy aimed at implementing cloud computing in its affiliates in countries with different cultural make up, particular care needs to be taken. If the strategy needs to be implemented in countries like Russia and Denmark and is led from the headquarters in Germany, all with quite different cultural make up, the tactics of the implementation need to be reviewed and adjusted per country accordingly. Russia has a very high national institution of power distance (93 out of 100); hence, it is necessary that the initiatives are first supported by the top management, before any wider implementation can start. The rest of the organization will "comply and follow" with the top management decisions. To the contrary to a country like Denmark, with low national institutions of power distance (18 out of 100), having the approval of the top management is not sufficient. More effort needs to be spent on all employees at various levels in the organization through organized dialogs and debates to obtain the understanding of the reasons for the implementation and bring certain level of consensus and alignment. This takes much more time and effort, hence may slow down the whole implementation process; however, if ignored, it may result in the initiative not being implemented.'

Similar considerations need to be given to other national institutions too. The countries with lower uncertainty avoidance (greater risk acceptance) will be more willing to accept the risks that come with the adoption of cloud computing. While the countries with higher uncertainty avoidance may require additional measures to be implemented by businesses to encourage them to take on cloud computing. As noted in the paper, 'This research also has interesting implications for governments and policy makers, since formal institutions are the reflection of laws and policies in a country. When aiming to increase technology adoption on a country level, the government should look at its laws and policies more critically and if necessary, adjust in order to enable higher adoption success. For example, businesses often adopt cloud computing from the perspective to bring efficiencies into their operations. However, cloud computing introduction may result in creation of uncertainties and risks with the employees of those businesses, who in turn may resist the technology adoption. It is the task of governments and policy makers to try and protect employees; however, they should not negatively impact businesses either.'

Beside its relevance to cloud computing, this research has relevance to any technology adoption by raising the awareness that each technology and each country need to be understood and analysed before embarking on the technology implementation journey.

In the second paper, *Country's governance quality impact on cloud computing adoption in the EU enterprises,* also using the neo-institutional theory as the theoretical basis, the research on the impact of the (formal) institutions on cloud computing adoption was furthered. The focus was shifted from the worldwide to better understanding the adoption of cloud computing in the EU. The data on the use of cloud computing in the EU in the period 2014 to 2021 shows large deviations amongst the member states. The countries such as Finland (63%), Sweden (58%), and Denmark (51%) have the highest levels of adoption of cloud computing services in their enterprises, while countries such as Bulgaria (9%), Romania (11%), and Greece (13%) have some of the lowest levels. Cloud computing has many benefits to enterprises in terms of cost and performance, and one would not expect to see such a large deviation across the EU countries when it comes to the adoption of cloud computing by enterprises. Answering the question of why there exists such a large variation in cloud computing adoption by enterprises across the EU countries is the focus of research in this paper.

Considering that the EU is governed under the set of common rules and regulations, it would be reasonable to expect that there is a certain level of coherency amongst the EU member states formal institutions, typically reflected in the laws and the policies of the country. However, that is not always the case. As noted by Farole et al. (2011), EU member states' institutional capabilities and governance impacts their policy implementation and adherence. In this research, the particular focus was put on the country's quality of governance (or good governance), reflecting specific country's institutional capabilities. 'Good governance' in a country is measured as the average of the four World Bank governance indicators[8] of Control of Corruption, Rule of Law, Government Effectiveness and Voice and Accountability. The EU countries, on average, have higher levels of good governance when compared to the rest of the world, however, there exist significant variations between the individual EU member states. There has been increasing focus on 'good governance' research and its impact on growth and development of economies and societies (Wu, C-H., 2021; Bota-Avram, 2014; Ngobo & Fouda, 2012; Bruno & Claessen, 2010; and others). However, no relevant research has been found that establishes an empirical link between a country's government governance and its effects on cloud computing adoption, a gap this paper is attempting to address.

Using the panel data on use of cloud computing services in enterprises in Europe in the period from 2014 until 2021 and applying GMM dynamic regression (similar to the first paper), it was found that the country's governance quality positively impacts cloud computing use in the EU enterprises. The EU member states with higher quality of governance have higher cloud computing adoption in their enterprises. Within the EU, good governance matters, hence the EU and its member states should look at ways to improve the governance of its member states in order to further the adoption of technology such as cloud computing. The data on use of cloud computing services in enterprises in Europe is sourced from Eurostat[9] and is based on the results of surveying 148,000 of EU enterprises with at least 10 employees in the EU NACE[10] classification (out of 1.5 million enterprises in this classification in the EU in 2021). The data is expressed as a percentage of enterprises using cloud computing services and was extracted in October 2022[11]. To accommodate for potential biases, four different models were used to control for factors such as net income, GDP, ICT sector development, as well as broadband internet availability in different countries. All four models tested show the

[8] Source: Worldbank. Worldwide Governance Indicators. https://www.worldbank.org/en/publication/worldwide-governance-indicators. Accessed 25th Feb. 2024.
[9] Source: Eurostat. Cloud computing services by size class of enterprise. https://ec.europa.eu/eurostat/databrowser/view/isoc_cicce_use/default/table?lang=en. Accessed 15th October, 2022.
[10] NACE sectors covers are manufacturing, electricity, gas and steam, water supply, construction, wholesale and retail trades, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, information and communication, real estate, professional, scientific and technical activities, administrative and support activities, and the repair of computers and communication equipment.
[11] Since that time, 2023 data was also made available, however that was after my research was already submitted and processed. The 2023 data has been added to the data set used in the final research paper.

consistent results in support of the research hypothesis: The higher the governance quality in an EU country, the higher cloud computing adoption in the enterprises in that EU country.

This research complements the research in the paper one and further points to the importance of the national institutions to cloud computing adoption in the countries, in this case to the EU states. This research was conducted on the EU member states, since the data on the use of cloud computing services in enterprises is available on the EU data sample only. 'It aims to provide additional input to the EU government(s) and decision makers and support them with additional insights in terms of drawing their attention to the importance of country's governance quality, and the improvement of it, for continued growth in the use of cloud computing in the EU enterprises, hence increase in digitalisation and achievement of their strategic objectives. Improving control of corruption, hence reducing corruption in a country; implementing greater application of the rule of law, hence ensuring legal system works well; ensuring government and its institutions work effectively and independently are all very important from various aspects, and in this research, it is shown that they are also very important for a country's adoption of technology such as could computing. EU and individual country governments and policy makers have significant influence on all of those as they are formal institutions and reflect policies and laws in a country. When aiming to increase technology adoption on a country level, the governments should look at its laws and policies more critically and if necessary, adjust in order to enable higher adoption success' (Karamujic, 2025). This is very relevant for the EU, since it aims to accelerate digitalisation, with the EU Commission setting a goal of 75% of the EU enterprises to have taken cloud computing services by 2030. The 2021 level was around 42%[12], and in the recent survey from 2023 it Increased to just below 47%, however still well below the desired level.

It is also interesting to note that government effectiveness in the first paper had a significant negative impact on cloud computing adoption when tested on 38 worldwide countries and other five national institutions, however when analysed in the isolated context of the EU countries, government effectiveness in a combination with the other three indices comprising 'good governance', shows a

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positive impact on cloud computing adoption. Greater government effectiveness indicates greater application of rules and regulation, including those that are limiting the use of public clouds outside of specific geographies. Such one regulation is the GDPR (General Data Protection Regulation) that was made into the law in Europe in 2018 and as noted in the paper one, it may have negative impact of cloud computing adoption in Europe when compared to the rest of the world. Khan and Gouvia (2017) find that GDPR introduction improves security and data privacy; however, it brings a set of challenges and serious implications on the cloud computing providers. Additionally, the research in the two papers was based on different data sets; paper one uses worldwide cloud computing revenues per country sourced from GlobalData in the period 2013 to 2017, while paper two uses the data on the EU Countries use of cloud computing services in enterprises sourced from Eurostat in the period 2014 to 2021. It would be interesting to extend the research from paper two to the rest of the world using a similar data set, and compare the findings to the research in the paper one. However, due to the lack of the data availability, the findings of the second research are limited to the EU countries only.

The third paper, *Does Gaia-X foster cloud computing adoption by European (EU) businesses?*, delves further in the EU and investigates the impact of the EU policies/initiatives on cloud computing adoption by the EU member states. The specific focus of the paper is on Gaia-X, 'made in Europe' public cloud computing infrastructure initiative, aimed at addressing ever increasing dominance of non-EU companies (hyperscalers) in the cloud computing infrastructure space in the EU (and globally). European cloud computing market by second quarter of 2021 was around 7,3 Billion Euros (source Synergy Research Group), of which European cloud computing share is only 16% and has been steadily decreasing over time. The USA hyperscalers such as Amazon, Google, and IBM make remarkable 66% of that market share and are expected to further increase (Statista, 2023).

Gaia-X aims to build 'high-performance, competitive, secure and trustworthy data infrastructure based on European values' (Baenfer, Buehler, Moeller and Svensson, 2021). Gaia-X is a major initiative and one can assume it requires sizable investment by the EU. In this research we pose a question if there is a significant increase in cloud computing services use by European businesses which could be attributed to the introduction of Gaia-X. If not, why are European businesses not using Gaia-X? The research previously published on the topic of Gaia-X are predominantly case studies or studies lacking academic rigor from the perspective of proving the phenomenon using the statistical methods. (Niebel, Reibers & Kraemer, 2022; Autolitano & Pawlowska, 2021; Celeste, 2021). The gap attempted to be addressed in this research.

Using structural breaks statistical methods, aimed at identifying the impact specific economic or political factors (exogenous shocks) may have on certain variables over time, we test if Gaia-X impacted cloud computing use by the EU enterprises in the period 2014 to 2023[13]. As stated in the paper: 'If there is an impact of Gaia-X introduction, one would expect to see a significant increase in the cloud computing use by the EU enterprises in 2022, when Gaia-X was in its full implementation, adaption and growth.' During the analysis, multiple structural break models were applied testing the null hypothesis of no breeks versus the alternative with the increasing number of breaks in each new model. The tests were repeated until the model was reached under which no further structural breaks were identified. The last significant model identified six structural breaks in the period from 2014 to 2023, showing likely impacts of events such as GDPR introduction and COVID-19 outbreak on the cloud computing use by the European enterprises. It could be said that Gaia-X introduction also impacted the cloud computing adoptions by European businesses, since the year 2022 was also found to be a significant break in the data. However, it is difficult to argue singular impact of Gaia-X, since the impact may have also been compounded by the other events, hence we conclude that the structural break analysis did not provide conclusive evidence that Gaia-X initiative had a significant impact on the use of cloud computing by the EU enterprises. To provide additional insights on the effects of Gaia-X on cloud computing adoption in the EU, a panel of IT professionals from the EU businesses was approached with a set of survey questions. The results of the survey uncovered a mismatch in Gaia-X and EU businesses goals. EU businesses select services that are cost efficient, reliable, and diverse. On the other hand, Gaia-X initiative focuses on the principles of digital sovereignty, data protection, free market access and European value creation. Those Gaia-X principles are important to the EU businesses, however when choosing a service, 91% of the EU businesses surveyed opt to use foreign public cloud computing infrastructure providers, rather than the EU Gaia-X alternative. This is

[13] The same data on the use of cloud computing services by the EU enterprises as in the second paper was used, only extended to 2023 due to new survey data being made available since the paper two was conducted.

in line with the economic theory, in particular the network effect theory (Katz & Shapiro, 1985). The existing hyperscalers are able to offer reliable, diverse, and cost-efficient services to the businesses, who in turn further use the hyperscalers' services, enabling them to advance their service offerings and improve price. To compete in this market, Gaia-X needs to appeal to the EU businesses and create a strategy aligned to the EU businesses' priorities in order to attract and keep them on Gaia-X. EpiCenter (2020) criticises Gaia-X of being more politically motivated initiative rather than being economically/financially advantageous to the EU businesses. Businesses are not likely to choose a cloud computing infrastructure provider 'just because it is made in Europe'. European businesses may opt for the European alternatives if and when available, nonetheless those need to be cost efficient, reliable and provide diverse set of offering, comparable to what is available by the foreign cloud computing infrastructure providers.

The following chapters contain the details of the three research papers, ending with concluding remarks, collective references and appendices.

2. Publications included in this PhD Thesis

This is a cumulative dissertation comprising of three separate research papers which are included as part of this PhD Thesis. Detailed bibliographical information on each of the papers is specified below, along with the current status identified as either published, accepted, or submitted and the relevant dates for each.

1. Published paper

Karamujic, L. (2025). Impact of national institutions on cloud computing adoption. Comparison of cloud computing to mobile broadband adoption. *Journal of Global Information Technology Management.* 28(1): 6-29. https://www.tandfonline.com/doi/full/10.1080/1097198X.2025.2453358

2. Accepted paper (awaiting publication)

Karamujic, L. (2025). Country's governance quality impact on cloud computing adoption in the EU enterprises. *Journal of regional research. Investigaciones Regionales.* https://investigacionesregionales.org/en/article/countrys-governance-quality-impact-on-cloud-computing-adoption-in-the-eu-enterprises/

Date of acceptance: 29th April, 2025.

3. Submitted paper

Karamujic, L. (2025). Does Gaia-X foster cloud computing adoption by European (EU) businesses? *Telecommunications Policy.*

Date of submission: 18th May, 2025.

3. Research Paper 1: *Impact of national institutions on cloud computing adoption. Comparison to mobile broadband adoption*

Abstract

Research shows that the adoption of cloud computing varies across countries, giving a rise to the obvious question as to why is that the case. This paper tests the proposition that national institutions, both formal and informal (such as national culture), affect cloud computing adoption in a country. To develop hypotheses, a specific perspective from neo-institutionalism theory has been drawn, focusing on the impact of national institutions on technology adoption. In an empirical examination of 38 countries' cloud computing revenues over a five-year period, it was found that four out of six selected national institutions significantly impact cloud computing adoption in a country. Those institutions being power distance, uncertainty avoidance, trade union strength and government effectiveness. Those results are further contrasted and compared to mobile broadband adoption as an example of an also recent; however, it is consumer-oriented technology, while cloud computing is predominantly business-oriented technology. The comparison is done to test if cloud computing has different institutional drivers when compared to a very different technology such as mobile broadband. In an empirical examination of 41 countries' mobile broadband revenues over a three-year period, it was found that none of the six selected institutions significantly impacts mobile broadband adoption. Thus, the adoption processes of cloud computing and mobile broadband, two very different technologies, possess rather different institutional drivers.

Keywords: Cloud Computing adoption, mobile broadband adoption, cross-country panel data, neo-institutional theory, formal institutions, informal institutions.

3.1 Introduction

There is an increasing agreement amongst economists that the difference in technology adoption accounts for a major difference in per capita GDP amongst the countries (Caliskan, 2015). This view is in alignment with the proponents of 'new growth theory' (Lucas, 1990; Aghion and Howitt, 1992; Fagerberg and Srholec, 2008), focusing on technology as the main force behind countries' growth and development.

The specific technology in focus of this study is cloud computing[14]. Today, cloud computing is used by most industries and businesses and is considered as one of the key technologies for the development of digital economy[15]. The business logic of using cloud computing is based on the notion that organizations can outsource their services (internally or externally), and in doing so obtain those services at lower costs compared to providing those services themselves. Organizations also gain access to the services which would normally be prohibitive for them to provide themselves (particularly true for SMEs[16]).

Cloud computing has some advantages for individual users; however, it has greater benefits for businesses, hence can be referred to as a business-oriented technology. Given the business logic and associated benefits, as well as the fact that cloud computing technologies have existed for a while, one would expect that the cloud computing adoption, when normalized per GDP, is similar across countries and national borders. However, in practice that does not appear to be the case. Observing the data of 49 countries' cloud computing revenues (as a proxy for cloud computing adoption), a significant variation in cloud computing revenues across the countries can be observed.

Most of the prior research has been focused on cloud computing adoption antecedents on firm-level (El-Gazzar et al., 2016), with limited research that explores the predictors of country-level cloud computing adoption (Vu, Hartley & Kankanhalli (2020), Senyo et al. (2018)). As noted by Sharma,

[14] Cloud computing definitions, benefits and risks can be found in the Appendix.
[15] Bukht and Heeks (2017), as well as Williams (2021) estimate that digital economy is to make around 5% of global economy and 3% of global employment.
[16] SME – Small to Medium Enterprises (Businesses)

Gupta, Acharya and Jain (2021), 'few authors have done cross-country studies and provided results to understand cross-country specific perspectives on cloud computing adoption'.

This gap in cross-country specific perspectives on cloud computing adoption is addressed in this research, by drawing on the neo-institutionalism and investigating the impact of selected national institutions, formal and informal, on cloud computing adoption.

To validate this standpoint of cloud computing adoption being affected by national institutions, a comparison to an adoption of a very different type of technology is made, namely mobile broadband[17] adoption. Mobile broadband in this context refers to the use of mobile networks (3G/4G) for delivery of data and services. Mobile broadband is used by both individuals and businesses; however, one can say that it is has greater benefits to individuals/consumers, hence can be referred to as a consumer-oriented technology. Observing the data of 98 countries' mobile broadband revenues (as a proxy for mobile broadband adoption), a significant variation in mobile broadband revenues across the countries can also be observed (refer to Graph 1.1 below).

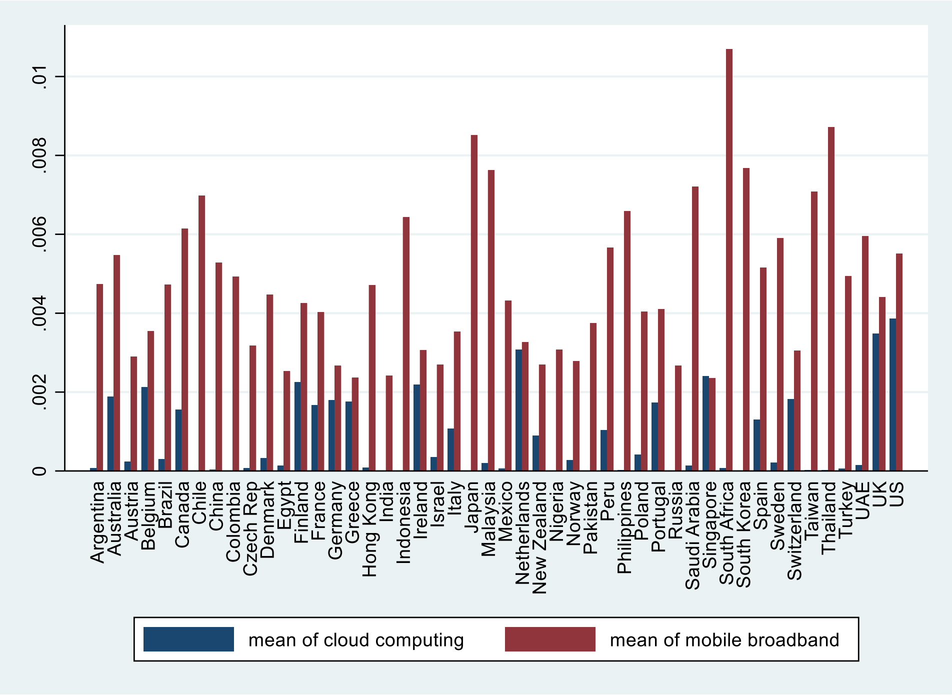
The comparison of cloud computing to mobile broadband is made only from the perspective to test if those two different types of technology differ in their adoption processes when taken from the new standpoint further explained in this paper. By showing that the impact of the institutions between cloud computing and mobile broadband differs significantly, we are showing that technology adoption should not be generalised and need to be treated with care. In this study we identify national institutions that are seen as relevant to cloud computing adoption. Some other institutions maybe more relevant to mobile broadband; however, mobile broadband specific institutions are not focus on this study.

The Graph 1.1 below shows comparison of means between cloud computing and mobile broadband adoption (proxied by respective revenues, see Data 3.1) per country, period 2016-2019 (both normalized for GDP), where it can be observed that besides the variations in the levels of adoption of both cloud computing and mobile broadband across the countries, the patterns of variations also differ. One would expect to see greater levels of mobile broadband adoption compared to cloud

[17] Mobile Broadband definitions, benefits and risks can be found in the Appendix.

computing in general due to the nature and use of the technology. However, in some countries cloud computing is much lower, and in some on similar or higher level than mobile broadband. This indicates that cloud computing and mobile broadband seem to have national determinants affecting their adoption.

Graph 1.1: Comparison of means of cloud computing and mobile broadband adoption per country, period 2016-2019 (normalized for GDP) when both data samples available. Source: GlobalData research. See, 3.1 Data.



The next section of the paper introduces institutional theory and national institutions, reflects on the relevant research in institutional theory and technology adoption methods, followed by the introduction of the framework used and formation of the hypotheses. The section after details the empirical analysis including the description of the data used, method applied, and the results obtained. The paper concludes with the discussion, contributions, and limitations.

2.2 Literature Review and Hypotheses Development

In the new institutional theories (neo-institutionalism), individuals are taken as given and it is assumed that ‘individual actions lead to the formation of institutions, but institutions do not change the individuals’ (Hodgson, 1993, pp. 8). In contrast to the old institutional theories, where was assumed that individuals develop with development of culture and institutions (Hodgson, 1993). According to the new institutional theory (Currie, 2011), developing and using technology is a subject to various institutional pressures referred to as constrains or simply institutions. Those institutions either push or inhibit individuals and groups to adopt the technology and may cause them to behave in not necessarily economic-rationalistic way. Hence, even though it may be argued that it is rational to use certain technology, in a national setting ‘organizations in different socio-economic and political contexts may often react differently to similar internal and external challenges due to constraints imposed by the environment they exist in’ (Weerakkody, Dwivedi & Irani, 2009, pp. 354). National institutions, as per new institutional theory, are ‘humanly devised constraints that structure political, economic and social interactions (North, 1991, pp. 97). Those constraints cause individuals and organizations operating within an environment (one country) to react differently to the technology being implemented, when compared to the individuals and organizations operating within a different environment (another country). Institutions provide constraints; however, as per new institutional theory, the main purpose for the existence of the institutions is to reduce uncertainly (North, 1991) present in our complex world (introducing technology such as cloud computing increases uncertainty to both organisations and individuals).

National institutions as such can be either formal or informal (North, 1991). Formal institutions are ‘formal rules (constitutions, laws, rights)’ (North, 1991, pp. 97) typically enforceable by the state via official channels. Informal institutions are ‘socially shared rules, usually unwritten, that are created, communicated, and enforced outside officially sanctioned channels’ (Hemke & Lewitsky, 2006, pp. 727). According to Hemke and Lewinsky, scholars who ignore informal institutions are at risk of missing important constraints and incentives. Informal institutions refer to the conventions and norms acceptable (or not acceptable) in the society. According to ‘National Character’ theory (Hennart & Larimo ,1998; Shetty, 1979), countries vary systematically in their psychological character which in turns reflect on businesses operating in those countries. ‘National Character’ is best measured via national culture parameters (Hofstede, 2001). According to Hofstede, national culture is ‘the mental programming of a group of people that distinguishes them from others’. Hofstede’s model is based on six parameters that reflect national culture, being power distance, individualism, masculinity, uncertainty avoidance, long-term orientation, and indulgence. Hofstede’s model is the most often used by scholars as the way of measuring informal national institutions.

Heavin and Fitzgerald (2004) study the impact of institutions on the development of an IT Industry in Ireland and find that the national institutions, both formal and informal, have a significant influence in development of the industry. In their study, Vu, Hartley and Kankanhhalli employ institutional theory 'to model technological and environmental predictors of country-level cloud computing adoption' (2020, pp. 2). They find for example that 'legal systems quality of a country, reflected in a rule of law' positively impacts cloud computing expenditure (2020, pp. 14). Focus of their study is on few formal institutions, though they give no specific considerations to a possible impact of informal institutions.

However, a different study by Crossland and Hambrick (2011) provides an interesting approach. Crossland and Hambrick (2011) analyze the impact of national institutions, both formal and informal, on 'latitude of managerial actions' or 'an extent to which executives (i.e. CEOs) are able to influence actions and outcomes of a firm', which they refer to as managerial discretion. Crossland and Hambrick find that national institutions impact managerial discretion in that they affect CEO's legal rights and responsibilities to stakeholders (formal institutions), as well as what is perceived as acceptable by the society (informal institutions). They show that managerial discretion significantly varies across the countries, and that it is dependent on formal and informal national institutions. When it comes to the formal institutions, Crossland and Hambrick use a selected set of formal institutions which they have found to be the most representative and relevant for their study being ownership dispersion, legal origin and employer flexibility. When it comes informal institutions, Crossland and Hambrick use Hofstede' nation culture parameters, being individualism, power distance and uncertainty avoidance, which they found the most relevant for their study of managerial discretion. Crossland and Hambrick (2011) study provides an example of the operationalization and the use of national institutions in the form of an empirical model or framework. The approach by Crossland and Hambrick can be similarly applied to analysing technological adoption determinants, and in this study, it is applied to cloud computing adoption and the impact of both formal and informal national institutions as its determinants. The institutional approach to cloud computing adoption (or technology adoption in general) on a national level including a cross-country comparison has not been found to have been applied in the past research.

To further justify the logic behind this approach, it is necessary to reflect on cloud computing adoption (and technology adoption in general) literature to date. One of the most used and researched theories in factors determining technology adoption in firms, is TOE framework, being Technology-Organizational-Environmental framework (Tornatzky & Fleischer, 1990). For example. Morgan and Conboy (2013) used TOE and surveyed various cloud providers to identify some of the key factors affecting the cloud adoption. They identified nine key factors, being 1) Technological (relative advantage, compatibility, complexity, trialability), 2) Organizational (increased collaboration, increased traceability, convincing IT manager) and 3) Environmental (security and legal issues, perception of the term cloud). Morgan and Conboy also identify that cloud computing adoption (in contrast with some other technologies) may experience resistance from the employees such as IT Managers and others, since it is perceived as a risk to their job security.

Alismaili, Shen and Huang (2020) also apply TOE framework and add an additional category, risk, with a set of factors highly significant to cloud computing being security, data privacy and confidentiality. Their study is focused on cloud computing adoption in SMEs in Australia. They noted that cloud computing adoption has been very low with Small to Medium (SME) businesses even though there are many potential benefits for them using cloud computing. They adopted TOE framework with the following categories and factors: 1) Technological (i.e. compatibility and trialability), 2) Risk (i.e. security, data privacy and confidentiality), 3) Organizational (i.e. top management support and firm size) and 4) Environmental (i.e. market scope and external computing support). They evaluated those factors in the context of SMEs in Australia and found out that technological, risk, and environmental factors are the most significant determinants of cloud adoption in the context of Australian SMEs.

TOE framework, even though a very useful framework to understand technology adoption, does not explain why there is a variation in technology adoption across countries.

Jan, Alshare and Lane (2022) reflect on previous models used to study technology acceptance from users' perspective such as technology acceptance model (TAM), unified theory of acceptance and use of technology (UTAUT), and others. They note that technology acceptance models have 'reported inconsistent results when employed in different cultural settings', hence they focused their study on the impact of national culture (Hofstede model) on technology acceptance models. Jan, Alshare and Lane (2022) find that national culture parameters such as individualism, power distance, and uncertainty avoidance have direct effect on technology acceptance models. Jan, Alshare and Lane research even though very interesting, only focuses on national culture, and not on other (formal) national institutions and does not have cloud computing in the scope of its study.

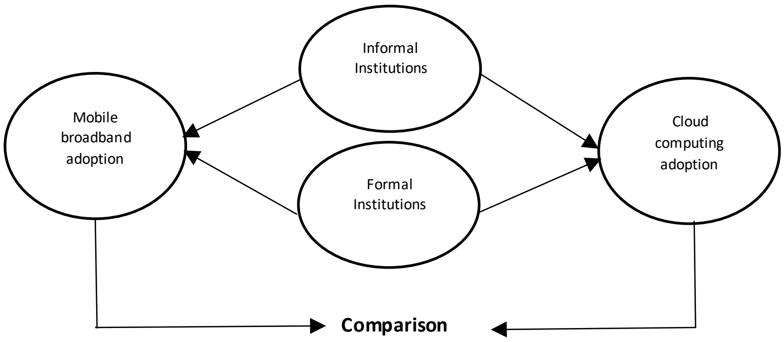
There were other studies into cloud computing adoption such as Low, Chen and Wu (2011) research on determinants of Cloud Computing adoption in high-tech industry in Taiwan or Sharma, Gupta, Acharya and Jain (2021) researching cloud computing adoption in India. Low, Chen and Wu explore determinants of cloud computing adoption in high-tech firms in Taiwan using surveys in order to collect the data. They found the variables such as top management support, firm size, and competitive pressure as being significant to cloud computing adoption. Their study is limited to one country only, being Taiwan, with the focus on high-tech companies only. Similarly, Sharma, Gupta, Acharya and Jain (2021) explore why cloud computing adoption in India is low and investigate factors of adoption using qualitative approach by interviewing experts from ITC firms in India. They find that resistance to change in the organization, possible financial losses, security, compatibility, and complexity are the main barriers to cloud computing adoption in India. There were other similar studies into cloud computing; however, they are also limited in scope and focused on few countries or geographies.

In contrast to the previous research, this paper offers a new perspective to cloud computing adoption, and technology adoption in general. It focuses on cross-country analysis of cloud computing using institutional approach and identifies few national institutions as determinants of cloud computing adoption. This kind of approach has not yet been applied in the previous research.

Additionally, cloud computing adoption is contrasted and compared to another type of technology, namely mobile broadband to assess if the national institutions, reflected in informal and formal set of parameters further described below, impact the two different types of technologies differently. If the impact is different and significant, it proves that those two technologies possess different institutional drivers, and that the national institutions are relevant for adoption of those technologies.

Figure 1.1 below depicts the framework used in this research.

Figure 1.1: The framework of the national institutions impact on cloud computing and mobile broadband



2.2.1 Informal National Institutions

It is commonly recognized that there exists a difference in culture between different nations, referred to as a national culture. National culture is commonly referred to as representing informal institutions in a country. Crossland and Hambrick (2011) as well as many other scholars, use Hofstede's national culture parameters as indicators of country's informal institutions, which is the approach adopted in this study too.

The notion of national culture's impact on technology is not new. Back in 1998, Herbig and Dunphy highlighted the significance of national culture for the adaptation of innovative technologies and stated that 'existing cultural conditions determine whether, when, how and in what form new innovations will be adapted'. According to Jan, Alshare and Lane (2022, pp. 1) 'it is clear that relationships do exist between national culture and adoption of technologies'.

The dimensions of national culture from Hofstede's model have been widely studied and analyzed from different perspectives. Lee, Trimi and Kim (2013) state the lack of prior research in the effects of culture on technology adoption and in their study provide a summary of the research done to date which is mainly based on surveys, case studies and field investigations involving limited samples. Table A2 in the Appendix summarises the findings from Lee, Trimi and Kim research and complements it with some of the findings from this research.

Zhao, Scheruhn and Von Rosing (2014) study the effects of national culture dimensions on cloud computing acceptance in SMEs in USA and China. They find that Hofstede's national cultural dimensions such as power distance, individualism, uncertainty avoidance, and long-term orientation impact cloud computing adoption in SMEs in those countries. They find that power distance, uncertainly avoidance and long-term orientation have negative effect, while individualism has positive effect on cloud computing adoption on SMEs in USA and China. They also state that the national culture should be added to the acceptance framework in cloud computing studies. However, their study is limited to USA and China.

Similarly, Hafezi and Zolait (2019) study the effects of national culture dimensions and information systems quality on cloud computing adoption in SMEs in the Gulf Cooperation Council (GCC) countries. They also use Hofstede's cultural parameters and note the lack of research in this area. The outcomes of the study are not yet published and will be based on surveying a number of firms across GCC. Jan, Alshare and Lane (2022) study the effects of national culture on technology adoption models in general and find that parameters such as individualism, power distance, and uncertainty avoidance have direct impact.

2.2.1.1 Power distance

Power distance, one of Hofstede national cultural parameters, frequently used in studies on national culture's impact on technology, and the first of informal institutions used in this study, refers to a society's acceptance that the power is distributed unequally and to the tolerance to following top-down strategies and unilateral decision making. In high power distance countries, innovation and technology in organisations is implemented only if supported by the hierarchy. Cloud computing as business-oriented technology would typically be implemented in the organizations on a request from the top management (executives), since as explained in the introduction, cloud computing brings many efficiencies to the organization. However, it may not be supported by lower management levels, nor other levels in the organization in general, since it reduces the control that middle level of management have as well as results in a number of the tasks (jobs) in the organization being outsourced. Hence, cloud computing would be expected to be positively associated with power distance in a country, since high power distance countries are more likely to follow top management decisions. Low power distance countries have flat structures and greater empowerment in the organisations, hence maybe more difficult to implement technology such as cloud computing due to the resistance by the lower levels in the organization. Thus,

Hypothesis 1: The higher the value of power distance in a country, the higher cloud computing adoption in that country.

In a comparison, mobile broadband as consumer-oriented technology would typically be implemented by individuals and not related to the organisational hierarchies, hence would not be expected to have a strong association with power distance. Thus,

Hypothesis 1a: There is no association between the value of power distance in a country and mobile broadband adoption in that country.

2.2.1.2 Individualism

Individualism (also referred to as collectivism as opposite term), another of Hofstede's parameters frequently used in studies on national culture's impact on technology and the second informal institution used in this study, refers to the degree to which individuals are integrated into groups. High individualism countries refer to loose ties with people and high focus on tasks. Low individualism countries refer to strong ties between people and give importance to the relationships (not tasks). Low individualism is also referred to as collectivism. In high individualism countries, individuals take decisions with less regard to the collective. As noted in the previous section, cloud computing as business-oriented technology would typically be implemented in the organizations on a request from the top management (executives) who would be taking those decisions. However, the implementation would depend on how collective responds to the decision made not necessarily who makes the decision, which is not measured by individualism but rather by power distance as explained before. Hence, it is unclear if cloud computing would be associated with individualism or collectivism. However, since most of the studies on impact of national culture on technology adoption include individualism in their model, it was decided to keep it in the scope of this study too. Thus,

Hypothesis 2: There is no association between the value of individualism in a country and cloud computing adoption in that country**.**

In a comparison, mobile broadband as consumer-oriented technology, would also not be expected to be associated with individualism or collectivism.

Hypothesis 2a: There is no association between the value of individualism in a country and mobile broadband adoption in that country.

2.2.1.3 Uncertainty avoidance

Uncertainty avoidance, another of Hofstede national culture parameters also very frequently used in the studies, and the third and last informal institution used in this study, refers to society's tolerance for uncertainly, ambiguity and change. Low uncertainty avoidance countries have greater acceptance to change and risk, hence change is done quicker, when compared to high uncertainty avoidance countries. Introducing technology such as cloud computing, brings certain level of risk in the organisations, hence countries with higher uncertainty avoidance would be less likely to implement it. Cloud computing would be expected to be negatively associated with uncertainty avoidance. Thus,

Hypothesis 3: The higher the value of uncertainty avoidance in a country, the lower cloud computing adoption in that country.

In a comparison, mobile broadband would not be expected to be associated with uncertainty avoidance. Thus,

Hypothesis 3a: There is no association between the value of uncertainty avoidance in a country and mobile broadband adoption in that country.

2.2.1.4 Notes on remaining Hofstede parameters

Hofstede's model remaining parameters such as masculinity, long-term orientation. and indulgance were not used in this study. Masculinity is one of the original Hofstede's model parameters, and refers to the distribution of roles between the genders. However, it is not expected to be associated with cloud computing adoption, hence not used in the study. The focus was on including only parameters perceived to have some impact. Similarly, indulgence refers to societies' acceptance of disciplines and norms versus focus on enjoyment and fun, which is also not expected to be associated with cloud computing adoption. Additionally, indulgence and long-term orientation were not a part of the original Hofstede's model and were added more recently. That resulted that the data on those parameters is not available for all the countries in the sample. If it were not for this data lacking, long-term orientation would have been an interesting parameter to assess in the context of cloud computing adoption, since it measures societies perseverance and adoption to changing trends.

2.2.2 Formal National Institutions

As previously noted, formal institutions refer to rules and regulations enforced by the state, hence as such they impact the firms' flexibility and ability to implement their strategies such as the implementation of new technologies (e.g., cloud computing). As previously noted, cloud computing maybe be perceived as risky to employee's job security, hence resulting in resistance to implementation unless there are sufficient national institutions in place to protect the employees' interests. Hence, the following formal institutions are selected for the purpose of this study, which were also found to be relevant in other studies as further explained below.

2.2.2.1 Employee protection legislation

Employee protection legislation or strictness of employment protection legislation is a labour market institution which reflects cost to employers of adjusting their workforce i.e., dismissing employees. Lommerund and Straume (2012) analyse impact of different formal institutions and find that employee (or employment) protection legislation has negative effect on technology adoption. Estevez-Abe, M, Iversen, T. and Soskice, D. (2001) studied employee protection mechanism and find that employee protection is designed to encourage workers to invest in firm- and industry-specific skills, hence making them more dependent on a specific firm or industry, hence less prepared to market fluctuations, where technology change can be seen as a market fluctuation.

Greater the employee protection legislation, less flexibility managers have in executing on their organizational strategies and policies. As noted in the introduction, the benefits of cloud computing introduction are particularly seen in creating efficiencies, and often resulting in cost savings via reduction and outsourcing of certain tasks(jobs). Having strong employee protection legislation in a country would limit management in their ability to fully execute on cloud computing introduction in that country, since they would not be able to flexibly adjust their workforce after such an introduction. With that, most of the expected efficiencies would not be materialized. Hence, cloud computing technology would be expected to be strongly negatively associated with employee protection legislation. Thus,

> Hypothesis 4: the higher the value of employee protection legislation in a country, the lower cloud computing adoption in that country.

In a comparison, mobile broadband technology would not be expected to have an association with employee protection legislation. Thus,

> Hypothesis 4a: There is no association between the value of employee protection legislation in a country and mobile broadband adoption in that country**.**

2.2.2.2 Trade union strength

Trade Union Strength is a labour market institution which reflects strength of trade unions. Doucouliagos and Laroche (2012) study impact of unions on technology adoption and find that unions have negative effect on technology adoption. Lommerund (2012) show that unions have an impact on technology adoption, and this can be exaggerated by assuming they can veto implementation of the technology that has negative impact on their members. As noted earlier, cloud computing introduction is often associated with outsourcing of tasks, and reduction of certain types of jobs, hence can easily be perceived as negative to certain union members. Trade union density has been often used as indication of union strength (Crounch, 2017; Crowley, 2004), where trade union density being 'the ratio of wage and salary earners that are trade union members to the total number of wage and salary earners in the economy'. In a recent study by Metten (2021) this is being challenged. Metten argues that density is too narrow measurement of union strength and cannot be uniquely applied across the countries. For example, in China union density is high while union strength is low, while on the other hand, the union density in France is low (i.e., 8%). However, the impact the unions have is France strong. Metten additionally states that the way unions work across the geographies is much more complex than what can be reflected in the membership density, as well as there is very little research done on developing countries, hence those have been excluded thus far. Metten proposes a different measure of union strength being Collective Labour Force Index (CLF) which is a weighted average of nine factors such as bargaining coverage, hiring and firing regulations, and others. In this study, Metten's CLF as proxy for trade union strength is being used.

Greater the trade union strength, less flexibility managers have in executing on their organizational strategies and policies due to the interference by unions, hence less willingness to invest time in implementing the technology or generally lower success rate. Thus,

> Hypothesis 5: The higher the value of trade union strength in a country, the lower cloud computing adoption in that country**.**

In a comparison, mobile broadband technology would not be expected to have an association with trade union strength. Thus,

> Hypothesis 5a: There is no association between the value of trade union strength in a country and mobile broadband adoption in that country.

2.2.2.3 Government effectiveness

Government effectiveness is a governance institution which reflects 'the quality of public services, civil service, policy formulation, policy implementation, and credibility of the government's commitment to raise these qualities or keeping them high'. In countries with more effective governments, labour markets are more regulated, hence less resistant to implementing labour reducing technologies. Governments take an active role in redeploying the workforce to other jobs, reskilling the workforce, etc. Hence, greater the government effectiveness, it is easier to implement new technological innovations. Rodriguez-Andres, Amavilah and Asongu (2016) study impact of formal institutions, in particular governance indicators, on ICT adoption, and find that government effectiveness has the highest positive effect on the ICT adoption. Doucouliagos and Laroche (2012) state that more regulated labour markets (hence stronger the role of government), less impact unions have on technology adoption`, hence greater the adoption.

However, cloud computing maybe different here. Greater government effectiveness can also indicate greater application of rules and regulation such as laws limiting the use of public clouds outside of geographies such as GDPR being General Data Protection Regulation in Europe, hence it may have negative impact of cloud computing adoption. GDPR is a new European Data Protection Legislation introduced to address the gap in previous legislations caused by the introduction of new technologies within digital economy such as cloud computing and its reliance on data use and its storage in digital remote locations referred to as 'clouds'. Khan and Gouvia (2017) find that GDPR introduction improves security and data privacy; however, it brings a set of challenges and serious implications on the cloud computing providers. GDPR implementation is costing companies significant amounts, and due to the openness of its interpretation (i.e., it is left to companies to interpret implementation of it to some extent), it remains and retains certain level of risk of potential non-compliance. For the analysis in this paper, it is assumed that GDPR and similar laws could be impacting cloud computing adoption and their impact as such are incorporated within government effectiveness index. This could be further looked at in more details in subsequent papers.

Hence, cloud computing would be expected to be negatively associated with government effectiveness. Thus,

> Hypothesis 6: The higher the value of government effectiveness in a country, the lower cloud computing adoption in that country.

In a comparison, mobile broadband technology would not be expected to have an association with government effectiveness. Thus,

> Hypothesis 6a: There is no association between the value of government effectiveness in a country and mobile broadband adoption in that country.

2.3 Data and Methods

2.3.1 Data

2.3.1.1 Cloud computing adoption

To measure cloud computing adoption, the data on cloud computing revenues from GlobalData research has been used (Source: GlobalData, Cloud Computing Industry Data using the figures from MarketLine's Industry Profile Series: Cloud Computing, undertaken in July 2018). Cloud computing revenues entail the revenues accrued from all cloud computing services (SaaS, PaaS, IaaS) and are recorded per country per year. GlobalData collected the data in a bottom-up fashion where each country was researched individually using different secondary sources such as industry associations, national statistical bureaus, and international databases. Furthermore, to accommodate for the difference in country's growth and development levels, cloud computing revenues in this research have been taken as a percentage of the countries relevant GDPs (Source: GDP data collected from the public statistics sites).

GlobalData research data was obtained for 49 countries for the five-year period, from 2013 to 2017 (2018 and 2019 forecasts also available; however, they are not used in the regression analysis). The data varies per country, per year since cloud computing adoption changes quite significantly from one to another year. Cloud computing revenues are considered as a good proxy for cloud computing adoption, since higher the revenues in a country accrued from the cloud computing services, greater adoption of cloud computing in the country assumed. Additionally, cloud computing revenues data is available across a large sample of countries over a longer period in order to perform panel analysis. No similar comparable data sample is found. For example, EU measures cloud computing adoption by enterprises; however, that measurement is only available for EU countries.

2.3.1.2 Mobile broadband adoption

To measure mobile broadband adoption, similarly to cloud computing adoption, the data on mobile broadband revenues from GlobalData research has been used (Source: GlobalData, Mobile Broadband Forecasts, 2020). GlobalData research measures mobile broadband adoption as the revenues generated by mobile service providers and others in the values chain from the provision of mobile data services, and records those per country per year. Furthermore, to accommodate for the difference in country's growth and development levels, mobile broadband revenues in this research have been taken as a percentage of the countries relevant GDPs (Source: GDP data collected from the public statistics sites). GlobalData research data was obtained for 98 countries for the four-year period, from 2016 to 2019 (actuals). The data varies per country, per year since mobile broadband adoption changes quite significantly from one to another year. Additionally, it is worth noting thar mobile broadband adoption can be measured using different proxies such as a number of mobile subscribers and others. The mobile broadband revenue proxy was chosen to make it as compatible and comparable to the cloud computing adoption proxy of cloud computing revenue.

2.3.1.3 Informal national institutions

To measure the three chosen informal national institutions, Hofstede national culture parameters of power distance, individualism, and uncertainty avoidance were used. For the purpose of research, Hofstede's data is available and freely downloadable from the Hofstede www site. Hofstede's data exists for 108 countries, and as previously mentioned, is commonly used in research and studies. This study uses the values of the relevant countries for which cloud computing and mobile broadband adoption data is available. The values of all Hofstede national culture parameters range from 0 to 100, with higher values indicating stronger effect on the parameter in questions. The values for a given country do not vary per year, meaning they are constant or fixed over time.

2.3.1.4 Formal national institutions

To measure the employee protection legislation, the OECD[18] index for employment protection legislation has been used. This index evaluates how difficult it is in each country to hire and fire employees, hence indicating the flexibility that managers have in that process. The data ranges from around 0 to around 4, with higher values indicating that the process of hiring and firing in a country is more complex and difficult. OECD index measurements are recorded yearly, with the data not fluctuating much between the years, since the countries do not typically change those processes from one to another year. The data is available for 69 countries in the data sample, for five years period, 2015 to 2019. There is not much (almost none) fluctuation in values per country from one to another year, hence this data is also constant over time.

Note: Estevez-Abe, M, Iversen, T. and Soskice, D. (2001) developed their own index of employment protection for a sample of 18 countries. They used OECD measurements for strictness on employment protection legislation plus some subjective evaluation of company-based protection to come to an index per country. Crossland and Hambrick (2011) in their study used Estevez-Abe, M, Iversen, T. and Soskice, D. (2001) index of employment protection as one of their formal institution measurements, employer flexibility, since their data sample almost matches the sample used in

[18] OECD, The Organisation for Economic Co-operation and Development, and organisation that focus on improving policies that improve lives for all. For more details refer to https://www.oecd.org/

Estevez-Abe, M, Iversen, T. and Soskice, D. (2001) study. However, in this research, there are more countries than are available with used Estevez-Abe, M, Iversen, T. and Soskice, D. (2001) index of employment protection, hence it cannot be utilised in this study.

To measure the trade union strength, Collective Labour Force Index (CLF) (Metten 2021) has been used. As previously mentioned, this index is a weighted average of nine factors such as bargaining coverage, hiring and firing regulations, and others[19]. The CLF index is available for 68 countries in the data sample, with the average measurement from 2000 to 2016 used for all years, hence this data is also constant per country over the time.

Lastly, to measure the government effectiveness, the World Bank Group[20] Government Effectives Index (GFI) has been used. The government effectiveness is one of six worldwide governance indicators[21] used by the world bank. World Bank captures the data for this index using various data sources reflecting the perception of governments. Government effectiveness index is available for 128 countries in the data sample, with the measurements recorded per year, from 2015 to 2019.

The data ranges from -2,5 (low effectiveness) to +2,5 (high effectiveness) and the variations in the data, per country, per year do exist[22].

For all the independent variables represented by informal and formal institutions, this study only uses the values for the relevant years and the relevant countries for which cloud computing and mobile broadband adoption data is available. Hence, the data described further above in this section is wider than what is used in this study.

Descriptive statistics and correlations for all the data used can found the Appendix, Table A4.

[19] For more details on Metten's CLF index, refer to Table A3A and Table A3B in the Appendix.

[20] World Bank Group is an international organisation aimed at fighting poverty and building prosperity. They have an extensive database of various indices that are available for research and general public use. For more details refer to www.info.worldbank.org/governance/wgi

[21] Six worldwide governance indicators are Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption.

[22] Since all the data values are used as logs in this research, 2.5 is added to all government effectiveness index values in order to ensure all the values are positive.

2.3.2 Methods

2.3.2.1 Dynamic regression (GMM)

Due to high correlations between dependent and independent variables (Appendix, Table A4A), a regression analysis has been chosen as the main method used in the methodology. 'Cross-country regressions are a recommended approach for evaluating the strength of partial correlations and capturing relationships between macro-level variables and outcomes. Previous studies have used this approach to gain insights into factors explaining cross country variations in technology diffusion' (Vu, Hartley & Kankanhhalli, 2020, pp. 21).

In this research, there are two dependent variables observed, namely cloud computing adoption (proxied by log of cloud computing revenues normalized for GDP), and mobile broadband adoption (proxied by log of mobile broadband revenues normalized for GDP). Those two dependent variables are tested against the same set of independent variables representing formal and informal national institutions, those being power distance, individualism, uncertainty avoidance representing informal institutions, and employee protection legislation, trade union strength, government effectiveness, representing formal institutions, all measured as log values.

Due to the panel structure of the data with the observations recorded over the years, panel regression analysis is used. Since it is expected that past values of dependent variables, cloud computing adoption and mobile broadband adoption, affect the future values, dynamic regression is used. One step system Generalized Method of Moments (GMM) dynamic regression is chosen since it is often more stable on smaller data samples[23] when compared to two step GMM and other dynamic regression method. Vu, Hartley and Kankanhhalli, 2020 in their study also apply GMM when examining factors affecting cloud computing growth and note that GMM method accounts for the presence of country-fixed effects and is more robust to heteroscedasticity and serial correlation potentially present in the error term. Since there is a possibility that there are other factors affecting cloud computing (and mobile broadband) adoption beside the ones specified in the model (independent variables not strictly exogenous), GMM seems to be an appropriate statistical method to

[23] The samples used in this research are considered to be of smaller size.

be applied. GMM assumes that the first differences of endogenous variables are uncorrelated with country fixed effects, which in this data set may be violated. Hence, to control for some of this potential bias, additional variable being net income per capita has been added. Net income per capita captures the level of development per country (Source: https://data.worldbank.org), hence adding it to the model is assumed to be a good addition in order to reduce some of the above-mentioned potential bias. Additionally, log-log regression is used, which is useful in interpreting results since one percent change in one of the independent variables (everything else held constant), explains x percent of the variation in the dependent variables. Additionally, log transformation is also used if variable(s) are skewed, as is the case here, hence transforming them into more normalised set.

The following statistical models are used to examine the predictors of cloud computing (1) and mobile broadband (2), respectively:

$$\text{lncloudcomputing}_{it} = \alpha + \beta \ \text{lncloudcomputing}_{it-1} + \gamma X'_{it} + \varepsilon_{it} \qquad \text{Eq (1)}$$

where $\text{lncloudcomputing}_{it}$ is the log value of cloud computing revenues taken as a percentage of the countries relevant GDPs by country i in year t (as a proxy for cloud computing adoption); $\text{lncloudcomputing}_{it-1}$ is the lagged level of the log value of cloud computing revenues taken as a percentage of the countries relevant GDPs by country i in year t; X'_{it} is a vector of independent and control variables used in the study, all as log values, as listed in the Table 1.1 below; and ε_{it} is the random error term.

$$\text{lnmobilebroadband}_{it} = \delta + \omega \ \text{lnmobilebroadband}_{it-1} + \theta X'_{it} + \varepsilon_{it} \qquad \text{Eq (2)}$$

where $\text{lnmobilebroadband}_{it}$ is the log value of mobile broadband revenues taken as a percentage of the countries relevant GDPs by country i in year t (as a proxy for mobile broadband adoption); $\text{lnmobilebroadband}_{it-1}$ is the lagged level of the log value of mobile broadband revenues taken as a percentage of the countries relevant GDPs by country i in year t; X'_{it} is a vector of independent and control variables used in the study, all as log values as listed in the Table 1.1 below and ε_{it} is the random error term.

2.4 Results

Table 1.1 below details the estimation results for the models specified in Eq (1) and Eq (2), resulting from dynamic regression using one step GMM.

Table 1.1 The impact of national institutions on cloud computing adoption (Model 1) and mobile broadband adoption (Model 2) as per the dynamic regression (GMM one step) from STATA.

	Cloud computing	Mobile Broadband
	Model 1	Model 2
Cloud computing adoption_lag value	0.998***	-
P value	0.000	
[95% Conf. Interval]	[0.976 1.020]	
(Std. Error)	(0.011)	
Mobile broadband adoption_lag value	-	1.503***
P value		0.013
[95% Conf. Interval]		[0.316 2.691]
(Std. Error)		(0.606)
Power Distance	0.109***	-0.055
P value	0.000	0.627
[95% Conf. Interval]	[0.060 0.159]	[-0.279 0.169]
(Std. Error)	(0.025)	(0.046)
Individualism	0.013	0.181
P value	0.795	0.423
[95% Conf. Interval]	[-0.084 0.109]	[-0.262 0.624]
(Std. Error)	(0.049)	(0.114)
Uncertainty Avoidance	-0.068**	0.211
P value	0.012	0.445
[95% Conf. Interval]	[-0.121 -0.015]	[-0.331 0.753]
(Std. Error)	(0.027)	(0.276)
Employee Protection Legislation	0.004	0.145
P value	0.760	0.481
[95% Conf. Interval]	[-0.023 0.031]	[-0.257 0.546]
(Std. Error)	(0.014)	(0.205)
Trade Union Strength	0.096***	-0.080
P value	0.008	0.737
[95% Conf. Interval]	[0.025 0.166]	[-0.546 0.386]
(Std. Error)	(0.036)	(0.238)
Government Effectiveness	-0.261***	-0.424
P value	0.000	0.411
[95% Conf. Interval]	[-0.390 -0.132]	[-1.433 0.586]
(Std. Error)	(0.066)	(0.515)
Net Income Per Capita	0.00000118***	0,00000327
P value	0.003	0.475
[95% Conf. Interval]	[0.000000391 0.00000198]	[-0.0000057 0.0000122]
(Std. Error)	(0.000000405)	(0.00000458)
Constant	0.069	38.068
P value	0.924	0.329

[95% Conf. Interval] (Std. Error)	[-0.224 0.362] (0.150)	[-38.336 114.472] (38.982)
N	177	122
Number of groups	38	41
Observations per group	5	3

Numbers rounded to 3 decimal places; ∗p < 0.1, ∗∗p < 0.05; ∗∗∗ p < 0.01.
Observations with missing data dropped.

Table 1.2: GMM Hypotheses tests:

	Cloud computing	Mobile Broadband
	Model 1	Model 2
Arellano-Bond test for AR(2)	z = -0.30 Pr > z = 0.765	Not reported since too few observations per group
Arellano-Bond test for AR(1)		z = -1.29 Pr > z = 0.198
Hansen test of overid. Restriction	chi2(8) = 23.83 Prob > chi2= 0.068	chi2(2) = 0.43 Prob > chi2 = 0.808

As per Table 1.2 above, Arellano-Bond tests and Hansen tests confirm the validity of GMM used in all models. In Model 2, Arellano-Bond AR(2) is not available since there are too few observations per group (being 3); however, Arellano-Bond AR(1) indicates no autocorrelation of Order 1.

As per Table 1.1, it can also be observed that the samples used in GMM are smaller than the total samples available due to some observations missing for some countries/years, hence the final data set with all observation is 38 countries for cloud computing and 41 countries for mobile broadband, over 5 and 3 years respectively.

Table 1.1 estimation results further uncover some interesting findings. In all models, the lag values of the dependent variables are significant, hence the past values of cloud computing and mobile broadband in a country, do significantly affect the future values. Hypothesis 1 proposes that the countries with greater power distance would have greater cloud computing adoption. As can be seen in the Model 1, Hypothesis 1 is supported (p value of 0.000). The relationship between the power distance and cloud computing is positive and significant, indicating that 1% increase in power distance results in about 0.109% increase in cloud computing adoption. On the other hand, Hypothesis

1a proposes that mobile broadband adoption is not associated with power distance, which is also supported as per Model 2. Power distance in a country significantly impacts cloud computing adoption; however, it has no impact on mobile broadband adoption. Hypothesis 2 proposes no association between cloud computing adoption and individualism. Similarly, Hypothesis 2a proposes no association between mobile broadband adoption and individualism. Both hypotheses are supported. Individualism in a country does not significantly affect cloud computing adoption nor mobile broadband adoption. Hypothesis 3 proposes that countries with high uncertainty avoidance would have lower cloud computing adoption. As can be seen in the Model 1, Hypothesis 3 is supported (p value of 0.012). The relationship between cloud computing adoption and uncertainty avoidance is negative and significant, indicating that 1% increase in uncertainty avoidance results in about 0.07% decrease in cloud computing adoption. On the other hand, Hypothesis 3a proposes that mobile broadband adoption is not associated with uncertainty avoidance, which is also supported as per Model 2. Uncertainty avoidance in a country significantly impacts cloud computing adoption; however, it has no impact on mobile broadband adoption. Looking at the informal institutions tested, two out of three impact cloud computing adoption, while none impact mobile broadband adoption. Turning to the formal institution test results, Hypothesis 4 proposes that countries with higher employee protection legislation have lower cloud computing adoption. As can be seen in the Model 1, the relationship between employee protection legislation and cloud computing is not significant, hence no association can be stated. Hypothesis 4a proposes no association between mobile broadband adoption and employee protection legislation, and as can be seen in the Model 2, this hypothesis is supported. Employee protection legislation is not significantly associated with neither, cloud computing adoption nor mobile broadband adoption. Hypothesis 5 proposes that countries with greater trade union strength have lower cloud computing adoption, which is not supported. As can be seen in the Model 1, there is an association between trade union strength and cloud computing adoption; however, it is positive and significant (p value of 0.008), indicating that 1% increase in trade union strength results in about 0,096% increase in cloud computing adoption. Hypothesis 5a proposes no association between trade union strength and mobile broadband adoption, and this hypothesis is supported. Trade union strength has significant positive affect on cloud computing adoption in a country, while it has no effect on mobile broadband adoption. Lastly, Hypothesis 6 proposes that countries with high government effectiveness would have lower cloud computing adoption. As can be seen in Model 1 above, this hypothesis is supported. The relationship between government effectiveness index and cloud computing adoption is negative and significant (p value of 0.000), indicating that 1% increase in government effectiveness index results in about 0.261% decrease in cloud computing adoption. Hypothesis 6a proposes no association between government effectiveness and mobile broadband adoption, and is also supported. The Model 1 above indicates that government effectiveness in a country is not significant for mobile broadband adoption. Looking at the formal institutions tested, two out of three impact cloud computing adoption, while none impacts mobile broadband adoption.

Net income per capita is also significant for cloud computing adoption; however, it is used only to control the bias and is not focus of this study.

The table 1.3 below summarises the impact of different national institutions on cloud computing and mobile broadband adoption, clearly indicating that cloud computing is significantly affected by number of national institutions. In contracts to mobile broadband adoption, which is not.

Table 1.3: Summary of the impacts of different national institutions.

Summary of Impacts		
National Institution	**Cloud computing**	**Mobile broadband**
Power Distance	**+ Significant**	Not significant
Individualism	Not significant	Not significant
Uncertainty Avoidance	**- Significant**	Not significant
Employee Protection Legislation	Not significant	Not significant
Trade Union strength	**+ Significant**	Not significant
Government Effectiveness	**- Significant**	Not significant

2.5 Discussion, Contributions, and Conclusions

The important question of the technology adoption determinants on an organizational and a country level has been occupying both scholars and practitioners for a while, since technology adoption is one of the key differentiators for success and growth of both organisations and nations. Particular focus of this study is on cloud computing adoption, as one of the significant, recent information technology inventions. It has been noted that cloud computing adoption varies across the countries, and specific reasons for this variation have been sought in the impact of national institutions. No similar study has been done to date; hence this study provides a new and different perspective at cloud computing adoption.

In the empirical analysis using cloud computing revenue of 38 countries, in the final sample across 5 years using dynamic panel regression techniques, it was found that a number of national institutions, both formal and informal, do impact cloud computing adoption. Four out of six hypothesised national institutions were associated with cloud computing adoption, being power distance, uncertainty avoidance, trade unions strength and government effectiveness. In countries with higher tolerance to following top-down strategies and unilateral decision making, as well as with lower risk avoidance/aversion, cloud computing is adopted more. Additionally, in countries with lower government effectiveness and higher trade union strength, cloud computing is adopted more. This indicates that national institutions do really matter in case of cloud computing adoption.

Cloud computing was further compared to another type of technology, namely mobile broadband, as an example of also a recent, very important technology invention; however, it is quite different to cloud computing. As noted, cloud computing is predominantly business-oriented, while mobile broadband is predominantly consumer-oriented technology, hence comparing and contrasting the adoption of the two seems appropriate in order to show that two different technologies' adoption processes possess rather different institutional drivers. In the empirical analysis using mobile broadband revenues of 41 countries, in the final sample across 3 years also using dynamic panel regression techniques, it was found that none of the national institutions tested impact mobile broadband adoption.

2.5.1 Contributions

This research makes several important contributions. Firstly, it contributes to the new institutional theory in which national institutions are positioned as very important in structuring political, economic and social interactions. Specifically, it is discussed how national institutions impact cloud computing adoption, as one of the key technological developments in the recent times having a strong potential impact on the economic activity in a country. In support of the neo-institutional theory, national institutions may cause individuals in a certain national setting not to behave in a necessarily economic-rationalistic way, hence the success of the technology implementation, such as cloud computing, will depend on the organisations understanding of that national setting and taking right measures to manage those in the best possible way.

Secondly, using a number of hypotheses, it is shown how national institutions impact cloud computing adoption in a country, and how they contrast to a different type of technology, being mobile broadband adoption. Those two types of technology, namely cloud computing and mobile broadband, are quite different as discussed earlier. Cloud computing being predominantly business-oriented while mobile broadband is predominantly consumer-oriented technology. The hypotheses show that a number of national institutions significantly impact cloud computing, while impact of those is limited in the case of mobile broadband. Hence, those national institutions are relevant considerations when adopting cloud computing (and similar business-oriented technologies); however, they are not that relevant in the case of mobile broadband (and possibly other similar consumer-oriented technologies). The institutional approach is a novel approach to researching technology adoption across-countries and warrants further research.

Lastly, this research is based on the empirical analyses using cloud computing and mobile broadband revenues data not previously used for academic research. Important findings and implications for both researchers and practitioners arise from this analysis and research.

2.5.2 Practical Implications

Showing that cloud computing as business-oriented technology is impacted by the national institutions more than mobile broadband as consumer(individual)-oriented technology could have a number of interesting implications. It is often assumed that businesses operate internationally, hence are global as such, while individuals are bound by national borders. This research shows that when it comes to technology adoption such as cloud, national borders need to be taken into consideration and are very important to the success of the technology implementation, more so than in the case of individual benefiting technology such as mobile broadband.

Noting the importance of national institutions to the success of the implementation of new technological initiatives should result in the implementation approaches by businesses and governments being adjusted and fitted to specific situations and environments. Just copying what is done in other geographies may not be the most effective approach. The findings of this research have important implications to managers in terms of business policies and strategies, when implementing new technologies such as cloud computing. This study should raise the awareness that each technology and each country need to be understood and analysed before embarking on the implementation journey. Without this awareness there are hidden risks to the implementation going above and beyond what is considered rational and is impacted by the national institutions or constraints (as referred to in the context of neo-institutional theory). This is particularly relevant for managers of multinational organisations, which often do not reside in the countries for which they develop the strategies and policies, hence may not be well aware of the specific national constraints operating in those countries. For example, if a multinational company is leading a strategy aimed at implementing cloud computing in its affiliates in countries with different cultural make up, particular care needs to be taken. If the strategy needs to be implemented in countries like Russia and Denmark and is led from the headquarters in Germany, all with quite different cultural make up, the tactics of the implementation need to be reviewed and adjusted per country accordingly. Russia has a very high national institution of power distance (93 out of 100), hence it is necessary that the initiatives are first supported by the top management, before any wider implementation can start. The rest of the organization will ‘comply and follow’ with the top management decisions. To the contrary to a country like Denmark, with low national institutions of power distance (18 out of 100), having the approval of the top management is not sufficient. More effort needs to be spent on all employees at various levels in the organisation through organized dialogs and debates in order to obtain the understanding of the reasons for the implementation and bring certain level of consensus and alignment. This takes much more time and effort, hence may slow down the whole implementation process; however, if ignored, it may result in the initiative not being implemented. Similar considerations need to be given to other national institutions too.

This research has also interesting implications for governments and policy makers, since formal institutions are the reflection of laws and policies in a country, which are typically imposed by the governments. When aiming to increase technology adoption on a country level, the government should look at its laws and policies more critically and if necessary, adjust in order to enable higher adoption success. For example, businesses often adopt cloud computing from the perspective to bring efficiencies into their operations. However, cloud computing introduction may result in creation of uncertainties and risks with the employees of those businesses, who in turn may resist the technology adoption. It is the task of governments and policy makers to try and protect employees; however, they should not negatively impact businesses either.

In sum, findings from this study imply that businesses and governments need to pay attention to the impact of the national institutions, both formal and informal, when implementing new technologies, and derive policies and strategies to moderate their impact. Besides specific application to cloud computing, the results of this research increase the awareness of businesses and governments to the importance of country specific parameters such as national institutions when implementing any new technology initiative. Without those important considerations, there is a risk that the effort spent on implementing new technologies will not produce optimal results and will end with low levels of adoption. Hence, when implementing new technologies, each technology and its implementation in the national institutional environment need to be well understood, hence specific actions need to be put in place to moderate the impact of those institutions.

Cloud computing is a technology focused on business benefits, and as shown in this research, its acceptance is impacted by selected national institutions. Similar could also apply for other upcoming technologies such as Artificial Intelligence and Robotics, which could also be perceived as mainly business-oriented technologies. However, they were not focus of this research but are interesting next research topics.

2.5.3 Limitations

As noted earlier, the formal institutions chosen in this study were selected mainly from the perspective of cloud computing, i.e., the institutions found to be relevant in explaining cloud computing adoption in a country. Hence, the hypotheses reflect limited expected impact of those onto mobile broadband adoption. There could be other national (formal) institutions better reflecting mobile broadband impact; however, that was not the focus of this study. The focus was on cloud computing adoption, and mobile broadband was selected only as comparative technology to test if those two different types of technology differ in their adoption processes when taken from the institutional perspective, since this is a novel perspective not yet applied in this way to the technology adoption.

There are also other aspects and parameters that may be considered relevant for cloud computing adoption; however, they are omitted and are not focus of this study. Focus is on national institutions impact as previously explained. Additionally, it is interesting that government effectiveness is significant to cloud computing adoption, and to the contrary to some other research on ICT determinants, government effectiveness has negative impact on cloud computing. As hypothesised in this paper, GDPR and similar laws could be impacting cloud computing adoption and their impact as such are incorporated within government effectiveness index. This could be further looked at in more details in subsequent papers.

Some scholars (such as Dobbin, 1994) suggest that formal institutions are developed to formalize informal institutions. Hence, there could be some indirect relationships between the variables which have also not been explored so far. This could also be a topic for a further study.

3 Research Paper 2: *Country's governance quality impact on cloud computing adoption in the EU enterprises*

Abstract

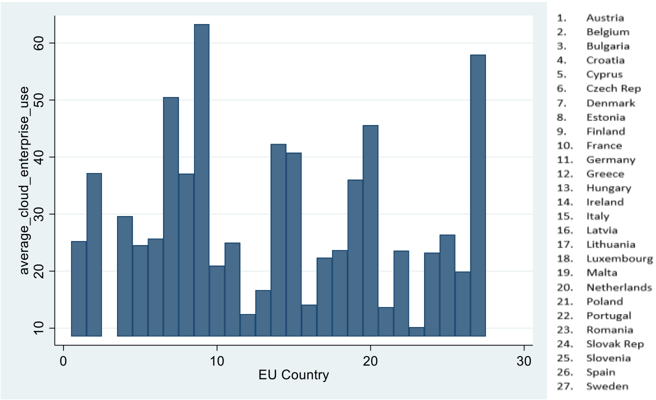
Cloud computing is widely recognised as a key technology that enables digitalisation, fuelling the digital economy growth. Using World Bank Governance Indicators, in this paper we examine how country's quality of governance (or good governance) impacts the use of cloud computing in the enterprises in the EU, hence affects digitalisation of the EU. In an empirical examination of 27 EU countries over a period from 2014 to 2021, it was found that good governance positively affects cloud computing adoption in the EU enterprises. In support of the institutional theory, we show that improving country's governance quality is an important step in accelerating cloud computing adoption by the EU enterprises, the finding providing an important input to the EU government in their execution of the Industrial Strategy 2030, in which digitalisation and cloud computing adoption play an important role. Businesses operating in the EU countries with higher quality of governance are more likely to implement cloud computing in their operations, a cost and performance benefiting technology, a valuable insight to the EU enterprises, which gain direct benefits from increased cloud computing adoption in their businesses.

Keywords: Institutions**,** Cloud computing adoption, Digitalisation, Government governance, EU (Europe), World governance indicators, Quality of government index

3.3 Introduction

Digitalisation is extremely important to growth and development of countries; hence EU has also been promoting the development of digital economy. In 2015, the EU Commission launched the Single Digital Market Strategy in order to assess the maturity of processes related to digitalisation, and in 2021, the Digital Europe Program was launched, with the aim to financially support the digitalisation of the EU countries. Cloud computing[24] is widely recognised as a key technology that enables digitalisation in our economies and societies. The business logic of using cloud computing resides on the premise that organisations can outsource their IT tasks and services at lower cost and higher efficiency. 'Cloud computing has some advantages for individual users, however it has greater benefits for businesses/enterprises' (Karamujic, 2025). Adoption of cloud computing by enterprises is one of the main objectives of the EU Commission Industrial Strategy 2030 with the aim of accelerating the digitalisation and transforming the EU into 'the continent with a high share of digitalised business.' The specific goal that the Commission set is for 75% of the EU enterprises to have taken cloud computing services[25] by 2030. Eurostat records the data on use of cloud computing service in enterprises in the EU, with the Figure 2.1 below depicting the average use of cloud computing services in enterprises in each of the EU countries in the period 2014 to 2021.

Figure 2.1: Average use of cloud computing services in enterprises in the EU



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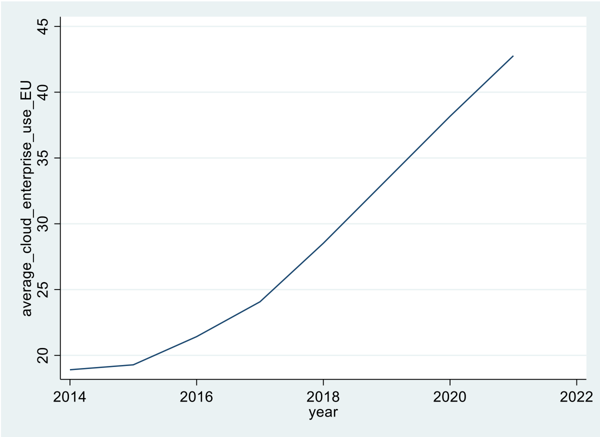
[24] 'Cloud computing is captured by the characteristics of on-demand computing and storage, with shared resources between multiple customers' (Vithayathil, 2017, p.1). 'Cloud computing, as a kind of massively scalable IT computing style, enables the capable and deliverable IT as services to external customers using internet technologies' (Plummer, D.C. et al., 2008).

[25] Cloud computing is one of the key technologies enabling digital transformation. The other digital technologies mentioned in the Commission Industrial Strategy 2030 are Big Data and AI (Artificial Intelligence)

As it can be observed in the Figure 2.1 above, all the EU countries are still well below the goal of 75% use of cloud computing by enterprises to be reached by 2030, with 2021[26] average across the union being just above 40% (see Graph 2.1 below (Source: Karamujic, 2025, 'Does Gaia-X foster cloud computing adoption by European (EU) businesses?').

Graph 2.1: Average % of EU enterprises using cloud computing services



Additionally, in Figure 2.1 above, one observes large deviations in the levels of adoption of cloud computing across the EU countries. For example, countries such as Finland (63%), Sweden (58%) and Denmark (51%) have highest levels of adoption of cloud computing services in their enterprises, while countries such as Bulgaria (9%), Romania (11%) and Greece (13%) have some of the lowest levels of the adoption in the EU.

Cloud computing has many benefits to businesses/firms/enterprises (Karamujic, 2025; Chen, Chaung & Nakatani,2016; Xue & Xin, 2016), in terms of cost and performance benefits, and as such is referred to as business-oriented technology. Considering cloud computing benefits businesses in general, regardless of national boundaries, one would not expect to see such a large deviation across the EU countries when it comes to the use of cloud computing services.

The EU, which is currently comprised of 27 independent countries, is governed under the set of common rules and regulations under the EU governance, with a number of laws and policies in the EU countries being common. However, due to the structure of EU, political and fiscal decentralization, and the principles of subsidiarity, the way the EU laws and policies are applied

[26] Data for 2022 and 2023 not published by Eurostat at the time of this research.

differs across the EU countries. Each EU country implements those laws in line with their own, country specific governance, rather that EU general governance. Farole et al. (2011) note that the individual EU countries often face policy implementation issues related to their own institutional capabilities and governance.

World Bank records governance indicators for over 200 countries in the world for the period since 1996 to 2022 (as per the current data). The indicators used by the World Bank are Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. Those indicators, in particular the four indictors being Control of Corruption, Rule of Law, Government Effectiveness, and Voice and Accountability, are often used as a proxy for the quality of government governance (often referred to as 'good governance'). The countries such as Finland, Sweden, and Denmark mentioned previously that have highest cloud computing use in enterprises, are also some of the top ranked counties globally when it comes to 'good governance' as per the World Bank data and Quality of Government Index (Charron, Lapuente & Dykstra, 2014; Independent, UK paper, issue 2016). Similarly, the countries with lowest cloud computing use in enterprises, are some of the bottom ranked counties globally when it comes to 'good governance'. Hence, leading to the proposition that government governance impacts cloud computing adoption in the EU enterprises.

In this paper, it is argued that cloud computing adoption in enterprises in individual EU countries is impacted by the specific country's institutional capabilities, in particular those reflecting country's quality of government governance. It is posed that the countries with higher quality of government governance will have lower corruption level, higher applicability of rule of law and in general more effective governments, hence businesses operating in those countries will be also able to operate more effectively, focusing on business objectives such as cloud computing adoption rather than being influenced by the presence of corruption and/or lack of the applicability of laws. As such, those countries will have higher cloud computing adoption in enterprises as opposed to those with weaker governance. No relevant research has been found that establishes an empirical link between a country's government governance and its effects on cloud computing adoption, a gap this paper is attempting to address.

The analysis is performed using the regression techniques on the panel data (per EU country/per year) of the percentage use of cloud computing service in enterprises and the average of the World Bank 'good governance' indicators, as a measure of the quality of government governance.

This study aims to provide insights to whether and how institutions reflected in government governance matter when it comes to the cloud computing adoption in the EU enterprises. The findings of the study are important to both the EU government in order to achieve its digitalization targets set in the Industrial Strategy 2030, as well as to EU firms/businesses which gain direct benefits from increased cloud computing adoption in their businesses.

In this article the following structure is applied: Section 2 introduces relevant theory and reflects on the relevant research such as quality of government measures and impacts, followed by the formation of the hypotheses. The section after details the empirical analysis including the description of the data used, method applied and the results obtained. The paper concludes with the discussion, contributions, limitations and implications for research and practice.

3.4 Literature Review and Hypotheses Development

There has been a number of studies that investigated the digitalization across countries, especially in the EU, such as studies by Tutak and Brodny (2022). In one of their studies, Tutak and Brodny analyse the level of business digital maturity in Europe by investigating the implementation of the digital technologies by companies. The digital technologies their study focused on are artificial intelligence, big data, cloud computing, 3D printing, robotization, the integration of internal process, integration with customers/suppliers, and cybersecurity. They found that Scandinavian countries (Finland and Denmark) and Malta have the highest levels of the implementation of those technologies, while Greece, Romania, Bulgaria, Hungary, and Latvia have the lowest levels. In a different study, Tutak and Brodny (2022) investigate digital maturity of the SMEs in the EU countries and find that there is a large discrepancy between the initial EU member states (the initial 14) and the new member states (additional 13). They also find out that there is a positive relationship between the digital maturity and some economic parameters such as GDP per capita. Both studies by Tutak and Brodny studies note there is a difference in the technology adoption by the EU businesses, however they do not explain the reason for this difference. A study by Kovac, Zmija, Roy, Kusa and Duda (2024) provides a literature review on the topic of digitalisation in the EU and Western Balkan countries and notes that socio-economic context has a potential impact on digitalization, and notes that it has not been sufficiently reflected in the research to date.

Institutions are humanly devised constraints and as such can be either formal or informal (North, 1991). Informal institutions refer to the conventions and norms acceptable (or not acceptable) in the society and are typically reflected in country's national culture. Formal institutions are 'formal rules (constitutions, laws, rights, policies)' (North, 1991, p. 97) and as such are reflections of laws and policies in a country. North (1991) notes that the main purpose of formal institutions is to reduce uncertainty of operating in a certain country. Formal institutions are echoed in government governance and are typically measured by the World Bank governance indicators. According to the new institutional theory (Currie, 2011), 'developing and using technology is a subject to various institutional constraints or simply institutions.' Karamujic (2025), notes 'the institutions either push individuals and groups to adopt the technology or not, and may cause them to behave in not necessarily economic-rationalistic way'.

Wan (2005) provides an institution-based theory of firm's strategy and performance, and states that due to the difference in quality of the formal institutions in different countries, resources and capabilities that companies can develop and have access to differ so does their performance.

There has been increasing focus on 'good governance' and its impact on growth and development of economies and societies. Wu, C-H. (2021) as well as other researchers (Bota-Avram, 2014; Ngobo & Fouda, 2012; Bruno & Claessen, 2010; and others) note that 'country governance is important'. Ngobo and Fouda (2012) based on their study of a relationship between good governance and the performance (profitability) of the firms in 21 African countries, find a positive association between good governance and firms' performance. They note that 'companies located in countries with better governance tend to perform better.' Additionally, they find that 'when the country's income level is lower, an improvement in public governance is more likely to impact a firm's performance than when the income level is relatively higher.

Bota-Avram (2014) note ‘the relevance of governance quality for the ease of doing business, highlighting the necessity to pay enough attention to ensuring good governance in order to provide effective development outcomes’. Keser and Gokmen (2018) establish a positive relation between government governance in the EU and Human Development Index measured a composite of education, literacy and income in that country. They find that at least three governance indicators measured by the World Bank, being Government Effectiveness, Regulatory Quality and Rule of Law have significant positive impact on the development of human capital in the country, hence note that ‘better government governance in a country, better its human development index.’

Kaufmann and Lafarre (2021) find that country’s governance quality is positively associated with sustainability performance, referred to as corporate social performance[27] of the firms in the countries. Charron, Lapuente and Dykstra (2014) in their research note that ‘even in a highly developed area such as Europe, significant quality of government variation exists between and within countries’ and that quality of government has a significant impact on almost all dimensions within societies and economies, such as welfare, education, health, economic performance and others. Karamujic (2025), finds that national institutions affect cloud computing adoption; informal institutions such as national culture and few formal institutions such as trade union strength and government effectiveness. The focus was on few formal institutions that were found relevant based on the previous research, with the analysis conducted using the data on 38[28] countries globally. Using a variety of sources on both national and sub-national level such as World Bank data complemented with variety of survey data, Charron, Lapuente and Rothstein (2011) of the University of Gothenburg developed a novel EQI (European Quality of Government Index), which is now commonly used in the research of government governance impacts. Such one study using EQI is the study by Rodrigues-Pose and Di Cataldo (2014). In their study, Rodrigues-Pose and Di Cataldo assess the impact that the government institutions have on the innovative capacity in the EU, stating that institutions ‘define degree of

[27] ‘Corporate Social Responsibility is the combination of environmental sustainability and social sustainability. Environmental sustainability ensures the long-term stability and resilience of the ecosystems that support human life, whereas social sustainability facilitates the respect and promotion of human rights and other basic social rights’

[28] Some of the EU countries used, such as Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Poland, Portugal, Spain, Sweden

economic uncertainly in the society and the way the collective decisions are made.' Rodrigues-Pose and Di Cataldo note that the individual EU countries' governments vary considerably and argue that the countries with weak government governance will result in lower innovative performance when compared to the countries with stronger government settings. Using the European Quality of Government Index (Charron, Lapuente & Rothstein, 2011), and including the World Bank Governance Indicators of Control of Corruption, Rule of Law, Government Effectiveness and Voice and Accountability, they find that 'the quality of government plays a strong and significant role in the innovative potential of European regions.' Rodrigues-Pose and Di Cataldo (2014) additionally find that 'ineffective and corrupt governments represent a fundamental barrier to the innovation in the EU'. Governments that have effective policies and keep corruption under control foster innovation more when compared to their counterparts that are more corrupt and ineffective.

Rodrigues-Pose and Di Cataldo (2014) in general acknowledge the importance of institutions on technology adoption and application, noting limited to date academic research of this phenomenon. Due to the importance of cloud computing technology to EU digitalisation, and the lack of research in the effects of the EU countries' institutions reflected in government governance on cloud computing adoption, this research arose.

The World Bank governance indicators are frequently used as a measure of government governance and are generally accepted to be accurate and reliable (Dollar & Kraay, 2003; Charron, Lapuente & Dykstra, 2014; Rodrigues-Pose & Di Cataldo, 2014; Rodriguez-Andres, Amavilah & Asongu, 2016; and others). Charron, Lapuente and Rothstein (2011) when working on the European Quality of Government Index identified that four out of six World Bank Governance indicators are particularly relevant when measuring Quality of Government (QoG), being Control of Corruption, Rule of Law, Government Effectiveness and Voice and Accountability. Those four indicators are also used in this study.

Control of Corruption as per the World Bank definition refers to 'the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.' In corrupt governments, the decisions are not necessarily made for the best of societies, but rather for individual or privileged groups gains. A number or previous studies identified significant and negative link between corruption and economic growth and development, including technological progress (Rodrigues-Pose & Di Cataldo, 2014).

Rule of Law as per the World Bank definition refers to 'the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.' Applicability, effectiveness and impartiality of courts are essential for investment and innovation (Rodrigues-Pose & Di Cataldo, 2014; Rose-Acerman, 2001). Vu, Hartley and Kankanhhalli (2020) in their study on country-level predictors of cloud computing adoption find that 'legal systems quality of a country, reflected in a rule of law' positively impact cloud computing.

Government effectiveness index definition refers to 'the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies'. As noted by Rodrigues-Pose and Di Cataldo (2014), effective governments are more capable of developing effective strategies and policies targeting the right areas of investments. Rodriguez-Andres, Amavilah and Asongu (2016) also find that government effectiveness has significant effect on the ICT adoption in their research in Sub Saharan Africa. In my previous research (Karamujic, 2025), in an empirical examination of the cloud computing revenues, as a proxy for cloud computing adoption, over a sample consisting of 38 countries globally (15 EU countries and 23 non-EU) over a five-year period, it was found government effectiveness, as one of six selected national institutions, significantly impacts cloud computing adoption in a country.

Voice and accountability as per the World Bank definition refers to 'the extent to which a country's citizens are able to participate in selecting their government, as well as a freedom of expression, a freedom of association, and a free media.' Rodriguez-Andres, Amavilah and Asongu (2016) relate voice and accountability to political governance in the country, 'the process by which those in authority are selected and replaced'.

As noted earlier, Charron, Lapuente and Rothstein (2011) use Word Bank's governance indicators of Control of Corruption, Rule of Law, Government Effectiveness, and Voice and Accountability as the main pillars and apply combined averages of those four pillars per country to obtain quality of government index. Since those World Bank indicators are only available on a national level, Charron, Lapuente and Rothstein (2011) complement those with survey data on the levels of quality, impartiality and corruption of sub-national governments, resulting in adjusted index on both national and sub-national levels (e.g. Austria as a nation versus sub-national regions of Vienna, Lower Austria, Upper Austria and others). Hence, Charron, Lapuente and Rothstein (2011) obtained adjusted scores which they refer to as European Quality of Government Index (EQI).

As noted before, Rodrigues-Pose and Di Cataldo (2014) in their study on the impact that the government institutions on the innovative capacity in the EU, use the European Quality of Government Index (EQI) as well as separate the World Band 'good governance' indicators of Control of Corruption, Rule of Law, Government Effectiveness and Voice and Accountability. The methodology applied in Rodrigues-Pose and Di Cataldo (2014) research, even though related to the innovation capacity, can be transposed to other technology domains, such as digitalization and cloud computing adoption. Similar to Rodrigues-Pose and Di Cataldo, this study poses that the quality of government governance' impacts the use of cloud computing service (instead of the innovative capacity) in the EU. Governments, via its institutions, are responsible for setting up relevant laws and policies, and quality of those will in turn affect if certain innovations and technological developments would be either promoted or inhibited in a particular country setting. One could argue that cloud computing, a technology that relies on the use of virtualisation and access to the remote data centres (commonly referred to as clouds), is particularly prone to the impact of governments. Thus,

> Hypothesis: The higher the quality of government governance in an EU country, the higher cloud computing adoption in the enterprises in that EU country.

To test the above hypothesis, the dynamic panel regression methods are applied. The methodology and the analysis are further described in Data and Method section.

3.3 Data and Method

3.3.1 Data

3.3.1.1 Use of cloud computing services in enterprises in Europe

Eurostat records the data on use of cloud computing service in enterprises in Europe in the period from 2014 until 2021 (with 2019 data missing). The data is based on the results of surveying 148,000 of EU enterprises with at least 10 employees in the EU NACE[29] classification (out of 1.5 million enterprises in this classification in the EU in 2021) including Small-Enterprises (10-49 employees comprising 83% of the data sample), Medium Enterprises (50-249 employees comprising 14% of the data sample) and Large Enterprises (250 or more employees comprising 3% of the sample). The data is expressed as a percentage of enterprises in the NACE sectors (defined earlier in the footnote 4) using cloud computing services. It covers all cloud services being Infrastructure as a Service, Platform as a Service and Software as a Service for all enterprises with 10 employees or more (Source: Eurostat). The data is available for all 27 EU countries in a panel format, per country, per year.
Note: In order to onbtain fully balanced panel, the missing data points were estimated by averaging of the two neighbouring values. For example, if 2015 data for a specific country was missing, it was estimated to be an average of 2014 and 2016 data points. This was only applied in few cases, hence should not have a significant impact on the data. Additionally, the values for 2019 are missing however have been estimated as an average of 2018 and 2020 values.
This data was also used in another research paper that by Karamujic (2025), 'Does Gaia-X foster cloud computing adoption by European (EU) businesses?'

3.3.1.2 World Bank Governance Indicators (WGI)

Six worldwide governance indicators are Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption. Each indicator is normalized to a range from -2.5 to 2.5, with zero mean and standard deviation of 1.

[29] NACE sectors covers are manufacturing, electricity, gas and steam, water supply, construction, wholesale and retail trades, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, information and communication, real estate, professional, scientific and technical activities, administrative and support activities, and the repair of computers and communication equipment.

Higher the value, indicates better perception of a given indicator. The data is captured via various data sources reflecting the perception of governments and is available since 1996 for over 200 countries. As noted earlier, those indicators are often used as a proxy for the quality of government governance and often referred to as 'good governance', in particular Control of Corruption, Rule of Law, Government Effectiveness and Voice and Accountability. The values of those four indicators are used to come to an average per country (per year) as an estimation (proxy) of the quality of government governance for each of the 27 EU countries. The data range that each indicator takes is somewhat narrower than in the total global data sample, ranging from around -0.5 to 2.5, hence the average of the four indicators ranges from around -0,1 to just below 2.0.

Since this research uses logs, 1.0 is added to the average of the World Bank indicators in order to ensure all the values are positive.

3.3.1.3 European Quality of Government Index (EQI)

The World Bank indicators are measured on a national level and assume that inter-country institutional variations are insignificant. This assumption has been challenged, resulting in a creation of a homogenous European Quality of Government Index (EQI) developed by the University of Gothenburg (Charron, Lapuent & Rothstein, 2011) measured on a sub-national level i.e. per region or province in a country. The index is developed first using an average of four of the World Bank indicators of Control of Corruption, Rule of Law, Government Effectiveness and Voice and Accountability. Subsequently, those World Bank indices' averages are combined with the survey data on the levels of quality, impartiality and corruption of sub-national governments, resulting in adjusted index on both national and sub-national levels. The values range from around -2.0 to +2.0 with the EU average being 0. Positive values imply regions are above the EU average, while negative values imply regions are below the EU average. Higher the value the better government governance perception. The EQI data was first collected in 2010 and then repeated for the periods 2013, 2017 and 2021.

3.3.1.4 General Notes on the Data used

All data values are rounded to the third decimal place.

Descriptive statistics and correlations for the data used can found the Appendix, Table AA.

3.3.2 Method

3.3.2.1 Dynamic Regression (GMM)

In this research, the dependent variable is the use of cloud computing services in enterprises in Europe in the period from 2014 until 2021. The independent variable is the quality of government governance which is proxied by the average of the four World Bank government governance indicators.

It is important to note that the European Quality of Government Index was also considered as a potential proxy for the quality of government governance, however it was decided not to be used. The main reason being that the measurement of the European Quality of Government Index is only available for 2 years (2017 and 2021) out of the relevant period from 2014 to 2021 for which cloud computing service in enterprises in Europe data is available. Additionally, the cloud computing service in enterprises in Europe data is only available on national level, with no subnational details, for which the European Quality of Governance Index would be relevant. Moreover, the average of the four World Bank indicators and the European Quality of government Index are highly correlated (0.966, reference Appendix A), hence it is sufficient to use one of them in the analysis, in this case the average of the four World Bank indicators for which yearly data is available for the full period 2014 to 2021.

High correlations present between dependent and independent variable (0.32, reference Appendix, Table AA) point to choosing a regression analysis as the main method in this analysis.

Since both dependent and independent variables are available in a panel structure with the observations recorded over the years, panel regression analysis is further selected. Additionally, it is expected that past values of dependent variable, being the use of cloud computing services in enterprises in Europe, affect the future values of the same variable, hence a dynamic regression is used. Vu, Hartley and Kankanhhalli (2020) choose GMM dynamic regression in their study on the analysis of the factors affecting cloud computing. They note that GMM method accounts for the presence of country-fixed effects and is more robust to heteroscedasticity and serial correlation potentially present in the error term compared to other regression techniques. GMM was also used in the study on the impact of national institutions on cloud computing adoption. Comparison of cloud computing to mobile broadband adoption (Karamujic, 2025). In that study, the focus was on the impact of informal and some formal institutions on cloud computing adoption in 38 countries globally, using cloud computing revenues as a proxy for the adoption. In this study however, the focus is on the impact of the quality of government governance in 27 EU countries on the use of cloud computing services in the EU businesses. Additionally, the previous study also compared cloud computing adoption to mobile broadband adoption proxied be the mobile broadband revenues in 48 countries globally. Even though the data and focus of the two studies are different, the methodologies applied are similar.

Log-log regression is also used since useful in interpreting results (one percent change in one of the independent variables (everything else held constant), explains x percent of the variation in the dependent variables). Since the independent variable, the average of the World Bank governance indicators, can take negative values, the data is slightly manipulated in order to apply logs, meaning a fixed value is added to each independent variable to make it positive. See further under Data.

The following statistical model is used to examine the relationship between the use of cloud computing in the EU business and the quality of government governance in the EU countries:

$$\text{lncloud\_use\_enterprise}_{it} = \alpha + \beta\ \text{lncloud\_use\_enterprise}_{it-1} + \gamma X'_{it} + \varepsilon_{it} \qquad \text{Eq (1)}$$

where $\text{lncloud\_use\_enterprise}_{it}$ is the log value of the use of cloud computing services in enterprises in Europe by country i in year t; $\text{lncloud\_use\_enterprise}_{it-1}$ is the lagged level of the log value of the use of cloud computing in the EU enterprises by country i in year t; X'_{it} is a vector containing the log of independent variable, the average of the four World Bank governance indices and a set of control variables as described in Version A, B, C and D below, and ε_{it} is the random error term.

- Model versions with varying control variables are:
- *Version A* with net income per capita as a control variable. Net income per capita captures the level of development per country (Source: Worldbank) with the data available for all 27 countries and for each year from 2014 to 2021 time period. As noted in the previous study by Karamujic (2025), ‘GMM assumes that the first differences of endogenous variables are uncorrelated with country fixed effects’, which could be violated in this data set. Furthermore,

the previous research by Ngobo and Fouda (2012), indicated that 'a role of good governance depends upon the country's income level'. To control for this potential violation and bias, net income per capita is added to the analysis.

- *Version B* adds ICT Sector as an additional control variable besides net income per capita. ICT Sector variable captures the percentage of the ICT sector in gross value added, meaning the contribution of the ICT sector to the growth economy (Source: Eurostat), with the data available for all but three EU countries (Cyprus, Ireland and Luxembourg) and the data points available for most of the years for the remaining twenty-four countries. In case the data was missing, the value from a previous year(s) is used (max of three years in the past).
  ICT Sector variable controls for the potential bias that the use of cloud computing is impacted by the extent of ICT sector development in a country.
- *Version C* adds and additional control variable being Broadband internet speed of over 100 Megabits availability in a country (Source: Eurostat) with the data available for all 27 countries and for each year from 2014 to 2021 time period.
  For businesses to effectively use cloud computing services they require internet speed of over 100 Megabits and more (Source: https://www.business.com/internet/bandwidth/), hence this additional variable controls for a potential bias related to the internet speed availability in different countries.
- *Version D* instead of net income per capita, uses GDP per capita in order to capture the level of development per country (Source: Worldbank) which in some studies (Tutak and Brodny, 2022) was found to be significantly related to the digitalization maturity. The rest of the control variables are consistent with the model version C, being ICT Sector and Broadband internet speed.

All model versions use time dummies to control for time-related shocks.

3.4 Results

Tables 2.1 and 2.2 below detail the estimation results for the models specified in Eq (1) resulting from dynamic regression using one step GMM.

Table 2.1: The impact of the average of the four World Bank governance indicators on the use of cloud computing services in enterprises in Europe as per the dynamic regression (GMM one step) from STATA

The impact of the average of the four World Bank governance indicators on the use of cloud computing services in EU enterprises				
	Model A	Model B	Model C	Model D
Use of cloud computing in enterprises _lag value	0.829***	0.873***	0.886***	0.892***
P value	0.000	0.000	0.000	0.000
[95% Conf. Interval]	[0.698 0.959]	[0.706 1.040]	[0.709 1.063]	[0.712 1.072]
(Std. Error)	(0.067)	(0.085)	(0.090)	(0.092)
Average of the four World Bank governance indicators	0.274***	0.205***	0.167**	0.178**
P value	0.000	0.001	0.043	0.024
[95% Conf. Interval]	[0.125 0.424]	[0.079 0.330]	[0.006 0.328]	[0.023 0.333]
(Std. Error)	(0.076)	(0.064)	(0.082)	(0.079)
Net Income Per Capita	-0.000000678	-0.000000511	-0.00000053	
P value	0.164	0.575	0.563	
[95% Conf. Interval]	[-0.00000163 0.000000278]	[-0.0000023 0.00000128]	[-0.00000233 0.00000127]	
(Std. Error)	(0.000000488)	(0.000000913)	(0.000000916)	
GDP Per Capita				-0.000000634
P value				0.425
[95% Conf. Interval]				[-0.00000219 0.000000923]
(Std. Error)				(0.000000795)
ICT Sector		0.004	0.002	0.001
P value		0.368	0.786	0.882
[95% Conf. Interval]		[-0.005 0.013]	[-0.010 0.013]	[-0.010 0.013]
(Std. Error)		(0.005)	(0.006)	(0.006)
Broadband			0.0003	0.0003
P value			0.213	0.209
[95% Conf. Interval]			[-0.0002 0.0009]	[-0.0002 0.0009]
(Std. Error)			(0.0003)	(0.0003)
Constant	0.254***	-36.717***	-32.147**	-31.95**
P value	0.001	0.006	0.038	0.035
[95% Conf. Interval]	[0.105 0.402]	[-62.804 -10.631]	[-62.536 -1.756]	[-61.652 -2.251]
(Std. Error)	(0.076)	(13.310)	(15.505)	(15.153)
N	189	166	166	166
Number of groups	27	24	24	24
Observations per group	7	5	5	5

Numbers rounded to 3 decimal places; ∗p < 0.1, ∗∗p < 0.05; ∗∗∗ p < 0.01.

Table 2.2: GMM Hypotheses tests:

The impact of European Quality of government Index on the use of cloud computing services in EU enterprises				
	Model A	Model B	Model C	Model D
Arellano-Bond test for AR(2)	z = 0.9 Pr > z = 0.367	z = 1.04 Pr > z = 0.297	z = 1.02 Pr > z = 0.308	z = 1.02 Pr > z = 0.307
Hansen test of overid. restriction	chi2(26) = 17.72 Prob > chi2= 0.886	chi2(26) = 16.46 Prob > chi2= 0.924	chi2(26) = 13.41 Prob > chi2= 0.980	chi2(26) = 11.68 Prob > chi2= 0.993

Firstly, important to note that Arellano-Bond tests and Hansen tests in Table 2.2 above, confirm the validity of GMM used, hence we can proceed with the analysis of the results in Table 2.1.

In Table 2.1, as expected, the lag values of the dependent variable are significant in all four models A, B, C and D with p values of 0.000, hence the past values of the use of cloud computing in the EU enterprises do significantly affect the future values.

This research's main hypothesis poses that the higher the quality of government governance in an EU country (proxied by the average of the four World Bank governance indicators), the higher cloud computing adoption in the enterprises in that EU country. As can be seen in all four models, this hypothesis is supported (Model A with p value of 0.000, Model B with p value of 0.001, Model C with p value of 0.043 and Model D with p value of 0.024). The relationship between the quality of government governance in EU countries and the use of cloud computing by EU enterprises is positive and significant indicating that 1% increase in the quality of government in the EU countries as measured by the average of the four World Bank governance indicators results in about 0.2% increase in cloud computing adoption in the enterprises in that EU country (measured as a percentage of EU enterprises that adopt cloud computing in that country). More accurately, 1% increase in the quality of government in the EU countries results in 0.274% increase in the percentage of EU enterprises that adopt cloud computing in that country as per Model A, 0.205% increase as per Model B, 0.167% as per Model C and 0.178% as per model D. Hence, the results obtained seems to be consistent across different models used with different control variables applied.

Model A has the most data points, while models B, C and D have less data since ICT Sector information is missing for 3 countries in the data sample.

3.5 Discussion, Conclusion, Contribution, and Limitations

In this research, it was illustrated that the quality of government governance positively affects the use of cloud computing in the EU enterprises. The empirical analysis was conducted using the average of the four World Bank governance indicators (Control of Corruption, Rule of Law, Government Effectiveness and Voice and Accountability) as a proxy for the quality of government governance. To accommodate for potential biases, four different models were used to control for factors such as net income, GDP, ICT sector development as well as broadband internet availability in different countries. All four models tested show the consistent results in support of the research hypothesis: The higher the quality of government governance in an EU country, the higher cloud computing adoption in the enterprises in that EU country.

3.5.1 Contributions

This research makes several important contributions. Firstly, it supports the exiting theories, in particular neo institutional theory. According to neo institutional theory, developing and using technology is a subject to various formal institutions which are represented by the World Bank governance indicators used in this research, being Control of Corruption, Rule of Law, Government Effectiveness and Voice and Accountability. Secondly, it empirically shows how the quality of government governance impacts the use of cloud computing services in the EU enterprises. Similar research has not been conducted year to date. Important findings and implications for researchers and practitioners arise from this analyses and research. Thirdly, it contributes to the growing literature on the importance of government governance and its impact on growth and development of economies and societies.

3.5.2 Practical Implications

Adoption of cloud computing by enterprises is one of the main objectives of the EU Commission Industrial Strategy 2030 with the aim of accelerating the digitalisation and transforming the EU into ‘the continent with a high share of digitalised business.’ The goal of 75% of the EU enterprises to have taken cloud computing services[30] by 2030 is quite a challenge, considering the 2021 EU average was just over 40%, with very large variations across the countries. This research aims to provide additional input to the EU decision makers and support them with additional insights in terms of drawing their attention to the importance of the government governance quality, and the improvement of it, for continued growth in the use of cloud computing in the EU enterprises, hence increase in digitalisation and achievement of their strategic objectives.

This research also aims to provide additional input to the EU businesses, for which the adoption of cloud computing and acceleration of digitalisation is also very important given its many cost and performance business benefits. Enterprises operating in countries with higher quality of government governance are more likely to implement cloud computing in their operations. Hence, when establishing or planning to grow in certain EU countries, this research provides important insights to EU businesses.

This research also confirms previous research (Wan, 2005; Ngobo & Fouda, 2012) that companies located in countries with better governance tend to perform, in this case measured by their adoption of cost and performance benefiting technology such as cloud computing.

3.5.3 Limitations

This research is focused on the use of cloud computing services in the EU enterprises and should be used in the context of the EU. In would be interesting to conduction similar research on a wider geography, however Eurostat only records the use of cloud computing services in the EU enterprises, and no similar data is available on a wider data sample. Additionally, there are also other aspects and parameters that may be considered relevant for cloud computing adoption; however, they are omitted and are not focus of this study. Focus is on the institutions echoed in government governance as previously explained.

[30] Cloud computing is one of the key technologies enabling digital transformation. The other digital technologies mentioned in the Commission Industrial Strategy 2030 are Big Data and AI (Artificial Intelligence)

4 Research Paper Research Paper 3: *Does Gaia-X foster cloud computing adoption by European (EU) businesses?*

Abstract

The digital economy has become increasingly important to growth and development of countries. Cloud computing is typically named as a key technology supporting the digitalization process, with cloud computing services fuelling the digital economy growth. The European providers' share of total European cloud computing revenues had been decreasing steadily as businesses turned to non-EU providers. Concerned with this trend of ever-increasing dominance of non-EU companies, the EU commission launched the Gaia-X initiative to create a 'made in Europe' public cloud computing infrastructure. Investigating the data from 2014 to 2023 on the cloud computing services use by European businesses, six significant breaks were found, indicating that there were events in this time period causing the cloud computing use to increase significantly. The break identified in 2022 could be pointing to the effect of Gaia-X, however, due to the number of other important events in the years prior such as GDPR introduction and Covid-19 outbreak, it is difficult to isolate the impact of Gaia-X. Addressing a panel of 41 experts on businesses cloud computing use additionally reveals a mismatch between the Gaia-X goals and business interests: while the Gaia-X principles emphasize digital sovereignty, data protection, free market access and European values creation, European businesses prioritize competitive prices, offerings, and reliability of services. In support of network effects theory, an initiative with a better fit to the EU businesses' priorities, may have further fostered the adoption of cloud computing in the EU.

Keywords: Cloud computing, Gaia-X, Digital economy, Digital sovereignty, Technological innovation, EU technology initiative

4.1 Introduction

Digital economy (Bukht and Heeks, 2017) is referred to 'that part of economic output derived solely or primarily from digital technologies with a business model based on digital goods or services and consists of the digital sector plus emerging digital and platform services'. Williams (2021) notes that the definition of digital economy developed and changed over the times; in early 1990 digital economy was mainly referring to the economic output related to the internet, while the later definitions refer to more novel technologies such as cloud computing, sensor and mobile networks. Bukht and Heeks (2017), as well as Williams (2021) estimate that digital economy is to make around 5% of global economy and 3% of global employment, hence it has become increasingly more important to the general growth and development. In digital economy and industrial revolution 4.0[31], digital services are offered virtually, compared to the past when services were traded physically. Rodigina, Moleva, Orlov and Musikhin (2021) state that 'services now account to an average of three-quarters of GDP in developed countries. Since 2000, global trade in service has quadrupled'.

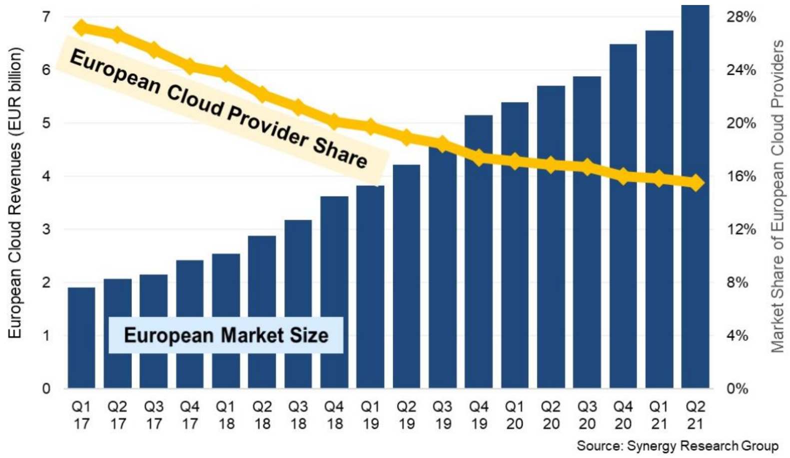
Due to the increasing importance of digital economy and digital services, there has been an increasing concern by the European Union member states that the digital economy and associated services are strongly dominated by non-EU (foreign) firms (Celeste, 2021; Autolitano & Pawlowska, 2021). Those concerns refer to the lack of the EU presence in the digital economy in general, as well as a risk that European values will not be preserved and will be potentially violated in the economy mainly dominated by the foreign firms. Cloud computing is an example of a digital service (or services) provided virtually for which above mentioned concerns by the EU have been attracting particular attention (Autolitano & Pawlowska, 2021).

Based on Synergy Research Group, European cloud computing market by second quarter of 2021 was around 7,3 Billion Euros, of which European cloud computing share is only 16% and has been steadily decreasing over time. American hyperscalers such as Amazon, Google and IBM make remarkable 66% of that market share and are expected further to increase (Statista, 2023). The

[31] Fourth industrial revolution marked by digital economy (Markova, Zyuzina and Koropuskov (2020))

European cloud market size is measured by European cloud revenue data and is available per quarter since 2017 Q1 until 2021 Q2, expressed in billions of Euros as depicted below.

Figure 3.1: European cloud market by quarter



'Cloud computing is captured by the characteristics of on-demand computing and storage, with shared resources between multiple customers' (Vithayathil, 2017, p.1). 'Cloud computing, as a kind of massively scalable IT computing style, enables the capable and deliverable IT as services to external customers using internet technologies' (Plummer, D.C., et al., 2008). In public clouds[32], external organizations referred to as cloud providers being conglomerates like Amazon, Google and IBM, provide cloud computing services such as *Infrastructure-as-a-Service (IaaS), Software-as-a-Service (SaaS)* or *Platform-as-a-Service (PaaS)* (Mell and Grace, 2011) towards other organizations globally. (Public) cloud providers supply cloud computing services to multiple organizations, hence, create economies of scale, allowing them provision of those services at lower costs and with reliable 24x7 service-guarantees (Chen, Chaung & Nakatani, 2016; Xue & Xin, 2016). 91% of organisations in the EU and the USA move to the cloud environments due to the cost benefits provided by cloud computing (Modi, 2013). Hence, and as referred throughout various literature, the main advantages to businesses of using cloud computing refer to the benefits related to lower Cost/Price, better and more diverse Offerings (current and future) as well as Reliable service provision (reliability).

[32] There are furthermore private and hybrid clouds, however those are mainly available to large firms and in recent times less represented compared to public clouds. In this study when referring to cloud computing, it implies public cloud computing.

Cloud computing does not come without risks and concerns such as security and privacy (Xue & Xin, 2016). A business using cloud computing solutions entrusts its data to a cloud solution provider, hence needs to have a high level of trust in that provider. Putting a company's data into a cloud increases the risk of potential data protection regulation violations, which companies are very apprehensive about, particularly in the EU with the existence of GDPR[33] (Karamujic, 2025).

A growing concern is the dependence on a few public cloud computing providers (as illustrated by Synergy Research Group) which gives a rise to new initiatives by the governments to protect their businesses from such dependence such as Gaia-X initiative in the EU (Celeste, 2021; Autolitano & Pawlowska, 2021).

Gaia-X is an initiative launched end of 2019 (October) by the EU member states, chiefly Germany and France. Gaia-X aims to build 'high-performance, competitive, secure and trustworthy data infrastructure based on European values' (Baenfer, Buehler, Moeller & Svensson, 2021). In January 2021, Gaia-X Association was formed by 22 organizations to develop technical framework and operate Gaia-X Services (Source: Gaia-X Home). The EU companies joining Gaia-x initiative increased to 270 by the end of 2021 and to 340 by the mid of 2022. Since 2022, the number of participants stayed constant in the rage of above 300 companies[34] (Source: Gaia-X Home).

Gaia-X is aimed at addressing the perceived lack of data handling transparency when data is handled by the global cloud computing providers, as well as regaining Europe's place in the digital economy, predominantly in the public cloud computing space, by investing in a creation of a federated public cloud 'made in Europe' (Celeste, 2021). Gaia-X is a federated environment in a sense that it brings together several cloud infrastructure and solution providers (referred to as 'Nodes') into Gaia-X to

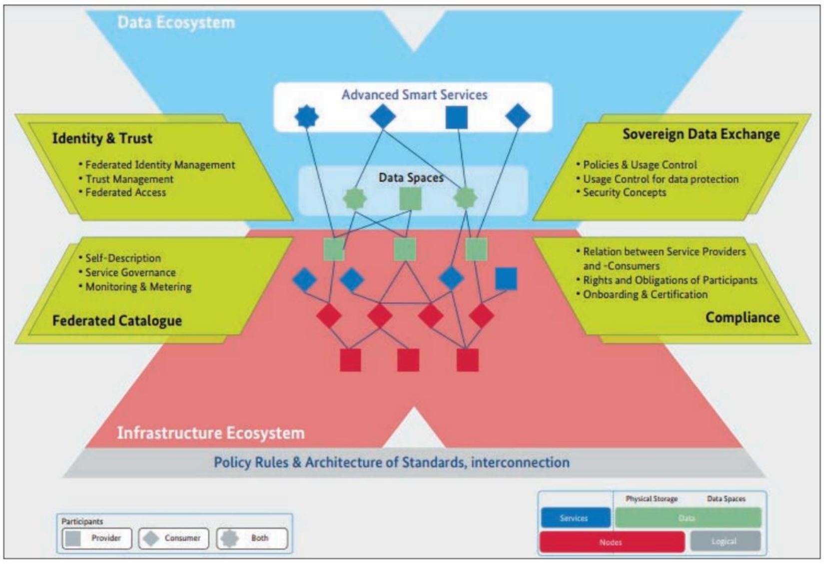
[33] GDPR (Global Data Protection Regulation) refers to the data protection legislation introduced in 2016 by the European Parliament and the European Council and was put into the force in May 2018 across the EU (European Commission (2023)). GDPR imposes how European data needs to be handled by entities established inside and outside of the EU in order to ensure individual's data is being protected in line with the European rules and regulations. GDPR is in some cases in a direct conflict with other legislations imposed by other countries, such as for example the Cloud Act in the USA. According to the Cloud Act, the USA law enforcement authorities can request that data is assessable by the USA firms even though this data maybe be stored outside the USA (the USA Department of Justice (2023)). (GDPR impacts and implications is a very interesting topic, however not a focus of this paper and maybe addressed in a separate paper).

[34] Even though there was a significant increase in Gaia-X participation by 2022 to above 300 companies, that is small number of companies, considering the total number of enterprises registered in EU (out of 1.5 million enterprises in this classification in the EU in 2021) (Source: Eurostat).

create a so-called federated cloud. The participation in this cloud is governed via a set of rules and compliance requirements.

Below is graphical illustration of Gaia-X architecture as illustrated by Braud, Fromentoux, Raider and Le Grand of Orange Labs in France (2021).

Figure 3.2: High-level view of Gaia-X architecture by Braud, Fromentoux, Raider and Le Grand (2021)



In accordance with Figure 3.2, Data Ecosystem is where the data is provided, verticals specific solutions are applied, and users of those solutions are interacting with Gaia-X. This is referred to as user level or user perspective. The green blocks, Identity & Trust, Federated Catalogue, Sovereign Data Exchange and Compliance are the core Gaia-X building blocks (or core principles). All participants of Gaia-X need to comply with those core principles to be a part of the Gaia-X ecosystem. Infrastructure Ecosystem is where infrastructure is provided by Gaia-X cloud provider participants. Hence, Gaia-X infrastructure as such is not a monolithic, proprietary public cloud itself, but rather a federation of multiple cloud providers. This 'federated cloud' is used for sharing, storing and handling of data via so-called 'DataSpaces'. In 'DataSpaces' companies and individuals store their data to be used by Gaia-X participants, while always retaining the control over the data, how it will be used and where it is stored. 'DataSpaces' is where the users interact with the Gaia-X ecosystem and obtain their needed services. User perspective and data spaces are organized in verticals/focus areas such as Industry 4.0/SME, Health, Energy, Mobility, Finance & Insurance and Travel, with the aim to use this data for specific purposes and by specific industry solutions. The point of contacts for each of those are appointed and it is expected that use cases and collaboration around those is created by Gaia-X participants. Hence, the approach is based on collaboration and cooperation between the participants with no strict governance of Gaia-X use cases. Up to middle 2021, there has been over 100 use cases trialled on Gaia-X (Gaia-X Home, 2022). Gaia-X geographical hubs are distributed across the EU such as those in Netherlands, Belgium, Great Britain, France, Spain, Portugal, Germany, Austria and others. The main purposes of the hubs are: 1. First points of contacts for those interested into Gaia-X to get initial information of how Gaia-X can be useful for them 2. Understanding what is available already in each market and what initiatives are in place (exchanging of the best practices) 3. Building up the ecosystem and channelling of the market requirements towards Gaia-X.

Hence in summary, Gaia-X is more than just public cloud infrastructure 'made in Europe' as noted earlier. It is a conceptual model that orchestrates participation of ecosystem of service providers in an environment with the aim of provision of services in line with the principles implied by Gaia-X framework. According to Baenfer, Buehler, Moeller and Svensson (2021), the Gaia-X guiding principles can be further described as: 1. European data protection, 2. Openness and transparency, 3. Authenticity and trust, 4. Digital sovereignty and self-determination, 5. Free market access and European value creation, 6. Modularity and interoperability, 7. User-friendliness. It is interesting to observe that the Gaia-X principles do not mention the previously identified advantages to businesses of using cloud computing such as Cost/Price, Offerings (current and future) and Reliability.

Below figure illustrates the 5-Year Gaia-X Outlook (Source: Deutsche Messe Technology Academy).

Figure 3.3: Gaia-X Outlook, Gaia-X Mission, Milestones, & Deliverables 2022

In accordance with the Figure 3.3, 2021 was marked as the year of Gaia-X set up and formation, while the year 2022 was aimed at increased adoption and implementation, followed by the years of Growth (2023), Expansion (2024) and Scale (2025). The figure above was published in 2022, hence it is reasonable to expect that 2021 set up and formation were already completed, hence the impact of Gaia-X should be felt from the year 2022 onwards.

The cost of establishing and running of Gaia-X model is not publicly made available, however seeing its complexity one can assume significant costs are incurred. The literature so far does not evaluate the success of Gaia-X initiative in terms of its support to cloud computing adoption by the EU businesses, the gap attempted to be addressed in this paper. Additionally, the papers previously published on the topic of Gaia-X are predominantly case studies or studies lacking academic rigor from the perspective of proving the phenomenon using the statistical methods. The additional gap attempted to be addressed in this paper.

4.2 Literature Review and Hypotheses Development

Celeste (2011) elaborates on the concept of digital sovereignty in the EU, which is one of the guiding principles of Gaia-X initiative. Digital sovereignty refers to the need to protect and preserve European values and rights in the digital economy, which as such is globalised and borderless, and dominated by foreign firms. Digital sovereignty stems from the concept of state sovereignty which in traditional economy was much easier to grasps and implement, however it has been a challenge in the new digital world, created by the advancement of technologies such as cloud computing. As such, digital sovereignty refers to the control of digital assets that are as such immaterial and are not bound to exist only within the state borders. In his paper, Celeste refers to digital sovereignty and initiatives such as Gaia-X and GDPR as EU's way of 'preserving its unique DNA of rights and values'. Via those initiatives, the EU promotes the concept of 'made in Europe'. One of the criticisms of this concept by Celeste is that it would trigger greater political and economic tensions with other countries and states, which would not help European economy nor would protect the EU data. They will instead lead to a certain level of 'protectionism and isolationism'.

In their study, Autolitano and Pawlowska (2011) state that 'Gaia-X represents one example of the concrete materialisation of the European Union's quest for digital sovereignty'. They provide an overview of Gaia-X and other previous initiatives in Germany and France aimed at the creation of sovereign clouds, such as Andromede (France) and Bundescloud (Germany). Autolitano and Pawlowska highlight that both previous initiatives had limited success due to their limited understanding of the market needs, as well as the difficulty to compete with the hyperscalers (large cloud service providers) offerings and capabilities. They also note that Gaia-X initiative may not provide wanted European alternative to the current hyperscalers in terms of European cloud infrastructure. This is mainly due to Gaia-X's 'peculiar structure of not being a monolithic, proprietary platform but a transparent cloud ecosystem', making it more difficult to provide services and capabilities that are offered by the large hyperscalers' coherent clouds. Autolitano and Pawlowska also note that Europe seems to lack financial resources available to global hyperscalers to be able to compete directly. Autolitano and Pawlowska propose that Europe focuses on its add value in terms of 'regulatory superpower' by building 'the trust framework for cloud services willing to operate in Europe by setting the highest standards for privacy and security', hence not attempting to build cloud infrastructure itself but provide standards in which the cloud service providers have to operate.
Autolitano and Pawlowska case study provides a good overview of the situation and highlights the potential issues with Gaia-X and warn of a possibility of Gaia-X failing. They also provide suggestions in terms of the future focus and development, however, their paper does not evaluate and prove the phenomenon using data and econometrics methods, the gap that will be addresses in this paper.

Gaia-X is offered as a federated cloud ecosystem, rather than being a monolithic, proprietary platform. Monolithic, proprietary platforms are already available for consumption by foreign (i.e., USA) cloud solution providers and are more fit for the use by businesses. The USA originated hyperscalers have been developing and perfecting cloud computing services over the years, driven by the need for cloud computing in their own country. The USA has been dominating cloud computing space by being one of the early adopters of cloud computing, having the greatest cloud computing revenues normalised for GDP out of all countries globally (Karamujic, 2025). When compared to the

USA hyperscalers, which are now also well established in the global market and the EU with extensive offerings and competitive pricing, the EU cloud computing providers such as Gaia-X will find it difficult to compete and stay competitive in terms of adequate cloud infrastructure offerings and attractive price. This notion is in support of the network effects economic theory (Katz & Shapiro, 1985), which rationalises that the existing and established cloud infrastructure providers have an advantage over the new entrants such as Gaia-X. Katz and Shapiro state that ‘there are many products for which the utility that a user derives from consumption of the good increases with the number of other agents consuming the good’. Liebowitz and Margolis (1994) additionally suggest that ‘the utility that the user derives from the good increases with the number of other users on the same network’, where the network can be referred to as cloud computing infrastructure. The existing hyperscalers have extensive offerings and competitive pricing making them very attractive to the users (both business and individual/consumer), who in turn use their offerings further, allowing the hyperscalers to further extend their offerings and reduce their pricing, hence making them even more attractive to users and creating so called network effect cycle. As per network effects theory, breaking network effect cycles requires clear strategies by the new entrants, focused around offering unique value propositions, that would make them retain the existing and attract new users (McIntyre & Srinivas, 2016). European policy information centre (EpiCenter) published an article in 2020 criticising Gaia-X of being more politically motivated initiative rather than being economically and financially advantageous to the EU businesses. EpiCenter also notes that the current incumbents, being the non-EU hyperscalers, have significant economies of scale advantages, which combined with high fixed costs to develop successful cloud operation, are making it very unlikely for the European cloud to successfully compete against. EpiCenter also notes that the objective of creating the European cloud is ‘protectionist since it implies opposition to specialization and globalization’. Niebel, Reibers and Kraemer (2022) note that the main benefit of Gaia-X should be towards SMEs[35], Small to Medium companies in Europe, being the main driver of European economy with 99% of

[35] SMEs in EU (as per European Commission classification) are companies with less than 250 employees and a maximum turnover of less than 50M Euros.

companies classified in this segment. They note that Gaia-X is aiming to address insufficient uptake of cloud computing by SMEs in Europe by giving SMEs access to alternative cloud computing solutions. Lack of cloud computing uptake by SMEs is problematic due the lack of their participation in digital economy, which was previously noted as increasingly important.

The EU focus on initiatives such as Gaia-X and cloud computing may encourage the use by European businesses (irrespective if they use Gaia-X or an alternative foreign cloud provider). As previously noted by Autolitano and Pawlowska (2021), Europe's focus on cloud computing 'by setting the highest standards for privacy and security', may result in increase of not necessarily the use of the EU cloud, but cloud computing use by European businesses in general.

To test if Gaia-X fosters cloud computing adoption by European businesses, the following proposition has been developed:

Hypothesis: Gaia-X results in an increase of cloud computing use by European businesses.[36]

To test the above hypothesis, the statistical tests for structural beaks or changes have been applied, assessing if Gaia-X as an exogenous shock impacts cloud computing use over time. Additionally, a panel of 41 experts on businesses cloud computing use were surveyed to provide further insights and confirm or otherwise the results of the statistical tests. The approach and the analysis are further described in Data and Method section.

[36] Based on the literature review and self-impression, it is likely that the above hypothesis will be rejected.

4.3 Data and Method

4.3.1 Data

4.3.1.1 Use of Cloud Computing Services in enterprises

Eurostat records the data on the use of cloud computing service in enterprises in Europe in the period from 2014 until 2023[37] (with 2019 and 2022 data missing). The data is based on the results of surveying 148,000 of EU enterprises with at least 10 employees in the EU NACE[38] classification (out of 1.5 million enterprises in this classification in the EU in 2021) including Small-Enterprises (10-49 employees comprising 83% of the data sample), Medium Enterprises (50-249 employees comprising 14% of the data sample) and Large Enterprises (250 or more employees comprising 3% of the sample). The data is expressed as a percentage of enterprises in the NACE sectors (defined earlier in the footnote 4) using cloud computing services. It covers all cloud services being Infrastructure as a Service, Platform as a Service and Software as a Service for all enterprises with 10 employees or more (Source: Eurostat). The data is available for all 27 EU countries in a panel format, per country, per year.

The Table 3.1 and Graph 3.1 below show yearly average percentages of the EU enterprises using cloud computing services and are shown for illustrative purpose only. The actual panel data is used in the analysis.

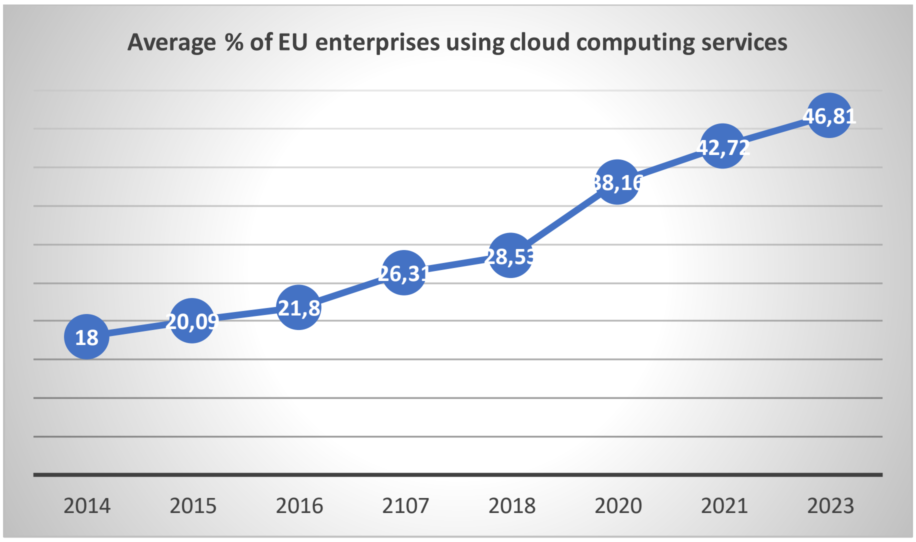
Table 3.1: Average % of EU enterprises using cloud computing services

Year	*2014*	*2015*	*2016*	*2017*	*2018*	*2020*	*2021*	*2023*
Average % EU enterprises using cloud computing	*18.00*	*20.09*	*21.80*	*26.31*	*28.53*	*38.16*	*42.72*	*46.81*

[37] The data for 2024 not available at the time of writing this article, May 2025

[38] NACE sectors covers are manufacturing, electricity, gas and steam, water supply, construction, wholesale and retail trades, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, information and communication, real estate, professional, scientific and technical activities, administrative and support activities, and the repair of computers and communication equipment.

Graph 3.1: Average % of EU enterprises using cloud computing services



4.3.2 Method

4.3.2.1 Panel analysis – Bai & Perron tests for structural breaks

Testing for structuctural beaks or changes has been widely used when looking at what impact economic or political factors (exogenous shocks) may have on certain variables over time. Bai & Perron (1998) offer the standand framework for structural breaks, with the researchers such as Karavias, Westerlund et al. (2021), and others applying Bai and Parron tests for strucural breaks on panel data (longitudinal data sets).

Using the panel data on the use of cloud computing services in enterprises in Europe in the period 2014 to 2023, Bai & Perron econometric tests for structural breaks (Stata, 2021, co-authored by Ditzen, Karavias & Westerlund) were appiled to test if the use of cloud computing services by the EU enterprises per country changes at any point in time during the period 2014 to 2023. If there is an impact of Gaia-X introduction, one would expect to see a significant increase in the cloud computing use by the EU enterprises in 2022, when Gaia-X was in its full implementation, adaption and growth. To test this, the null hypothesis of no breaks versus the alternative hypothesis of 's' number of breaks are performed, using Stata's 'xtbreak' function for multiple structural breaks at unknown point in time. In Model 1, it is tested if there is one most significant break in the time period 2014 to 2023 that could have impacted cloud computing adoption by the EU. In this time period there were other significant events besides Gaia-X introduction such as GDPR introduction and Covid-19 outbreak that would have significantly impacted cloud computing use by the EU enterprises. GDPR was introduced in 2016, with the EU wide implementation taking place by the middle of 2018. Covid-19 outbreak started in 2019, spreading over the years to come, with the possible greatest impact on the cloud computing adoption in 2020 (Alashhhab et al., 2021). Hence, to test if there are multiple breaks in the data, the 's' value of the number of breaks is increased to three in Model 2; four in Model 3; six and seven in Models 4 and 5 respectively. As noted earlier, Gaia-X would have been expected to have the greatest impact on cloud computing adoption in 2022, hence the break in 2022 could indicate potential impact of Gaia-X introduction on cloud computing adoption by the EU Enterprises.

The data on cloud computing use by EU enterprises is organized in a panel format per country for all 27 EU countries, per year for the period from 2014 to 2023. Since the structural breaks tests require a fully balaned panel, the missing data points were estimated by averaging of the two neighbouring values. For example, if 2015 data for a specific country was missing, it was estimated to be an average of 2014 and 2016 data points. Similar applies for the years 2019 and 2022, for which the original data was not available.

4.3.2.2 Panel of experts

The proposition of this research was furthermore tested by a panel of experts, IT professionals such as CTIOs[39], IT Directors or Lead Enterprise Architects working in the EU enterprises and having a direct responsibility for the decisions related to cloud computing infrastructure use and applications. The experts were sourced from the businesses operating in various industries such as information and (tele)communications, energy, transport, banking, consulting services and others, and across many countries in Europe (Austria, Croatia, Czech Republic, France, Germany, Italy, Netherlands, *Norway*[40], Poland, Portugal, Romania, Slovakia, Spain, Sweden, *Switzerland*), hence making it a diverse and representative sample across European businesses. The experts were approached to answer an on-line survey[41] with the list of questions noted in the Table 3.2 below.

[39] CTIO - Chief Technology and Information Officer

[40] Few participants from Norway and Switzerland were also contacted (unclear if they answered the survey or not). Those are highly technologically developed countries and businesses in those countries typically behave in a very similar way to the EU businesses.

[41] SurveyMonkey (https://www.surveymonkey.com/) surveying tool used to conduct the survey of the panel of experts.

Table 3.2: Survey questions

#	*Description*	*How to Answer*
1	Are you already aware of Gaia-X initiative (public cloud computing infrastructure ‘made in Europe’)? https://gaia-x.eu/	Please answer either Yes or No.
2	Does your business opt for alternative (foreign) public infrastructure providers (i.e., hyperscalers) or for the EU Gaia-X alternative?	Please answer either Foreign or EU.
3	Did Gaia-X in any way positively affect your business's use of cloud computing infrastructure? (even though you may or may not be using Gaia-X infrastructure itself)	Please answer either Yes or No. If yes, please specify how.
4	What is the most important for your business when selecting cloud computing infrastructure provider: a. Price/Cost b. Offerings (current solutions available) c. Innovation capability (ability to offer new solutions) d. European Data Protection e. Openness and transparency f. Authenticity and Trust g. Digital Sovereignty and Self-determination h. Free Market Access and European Value Creation i. Modularity and Interoperability j. User-Friendliness k. Reliability (performance of the cloud infrastructure)	Please select top 3
5	What is the least important for your business when selecting cloud computing infrastructure provider: a. Price/Cost b. Offerings (current solutions available) c. Innovation Capability (ability to offer new solutions) d. European Data Protection e. Openness and Transparency f. Authenticity and Trust g. Digital Sovereignty and Self-Determination h. Free Market Access and European Value Creation i. Modularity and Interoperability j. User-Friendliness k. Reliability (performance of the cloud infrastructure)	Please select least 3
6	Would you prefer to stay anonymous or is it OK that your name is referenced to in the research?	Please answer either Anonymous or Referenced. If referenced, please write your name.

The survey question one is of informative nature with the purpose of getting a perspective on how many of the participants are aware of Gaia-X. Considering it is a major initiative in the EU, one would expect majority of businesses to be at latest aware of it.

The survey question two is used to confirm the Synergy Research Group findings and a general assumption that EU businesses opt for alternative (foreign) public infrastructure providers instead of opting for the EU Gaia-X alternative.

The survey question three is directly linked to the main Hypothesis posed in this research being ‘*Gaia-X results in an increase of cloud computing use by European businesses’* by asking the participants if Gaia-X in any way positively affects their business's use of cloud computing infrastructure (even though they may or may not be using Gaia-X infrastructure itself).

The survey questions four and five are aimed to further support or otherwise the Hypothesis posed, by searching deeper into how European businesses make their cloud computing decisions. The survey question four asks the participants to choose the three (3) most important principles on which they choose a cloud computing infrastructure, while the survey question five asks the participants to choose the three least important (3) principles on which they choose a cloud computing infrastructure. The list presented to the survey participants to choose from consists of the total of eleven (11) principles. Seven (7) of those are the guiding principles (Baenfer, Buehler, Moeller & Svensson, 2021) on which Gaia-X is developed as explained in the introduction, referring to the survey questions d to j. Four (4) additional principles such as Price/Cost, Offerings (current solutions available), Innovation Capability (future offerings/ability to offer new solutions) and Reliability, as noted in the introduction, are in various literature identified as the main advantages to businesses of using cloud computing. Those additional principles are not noted under Gaia-X main principles, and are added to the survey questions a-c and k. Asking the experts to prioritise and choose the principles, will verify if Gaia-X and its principles really appeals to European businesses cloud computing decision makers or if there are important decision-making principles omitted (such as four additional principles), hence possibly a reason as to why Gaia-X may not be successful.

Sending online surveys to the targeted population, using personal relationships/contacts, as well as pre-contacting participants will result in an average online survey response rate of 44.1% and is much more effective than simply sending it to more participants (Wu, Zhao & Fils-Aime, 2022; CustomerThermometer, 2023). The sourcing of the experts in this online survey was a combination of using the existing network of contacts developed over the years of business interactions, hence benefiting the networking effects by reaching the contacts of the contacts, as well as sourcing the experts via LinkedIn, targeting the population that fit the profile (IT professionals with direct responsibility for cloud computing decisions). From 90 IT professionals whom the survey was circulated to, 41 answered and provided their input, resulting with 45.6% success rate.

4.4 Results

4.4.1 Panel Analysis

To identify if Gaia-X had an affect on the cloud computing use by the EU businesses, as previously explained, Bai & Perron econometric tests for structural break were applied (Stata, 2021).

Below Table 3.3 shows the results of the structural breaks tests using the data on the cloud computing used by the enteprises in all 27 EU countries.

Table 3.3: Bai & Perron test for multipe breaks in cloud computing use by European enterprises.

Model 1: # of breaks 1 (Ho: no breaks & H1: 1 break)	Model 2: # of breaks 3 (Ho: no breaks & H1: 3 breaks)	Model 3: # of breaks 4 (Ho: no breaks & H1: 4 break)	Model 4: # of breaks 6 (Ho: no breaks & H1: 6 break)	Model 5: # of breaks 7 (Ho: no breaks & H1: 7 break)
Estimated Break: 2018 Test Statistics: 188.66 1% critical value: 13.00 5% critical value: 9.10 10% critical value: 7.42 Trimming: 0.1 The test statistics (188.66) is much larger than critical values at 1%, 5% and 10% significance. Hence, Ho of no breaks can be rejected. There is a structural break in 2018.	Estimated Breaks: 2016 2018 2020 Test Statistics: 66.67 1% critical value: 8.42 5% critical value: 6.84 10% critical value: 6.09 Trimming: 0.1 The test statistics (66.67) is still much larger than critical values at 1%, 5% and 10% significance. Hence, Ho of no breaks can be rejected. There are 3 structural breaks, in 2016, 2018 and 2020.	Estimated Break: 2016 2018 2020 2021 Test Statistics: 39.98 1% critical value: 7.31 5% critical value: 6.03 10% critical value: 5.44 Trimming: 0.1 The test statistics (39.98) is larger than critical values at 1%, 5% and 10% significance. Hence, Ho of no breaks can be rejected. There are 4 structural breaks, in 2016, 2018, 2020 and 2021.	Estimated Break: 2016 2018 2019 2020 2021 2022 Test Statistics: 12.59 1% critical value: 5.74 5% critical value: 4.80 10% critical value: 4.32 Trimming: 0.1 The test statistics (12.59) is still larger than critical values at 1%, 5% and 10% significance. Hence, Ho of no breaks can be rejected. There are 6 structural breaks, in 2016, 2018, 2019, 2020, 2021 and 2022.	Estimated Break: 2015 2016 2018 2019 2020 2021 2022 Test Statistics: 4.35 1% critical value: 5.05 5% critical value: 4.23 10% critical value: 3.83 Trimming: 0.1 The test statistics (4.35) is smaller than the critical value at 1%. Hence, Ho of no breaks, can not be rejected at 1% confidence and it is also very close to 5% confidence value.

The Table 3.3 indicates that there are significant breaks in the data using ‘xtbreak’ Stata command. Trimming value is set to 0.1, instead of the standard 0.15, hence reducing the trimming of the data set at the start and at the end to 10% instead of the standard 15% to allow for detecting the break in 2022. As can be seen in the Model 1, when only one break is allowed in the period tested (2014-2023), 2018 is found to be the most significant structural break. This means that in 2018 there were the most significant changes in cloud computiong adoption by the EU enterprises. As previously suggested, the break in 2018 occurs most likely due the General Data Protection Regulation (GDPR) being set in the middle of 2018 as the binding European regulation by which all EU companies had to comply with.

By the introduction of GDPR, the cloud computing providers had to comply with a number of principles related to increased data protection and transparency, hence possibly increasing the trust by the EU enterprises in the use of cloud computing (Lynn et al., 2021). Hence, Model 1 does not uncover yet the possible impacts of Gaia-X on the cloud computing adoption in the EU, since if that was the case we would have expected the most significant break to occur in 2022 as expalined earlier. Considering a very large value ot the test statistics in the Model 1 (188.66), the next test, in the Model 2, is increased to searcing for three breaks in the data. In the Model 2, we observe two additional years appear as significant, 2016 and 2020. 2016 is the year of GDPR introduction, hence there could have been some anticipation impact by the EU enterprises in the potential impact of GDPR on cloud computing adoption. 2020, as previously noted, was the year in which Covid-19 had the most impact on cloud computing use by the enterprises worldwide, hence in the EU too. Hence, Model 2 still does not uncover us the possible impacts of Gaia-X on the cloud computing adoption in the EU. In the Model 3, where four breaks are being searched for, one additional year appears as significant, being 2021. This test uncovers that in 2021 also was also a significant change in cloud computing adoption by the EU enterprises, on the top of 2016, 2018 and 2020. 2021 break could be explained by futher significant impact of Covid-19 outbreak on the European businesses. There could have been some anticipation impact of Gaia-X in 2021 too, since it was when Gaia-X Association was formed with the first companies joining it. However, it is not conclusive and difficult to isolate the impact of Gaia-X on 2021 break. Since the test statistics is still large in Model 3 (39.98) with four breaks, the next test in Model 4 is increased to searcing for six breaks in the data. In the Model 4, the breaks in two additional years, being 2019 and 2022, are found. The test statistics of 12.59 is still significant at 1% level, hence the null hypothesis of no breaks can be rejected and the years 2016, 2018, 2019, 2020, 2021 and 2022 are all significant break years. As noted before, if Gaia-X was impacting cloud computing in the EU enterprises, we would have expected the break in 2022, which is confirmed by the Model 4. While the test statistics in Model 4 is still large, an additional test in Model 5 is performed, testing for 7 breaks in the data. Model 5 test statistics of 4.35 rejects the null hypothesis at 1% confidence level, with also very close value to the 5% confidence, hence we stop with further testing and note the Model 4 as the last significant test result.

Based on the structrual break tests on the data in the period 2014 to 2023, we find the breaks in six years, showing likely impacts of events such as GDPR introduction and COVID-19 outbreak on the cloud computing use by the European enterprises. It could be said that Gaia-X introduction also impacted the cloud computing adoptions by European businesses, since the year 2022 was also found to be a significant break in the data. It is difficult to argue singular impact of Gaia-X, since the impact may have also been compounded by the other events.

To test the hypothesis further, the panel of experts was approached to provide additional insights if Gaia-X affected cloud computing adoption by the EU enterprises.

4.4.2 Panel of experts

Based on the feedback from the panel of 41 experts, European IT professionals involved in the decision making of cloud computing use by their respective businesses, the following was found:

- Majority (61%) of them were aware of Gaia-X initiative.
- Almost all (91%) opt to use foreign public cloud computing infrastructure providers, rather than the EU Gaia-X alternative.
- Large majority (87%) of the EU businesses do not find Gaia-X positively affecting (increasing) their business's use of cloud computing infrastructure, hence do not support the hypothesis posed in this research.
- The top three most important principles for the EU businesses when making cloud computing infrastructure decisions are Price/Cost (80%[42]), Offerings (current solutions available) (54%) and Reliability (performance of the cloud) (59%).
- The least three important principles for the EU businesses when making cloud computing infrastructure decision are Free Market Access and European Value Creation (61%[43]), User-Friendliness (49%) and Digital Sovereignty (34%).
- Most of participants (81%) choose to remain anonymous.

[42] % of the sample population that finds the principle most important
[43] % of the sample population that finds the principle least important

It is interesting to observe that none of the top three principles chosen by European businesses are Gaia-X principles, but rather the general principles which businesses perceive as the main advantages of cloud computing use being Price[44] of the cloud services; Offerings available on the cloud and Reliability of the cloud services. Gaia-X principles are hence all ranked lower in the importance by European businesses cloud computing decision makers. It does not mean they are not important at all, however, are less important than Price, Offerings and Reliability.

4.5 Discussion, Contribution and Conclusions

Using the panel data on the use of cloud computing services in enterprises in Europe in the period 2014 to 2023, it was found that there were a number of significant events (breaks) that would have affected cloud computing use by the European businesses. Gaia-X could have been one of those events, however the data is not fully conclusive to come to such a decision. There were other significant events such as GDPR introduction and Covid-19 outbreak that would have had possibly even greater impact. Surveying the panel of experts, IT professionals responsible for cloud computing decisions in their companies, it was found that European businesses opt to use foreign cloud computing providers and do not find Gaia-X positively affecting their business's use of cloud computing. None of the Gaia-X guiding principles made their top three priorities when selecting cloud computing infrastructure. To European businesses, Price/Cost, Offerings and Reliability of the cloud are the most important priorities, which are not Gaia-X guiding priorities (principles). Gaia-X seems to neglect European businesses top priorities when choosing cloud computing infrastructure, hence creating a clear disconnect between what is important for businesses and what Gaia-X aims to address. As previously noted by the European policy information centre (EpiCenter), Gaia-X seems to be more politically motivated initiative rather than being economically/financially advantageous to the EU businesses. Network effects theory highlights that a network such as cloud computing infrastructure creates value by having more users on it, and to achieve that, it needs to offer unique value propositions to its users, that are aligned to their business objectives. Gaia-X seem not to have achieved that as of yet.

[44] Referring to cloud computing services being offered at lower price/cost for businesses

Additionally, Gaia-X developed from being a monolithic infrastructure to a federated cloud, difficult to implement and compete in the market with the existing hyperscale's, both from the price and features and functionalities perspectives. In the meantime, the hyperscalers adopted their offerings to fit developing European regulatory standards, hence making it continually difficult for Gaia-X and other European cloud infrastructure providers to justify their add-value and with that to encourage European business to use it actively and proactively.

Furthermore, the EU with Gaia-X was a late entrant to the cloud computing infrastructure market in comparison to the USA companies, hence as such having a competitive disadvantage. Additionally, the EU governance and structure and decision-making processes are much more segmented and decentralized compared to the USA and China for example. Becoming a significant cloud computing infrastructure player also requires a significant investment and commitment on a global scale, which the USA and Chinese companies (supported by their governments) undertook. By contrast, we saw the EU attempting to become a cloud infrastructure provider, and at the end reverting towards a 'concept' and federated set up, likely more cost efficient, however much more difficult to implement and compete with in the market. Crescenzi, R., Rodríguez-Pose, A. and Storper, M. (2007) look at the territorial dynamics of innovation and compare the USA to the EU. They find that the imperfect market integration in the EU, as well as institutional and cultural barriers across the continent compared to the economically and culturally integrated USA market are some of the more significant differences and barriers to the EU technological innovation capacity. The USA integrated market[45] is able to more rapidly respond to the change in technological trends and mobilise its capital, both monetary and human, when compared to an imperfectly integrated EU market. Crescenzi, R., Rodríguez-Pose, A. and Storper, M. also point out that the USA and the EU differ significantly in 'the institutions and policies governing the invention, development and adoption of new technologies'. In the USA there exists a nation-wide 'national system of innovation' which is characterised by 'consistent innovation policies with large-scale federally funded projects'. Unfortunately, the EU innovation system is still fragmented, focused on small-scale projects and highly bureaucratic

[45] Similar to the USA, Chinese market is also (and even more) highly integrated, where we also observe significant technological invention in general and in cloud computing infrastructure in particular.

government policies. Sharif (2012) analysed national technological innovation governance policies in Japan and South Korea, and found there are a number of pillars on which technological innovation governance policy needs to be grounded on, some of them being stronger public-private partnership for specialization in targeted technology areas, strong research university incubator and prioritised technological innovation project funding.

The failings of Gaia-X to establish itself as a dominant cloud infrastructure provider, can be reflected in the findings from the above-mentioned papers. Lack of market integration in the EU, hence fragmented innovation system and divergent views from the EU member states, resulting in unclear direction and governance of the EU driven initiatives, can be seen in Gaia-X. Additionally, even though only on the assumption level[46], it can be suspected that due to the lack of coherency in the EU market, there is also lack of prioritised funding for the EU technological initiatives, causing those initiatives to fall behind in comparison to the more coherent market initiatives such as the USA initiatives.

In this research, we do not conclude that Gaia-X did not make any impact. It probably had some effect on the cloud computing use by the European enterprises, however, an initiative with a better fit to the businesses' priorities may have had a better success. The initiatives that foster cloud computing use by the European businesses are highly relevant, and in the current times of increased geopolitical tensions even more important. Many businesses are considering multi-cloud strategies to reduce their dependence on any single cloud computing provider, and the EU still has a chance to support European business in their ambitions by focusing on what is really important to them.

4.5.1 Contributions

Up to date, there is limited academic research done on Gaia-X initiative and its impact on the EU businesses, the gaps that are aimed to be addressed in this paper. This paper appears to be the first paper that proves that Gaia-X initiative, as an example of the EU technological initiative, that may have not yet performed as expected in encouraging cloud computing adoption by the EU businesses. Previous papers on Gaia-X were predominantly case studies without a significant statistical analysis.

[46] Since no funding information for Gaia-X is available

Additionally, this paper also identifies the possible reasons as to why is it the case that Gaia-x has not been as successful in encouraging cloud computing adoption by the EU businesses. Those reasons could be incorporated as improvements in Gaia-X future development, as well as incorporated in similar technology initiatives in the future.

4.5.2 Practical Implications

Looking at the cloud computing adoption and digitalisation in general, the USA as a market has been at the forefront with most of hyperscalers coming from the USA. When compared to the hyperscaler services, Gaia-X infrastructure services are challenging to maintain at the same or higher value and lower costs, hence most of the businesses opt for foreign providers. European businesses may opt for the European alternatives if and when available, nonetheless those need to be compatible with the foreign options available. It is unlikely European businesses would choose the European providers, just because they are European and without other business benefits being identified.

The EU has a specific set of drivers and limitations, which when compared to the USA (and some Asian countries such as Japan, South Korean and China) are seen as limiting factors for the EU to be a significant driver of digital economy technological inventions and initiatives, hence as such become 'the most dynamic and knowledge-based economy in the world' as inspired by the European Council. This paper shows that those limiting factors are still very present and need to be seriously taken into consideration when devising technological innovation initiatives in the EU. In the latest EU digital strategy, being '2030 Digital Compass: the European way for the Digital Decade' some of the mentioned limiting factors are being recognised. 2030 Digital compass refers to the need that the large technological projects require 'critical mass of funding and alignment of all the actors' and the EU has called 'for further strengthening synergies between the use of the EU and national funds' for such projects. This is a positive sign, however the implementation of it is still to be observed in practice.

4.5.3 Limitations

The panel data set on the use of cloud computing services in enterprises in Europe is available in the period 2014 to 2023. The data for 2024 available only for few EU countries, hence could not be used in this research at this stage. One could argue that Gaia-X needs more time to show its full effects since it was only initiated end of 2019, with the full implementation in 2021 and adoption expected in 2022 and onwards. However, considering the shortcomings noted in this research, it is unlikely Gaia-X will take a full effect unless its shortcomings are overcome successfully.

The panel of experts consists of 41 respondents, IT professionals across the industries and countries in Europe, maybe seen as somewhat small considering the total population being much larger (hard to exactly estimate though).

5.Concluding remarks

My research provides important contributions to both practitioners and researchers. It shows that national institutions, both formal and informal, matter when it comes to the adoption of technology such as cloud computing. It supports the neo-institutional theory in which national institutions are positioned as very important in structuring political, economic and social interactions.

Both, businesses and governments, will benefit from understanding the differences and determinants of the cloud computing adaption, in that they can better shape their policies and adjust their strategies. Both, businesses and governments need to take an active role in understanding institutional environments in which they operate in order to foster adoption of technology such as cloud computing. The institutional approach is a novel approach to researching technology adoption across-countries and warrants further research.

The first paper has generic relevance, since the research data is based on 38 countries globally for which cloud computing revenues were available and compared to 41 countries with mobile broadband revenues. The second and third papers focus more on the EU, which is below its ambition of cloud computing adoption. As noted in its digital strategy, ’2030 Digital Compass: the European way for the Digital Decade’, EU aims to have 75% of its enterprises take cloud computing services by 2030. 2023 data indicates that just below 47% of the EU Business are using cloud computing services, with a trend that was increasing over the years. The EU still has a significant gap to bridge in order to meet its 2030 ambition, hence the finding of this research seem relevant and timely. Improvement in a country’s governance quality or ‘good governance’, as well as aligning its initiatives such as Gaia-X better to the EU businesses objectives are some of the actions this research finds relevant for the EU to foster cloud computing adoption.

My research shows that the impact of national institutions is stronger on cloud computing as a business-oriented technology, than it is on mobile broadband as a consumer-oriented technology. Beside its relevance to cloud computing, similar findings to those noted in this research could also be applicable for other upcoming technologies such as Artificial Intelligence and Robotics, which are also perceived as business-oriented technologies. Those technologies were not in focus of this research, but are interesting next research topics and very relevant for the future and growth of the economies. This research also points to some of the limiting factors for the EU to be a significant driver of digital economy technological inventions and initiatives (as aspired by the EU Council). Lack of market integration in the EU, hence fragmented innovation system and divergent views from the EU member states, results in unclear direction and governance of the EU driven initiatives. Lack of coherency in the EU market, with a lack of prioritised funding for the EU technological initiatives, causes those initiatives to fall behind in comparison to the more coherent market initiatives such as the USA initiatives. Those are some additional pointers for the EU to take into consideration when attempting to encourage technology adoption in the member states.

When it come to the limitations, there are several other aspects and parameters that may be considered relevant, however are omitted and are not in focus of this study. The focus of this study is on the impact of selected national institutions. The national institutions were selected mainly from the perspective of cloud computing, i.e., the institutions found to be relevant in explaining cloud computing adoption in a country. There could be other national (formal) institutions better reflecting mobile broadband impact; however, that was not the focus of this study. The focus was on cloud computing adoption, and mobile broadband was selected only as comparative technology to test if those two different types of technology differ in their adoption processes when taken from the institutional perspective. As noted in paper one, some scholars (such as Dobbin, 1994) suggest that formal institutions are developed to formalize informal institutions. Hence, there could be some indirect relationships between the variables which have also not been explored so far. This could also be a topic for a further study.

As noted earlier, the results of paper two should only be used in the context of the EU. It would be interesting to conduct similar research on a wider geography, however Eurostat only records the use of cloud computing services in the EU enterprises, and no similar data is available on a wider data sample. Additionally, there are also other aspects and parameters that may be considered relevant for cloud computing adoption; however, they are omitted and are not in focus of this study. The focus is on the institutions echoed in government governance as previously explained.

One could also argue that Gaia-X needs more time to show its full effects. The paper identifies the possible reasons as to why it is that Gaia-X was not successful, which could be incorporated as improvements in Gaia-X future development, as well as incorporated in similar future technology initiatives. However, without a consideration of shortcomings and implementation of improvements, it is unlikely that Gaia-X will have a significant impact on the use of cloud computing services in the EU businesses. In general, governments, when implementing initiatives aimed at fostering technology adoption such as cloud computing, need to make sure that those initiatives align to the businesses' goals, otherwise they run a risk of non-acceptance and low adoption by the business communities.

In recent times, many companies are considering multi-cloud strategies. Multi-cloud refers to using more than one cloud computing service provider simultaneously, hence avoiding relying on a single cloud vendor (Oracle, 2025). This is additionally fueled by the recent geopolitical instability, hence possibly creating an additional opportunity for the initiatives such as Gaia-X to be considered as an alternative for the EU businesses. The topic of multi-cloud strategies considerations and its impacts was not addressed in this research and could be an interesting topic of further research.

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Appendices

Cloud computing definitions

Cloud computing and virtualizations are the terms frequently used together. Put simply, virtualization refers to a separation of hardware and software. What was previously proprietary hardware is being replaced by commonly available hardware and is being used by multiple software applications. Those so-called virtual machines are creating significant benefits to organizations in terms of cost reduction of hardware. When organizations decide to take virtual machines into cloud, hence those can be used on demand without direct management by the user and are provided by so called cloud providers, this is referred to as cloud computing.

Cloud computing allows firms, regardless of their size, to access world-class IT services on demand (Vithayathil, 2017). ‘Cloud computing is captured by the characteristics of on-demand computing and storage, with shared resources between multiple customers’ (Vithayathil, 2017:1).

The cloud computing can be provided via different *cloud environments* being public, private and hybrid (Mell and Grace, 2011). In *public* clouds, external organizations referred to as cloud providers, provide cloud computing services towards various organizations globally. Cloud providers provide those services to multiple organizations hence create economies of scale, allowing them to provide those services at lower costs. Services are provided via internet. In *private* clouds, parts of large organizations provide cloud computing services centrally to others in their organization. There is similar centralization logic as with public clouds, just that in the case of private clouds, the cloud services are provided internally within an organization typically via their intranet (not publicly via internet). In *hybrid* clouds, an organization chooses to provide some services internally via private clouds (typically critical services) and some via public clouds (typically non-critical services).

Cloud computing services can be split into three main *cloud categories* (Mell and Grace, 2011)*; Infrastructure-as-a-Service (IaaS)* refers to providing hardware and IT resources on demand; *Software-as-a-Service (SaaS)* refers to providing software on demand, and *Platform-as-a-Service (PaaS)* refers to providing hardware and software tools over the internet, hence those tools are typically used to develop applications and test software.

Cloud computing benefits

Affordability is one of the cost benefits of cloud computing. Cloud solutions are typically charged on pay-as-you use basis. In this way, businesses manage their spent more effectively and only pay for what they need and use. *Efficiency* is another cost benefit of using cloud since it allows businesses to avoid high initial set up costs that would be required if they were providing the technology solutions themselves. Additionally, businesses are able to reduce costs previously present in the organization by outsourcing certain tasks and services. Note: this is seen as a benefit to the organization; however, it is perceived as increased uncertainty and risk to the employee's job security. *Scalability* is also a cost benefit of cloud computing. The need for more or less of a certain type of service can be easily scaled using cloud solutions, hence ensuring the optimal use of the available capital in a company. *Reliability* is a performance-based benefit of cloud computing. Cloud solutions are typically provided by large, reputable firms, with strong brands with 24x7 service guarantees such as Amazon, Google and IBM.

Cloud computing risks/disadvantages

One of the most referred to risks associated with cloud computing is *Security*. A business using cloud computing solutions entrusts its data to a cloud solution provider, hence the need to have a high level of trust in that provider. Security concerns are tightly linked to *Legislative issues*, which have become a more frequent concern in recent years, particulary in Europe where the data protection regulations have been strengthened. Within the European Union (EU), there are regulations restricting personal data leaving EU boundaries, and in some cases a country's boundaries too. Putting company data into a cloud increases the risk of potential data protection regulation violations, which companies are very apprehension about. Outsourcing of services is also often associated with a *Loss of Control*. In some cases, managers lose a significant amount of business they used to control, hence creating certain internal resistance to cloud computing. A new and growing concern is the *dependence on a few public cloud computing providers* which gives rise to new regulations and initiatives by governments to protect their businesses from such dependence

Mobile Broadband Definition. benefits and risks/disadvantages

With mobile broadband, consumers get access to the 'pipe' and decide how to use it. Mobile broadband is not to be confused with fixed broadband or IT Infrastructure availability in general. The main benefit of mobile broadband service is considered to be *convenience/flexibility*. Mobile broadband extends the benefits of mobility to internet/data services, which historically were only consumed at a home or at a workplace. On the other hand, *cost* is considered the main disadvantage(risk) of mobile broadband. Convenience/flexibility comes at a price, hence mobile broadband services are more expensive than fixed broadband services (available at home/office), even though the price has been dropping over time.

Table A1: Hofstede's national culture model parameters/dimensions

Six Dimensions of the Culture from Hofstede Model in relation to possible impact to technology adoption	
Power distance	Measures the extent to which the less powerful members of the society accept and expect the power to be distributed unequally. Scores 0-100. Higher the score, larger power distance in a country/society exist. European countries typically have low PDI values. In High PDI countries, innovations and technology only come about if supported by hierarchy, which is not the case in low PDI countries. PDI has correlation to IDV (Individualism). Low PDI relates to High IDV.
Individualism	The degree to which individuals are integrated into groups. Individualism refers to loose ties between people, while Collectivism (on opposite scale) refers to strong ties. Low IDV countries give importance to the relationships, while High IDV countries give importance to tasks. Low IDV countries also give importance to provisions by company such as training, and job security. Scores 0-100. Higher the score more individualist country/society. European countries typically have high IDV values. Also, richer countries have higher IDV.
Masculinity	The distribution of roles between genders, in terms of what is expected of males versus females. Low MAS countries (hence Feminine) typically balance work-life and value job security and friendly work atmosphere as opposed to High MAS countries. In High MAS countries work is 'prioritized' over family. Scores 0-100. Higher the score greater Masculinity in country/society exist. Japan is on the top of the scale. European countries have many countries in low MAS; however, there are countries in higher range e.g. Italy.
Uncertainty avoidance	A society's tolerance for uncertainly and ambiguity: The degree to which the members of the society feel threatened by unknown and ambiguous situations. It is compiled on the basis of Rule Orientation, Employment Stability and Stress. Typically, low UAI may indicate greater acceptance to change (including technological change) and more advanced modernization and the change is done quicker (when compared to high UAI countries). In low UAI societies, uncertainty and change is accepted as a normal way of life, while in high UAI uncertainly is to be avoided and considered to be dangerous. Job change is also avoided in high UAI societies. Probably most relevant indicator for this study.

	Score: 0-100. Higher the score more uncertainly avoidant country/society. Russian and Japan on the top end. European countries have many countries in low UAI; however, there are countries in higher/mid range e.g. France.
Long-term orientation	Measures society's perseverance & adoption to changing trends. Values associated with LTO are thrift, perseverance and adopting to changing circumstances. Short Term Orientation values norms and tradition, fulfilling social obligations and protecting one's "face"; Fixed norms always apply and traditions do not change. Scores: 0-100. Higher the score, greater Long-Term Orientation in country/society exist. High are China, Russia, Germany, Mid-range US and very short are Egypt and Arabic countries.
Indulgence	Feeling of subjective happiness. High Indulgence societies allow free gratification of basic human desires leading to enjoying life and having fun, as opposed to Restrained where desires are controlled by norms. High Indulgence refer to less disciplines and norms and focus on enjoyment and fun. Scores: 0-100. Higher the score, greater Indulgence country/society exist. High score for Mexico, Sweden, UK, USA, and low are France, Italy and Arabic countries.

The description derived from Hofstede G, 'Culture's consequences' (1999) and (2001), as well as from the website: http://www.geert-hofstede.com/

Table A2: Summary research in the effects of culture on technology adoption. Adopted from Lee, Trimi amd Kim (2013)

Researcher	Dependant variables	Methodology	Published by
Straub (1994)	Media use, National culture (UAI)	Field interviews and surveys comparing the USA and Japanese respondents, Hostede's indices	Information Systems Research
Straub, Keil and Brenner (1997)	Information systems use, National culture (IDV, PDI, UAI, MAS)	Survey of airline employees from the USA, Japan and Switzerland	Information and Management
Hasan and Ditsa (1999)	Technology transfer outcome, National culture (UAI, PDI, IDV, MAS)	Field study of 10 firms in Middle East, Africa and Australia	Journal of Global Information Management
Png, Tan and Wee (2001)	Dimensions of National Culture (UA and PDI) and Corporate Adoption of IT Infrastructure	Survey involving 153 business from 24 countries	IEEE Transactions on Engineering Management
Al-Ghatani (2003)	Rate of technology adoption, National culture	Survey of 1200 Saudi managers and government officials	Information Technology for Development
Bagchi, Hart & Peterson (2004)	IT Products (PC, Telephone, Cell Phone, Fax, the Internet, and Pager),	OLS regressions using Hofstede and World Bank data for 31 nations worldwide	Journal of Global Information Technology Management

	National Culture (IDV, PDI, UAI, MAS)		
Waarts and Van Everdingen (2005)	ERP (Enterprise Resource Planning) software adoption, National culture	Empirical study across 10 European countries.	European Management Journal
Steers, Meyer, Sanchey-Rund (2008)	Ethanol adoption in Brazil, Broadband internet usage in S. Korea, National culture	A cultural analysis of the adoption of Ethanol in Brazil and Internet Economy in South Korea	Journal of World Business
Lee, Trimi and Kim (2013)	Mobile phone use, national culture (IDV, UA, LTO)	Mobile phone subscription data for the USA and South Korea, Hofstede’s indices, Bass Model	Journal of World Business
Zhao, Scheruhn and von Rosing (2014)	Cloud computing adoption (SMEs), National culture dimensions (PDI, IDV, UA, MAS, LTO)	Effects of national culture dimensions on cloud computing acceptance in SMEs in USA and China.	16th International Conference, HCI (Human-Computer Interaction) 2014
Arpaci, Yardimci Cetin & Turetken (2015)	Smartphone adoption in Canada and Turkey; National culture	A multi-group structural equation model analysis using the data from private sector organizations in Turkey and Canada	Journal of Global Information Technology Management

Hafezi and Zolait (2019)	Cloud computing adoption, National culture dimensions (PDI, UA, IDV, MAS)	Effects of national culture dimensions and information systems quality on cloud computing adoption in SMEs in GCC	2019 International Conference on Innovation and Intelligence for Informatics, Computing & Tech.

Table A3A: CLF index factors and their effects. Source, Metten (2021)

Dimension	Factor	Effect
Associational	Union density	+
	Collective bargaining coverage	+
	Collective bargaining centralization	+
Structural	Labor force participation rate	-
	Share of employees in agriculture	-
	Democracy	+
Institutional	Ratification of ILO core labor standards	+
	Hiring and firing regulations	+
	Hours regulations	+

Table A3B: CLF factors weights. Source, Metten (2021)

Dimension	Weight
Associational	**35%**
Union density	31%
Collective bargaining coverage	23%
Collective bargaining centralization	18%
Structural	**30%**
Labor force participation rate	15%
Share of employees in agriculture	29%
Democracy	24%
Institutional	**35%**
Ratification of ILO core labor standards	17%
Hiring and firing regulations	22%
Hours regulations	15%

Table A4: Descriptive statistics and bivariate correlations

Variable Name	N	Mean	St Dev	1.	2.	3.	4.	5.	6.	7.	8.
1. Cloud Computing Revenues normalized for GDP	190	0,0008	0,001	1	-0,251**	-0,405**	0,206**	0,421**	-0,319**	0,560**	-0,132
2. Mobile Broadband Revenues normalized for GDP	152	0,0047	0,002	-0,251**	1	-0,066	-0,395**	-0,15**	0,256**	-0,312**	-0,1
3. Employee Protection legislation	190	2,25	0,81	-0,405**	-0,066	1	-0,048	-0,361**	0,465**	-0,518**	0,14
4. Trade Union Strength	185	5,98	2,04	0,206**	-0,395**	-0,048	1	0,354**	-0,437**	0,51**	0,115
5. Government Effectiveness Index	190	1,001	0,72	0,421**	-0,15**	-0,361**	0,354**	1	-0,696**	0,647**	-0,349**
6. Power Distance	190	52,13	21,51	-0,319**	0,256**	0,465**	-0,437**	-0,696**	1	-0,648**	-0,317**
7. Individualism	190	53,66	22,93	0,560**	-0,312**	-0,518**	0,51**	0,647**	-0,648**	1	-0,371**
8. Uncertainty Avoidance	190	65,79	22,53	-0,132	-0,1	0,14	0,115	-0,349**	-0,317**	-0,371**	1

** Correlation at 0,01 level

* Correlation at 0,05 level

Table AA: Descriptive statistics and bivariate correlations

Variable Name	N	Mean	Standard Deviation	Min	Max	1.	2.	3.
1.Use of cloud computing services in enterprises in Europe	216	28.758	16.645	4.9	75.5	1	0.32***	0.35***
2.Average of the four World Bank governance indicators	216	1.026	0.555	-0.1	1.963	0.32***	1	0.966***
3.European Quality of government Index (EQI)	216	0.38	0.948	-1.812	1.753	0.35***	0.966***	1

Numbers rounded to 3 decimal places; $*p < 0.1$, $**p < 0.05$; $***\ p < 0.01$.