IT ADOPTION IN EUROPE:
DO REAL ESTATE AND CONSTRUCTION INDUSTRIES DIFFER FROM THE REST?

Abstract. This thesis concerns an empirical analysis of the divergence in IT adoption rates at industry and country level in Europe, with a specific focus on real estate and construction industries. Data on ERP and CRM adoption rates for ten NACE Rev. 2 industries in 26 European countries is analyzed using descriptive statistics and a multivariate regression method. Descriptive statistics show a wide variability in IT adoption across industries in Europe. Specifically, the mean of both ERP and CRM adoption in Europe is the lowest for construction industries. Multivariate regression results show that country, industry and time effects explain most of the variation in ERP and CRM adoption. Results of a Chow test show that the effect of various IT adoption drivers is different for Real estate and construction industries. Compared to other industries, increased competitiveness enhances ERP and CRM adoption to a larger extent in Real estate and construction industries. Also, in contrast to other industries, increased urban density stimulates IT adoption in Real estate and construction industries. Finally, findings show that the effect of employment protection and strong institutions is larger for ERP adoption compared to CRM adoption.

Keywords. *IT adoption, real estate, construction, Europe*

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PREFACE

In front of you lies my Master's thesis: "IT Adoption in Europe: do Real Estate and Construction Industries Differ from the Rest?" This thesis marks the end of my academic career at the University of Groningen as well as the start of my professional career. I had a great time as a student and look forward to start working in the rapidly evolving world of real estate and IT.

This thesis was written during my internship at cegeka-dsa. Here I have been given complete freedom to conduct my research and apply my findings in an additional market research. A special thanks to Jarno Cislo and Rick Peters for their input and supervision over the past five months. Further, I want to sincerely thank my supervisor Arno van der Vlist for his constructive feedback and guidance during the process. I really appreciate it! Finally, my warmest thanks go to my girlfriend Romy and my parents. I would not have succeeded without your continued support.

I hope you enjoy your reading.

Cas Ruiken
Veenendaal, January 24, 2020

CONTENTS

1. INTRODUCTION

1.1 Motivation

Information technology (IT) adoption by firms has become an essential part of successful business operations (Behera et al., 2015). IT solutions for communicating data and information improve the decision-making process in business operations and is instrumental to growth and development (McKinsey Global Institute, 2018). IT further enables growth and development by improving collaboration in business processes (Acar et al., 2005; Búrca et al., 2005; Levy et al., 2001), creating lower production and labor costs, adding value to products and services, and increasing competitive advantage (Corso et al., 2003; Levy et al., 2001; Nguyen et al., 2007). Given this, the optimal result of IT solutions is achieving superior business results with a transparent system, motivated people, and organizational commitment for continuous growth (Na et al., 2007). Taking into account these opportunities, the obvious question is whether all industries and countries are adopting at a similar pace.

Although IT seems crucial, it is well-known that adoption rates in Europe vary considerably across industries and countries (DeStefano et al., 2017). For instance, 52% of the firms in the European computer manufacturing industry adopted an Enterprise Resource Planning (ERP) system in comparison to 33% in the Real estate industry. At the same time, 60% of the firms in Finland use cloud computing, while this is 9% in Poland (European Commission, 2018). These differences in IT adoption contribute to divergence in aggregate productivity growth (van Ark et al., 2000). For this reason, governments implement policies to encourage IT adoption. Yet, these policies are based on aggregate measurements of IT investment and do not consider the cause of differences in IT adoption (DeStefano et al., 2017). The topic of this thesis is to examine differences in IT adoption rates at industry and country level in Europe, with a specific focus on both the Real estate and construction industry.

1.2 Literature review

Earlier studies have discussed the adoption of new technologies in industries and countries. Most of these models and frameworks have focused on one firm at a time at the level of a single country (Oliveira & Martins, 2011; Vicente & López, 2011). Crepon et al. (1998) argued that the probability that a firm engages in research into new technologies increases with size, market share and diversification, and with the demand pull and technology push indicators. In other words, an increased research budget induces innovation and accordingly raises productivity output. However, it has been found that the exact output of a technology for a firm is dependent on the context of social, political and economic structures and institutions (Schumpeter, 1983; Perez, 2002; Scarbrough & Corbett, 1992). In addition, DeCanio and Watkins (1998) found that to be economically efficient, firms make decisions that do not necessarily maximize profits. This decision to adopt a new technology has been widely investigated. First, the Diffusion of Innovations Theory (DOI) discussed the adoption-process of new technologies on the firm and global level based on adopter characteristics, characteristics of an innovation, and the innovation decision process (Taherdoost, 2018). Moreover, DeCanio and Watkins (1998) elaborated on adopter characteristics with their study on the relation between organizational structures and the adoption-process. Other studies have focused on the role of employees with regards to new technology adoption. First, the Technology Acceptance Model (TAM) built on the factors perceived usefulness, perceived ease of use, and attitude towards use (Taherdoost, 2018). In addition, the Task-Technology Fit Model (TTF) argued that new technologies will only be adopted if the functions available fit the activities of the user and lead to the greatest net benefit (Dishaw & Strong, 1999). In line with these diverse theories on the adoption of new technologies, various approaches have discussed digital technologies adoption at industry and country level.

Few studies have emphasized differences in IT adoption rates at industry and country level in Europe. Andrews et al. (2018) explored whether differences in IT adoption rates by industries stem from differences in industry settings. It was found that industry settings affect firms' capabilities and incentives to adopt IT technologies. For instance, the real estate industry in particular is affected by IT adoption as a result of improved information provision (Kummerow & Lun, 2005). Therefore, Dixon (2005) argued that there is a need for further research on IT adoption drivers for the Real estate industry. Further, differences in IT adoption rates between countries were attributed only to institutional arrangements based on reviews of existing theories (Mignerat & Rivard, 2009). For this reason, this thesis extends the relatively small amount of literature on differences in IT adoption at industry and country level in Europe.

1.3 Research problem

Although a variety of literature on IT adoption is present, research on the explanation of differences in IT adoption rates between industries and countries with a focus on real estate and construction is limited. To fill this literature gap, the aim of this research is to examine differences in IT adoption at industry and country level in Europe with a specific focus on the Real estate and construction industry. This thesis answers the central question that is: *What drives differences in IT adoption at industry and country level in Europe?* Three research questions are formulated:

1. *How can IT adoption in industries and countries be explained?*

For this research question, the theoretical framework of this thesis is constructed. Academic literature is reviewed in order to determine the drivers of IT adoption. Based on these drivers, hypotheses are formulated that are tested in the next section.

2. *What are the drivers for IT adoption in industries and countries in Europe?*

This research question is answered by using statistical analysis. The dataset used is from Eurostat and is complemented with World Bank and OECD data. Descriptive statistics are used to analyze divergence in IT adoption between industries and countries in Europe. Multivariate regression analysis is used to determine IT adoption drivers. For this, multiple independent variables that emerged from the theoretical framework and two indicators for IT adoption are used. With this, the effect of drivers on IT adoption at industry and country level in Europe is examined.

3. *To what extent do the effects of IT adoption drivers differ between industries and countries?*

For this last research question, extra tests are performed in order to analyze the robustness of the effect of drivers on IT adoption at industry and country level in Europe. A Chow test is performed in order to decide whether extra (separate) regressions are required for the Real estate and construction industry. In addition, two robustness checks are conducted. The robustness of the results to changes in independent variables is examined by using replace variables. Accordingly, the robustness to possible outliers is tested by running the regressions excluding one country at a time.

1.4 Outline

The remainder of this research is structured as follows. Chapter 2 discusses the theoretical framework for IT adoption in industries and countries. Chapter 3 discusses the descriptive statistics and introduces the empirical approach to measure the effects of IT adoption drivers at industry and country level in Europe. Chapter 4 presents the results of the statistical analysis and robustness tests. Chapter 5 concludes by addressing the central research question.

2. THEORETICAL FRAMEWORK

2.1 Adoption of new technologies

New technology adoption can be explained on the basis of theory of the firm. A new technology is a set of productive techniques, which compared to the established technology offers a significant improvement in terms of increased output or savings in costs for a given process (Merrill, 1964). In a capitalist economy, it is the entrepreneur who innovates by applying these new combinations of productive techniques (Schumpeter, 1939). The chance of sucesfully diverting labor to a new technology and achieving significant process improvement is dependent on the firms' organizational structure (DeCanio & Watkins, 1998). Changes in the organizational structure made by the entrepreneur can increase new technology adoption. This is because the actions of the firm are the function of the organizational structure and the capabilities of the firms employees (DeCanio & Watkins, 1998). Others (Kautonen et al., 2013; Liñán & Fayolle, 2015; Krueger, 2007) similarly noted that adoption of a new technology is highly dependent on the individual attitude and actions of the entrepreneur.

Institutions shape the context in which firms operate which influence new technology adoption (King et al., 1994; Vicente & López, 2011). Institutional factors, including the social, political and cultural framework of a society, shape the "rules of the game" in which entrepreneurs operate (North, 1994). Three kinds of institutional pressures on firms exist: coercive, normative and mimetic pressures (Mignerat & Rivard, 2009). Coercive pressures stem from the legal environment of the firm and from the existence of standards, which are determined by the identity of the firm. Normative pressures are caused by professionalization: inter-organizational networks, similar educational backgrounds and mimetic behaviors in a profession. Mimetic pressures often develop at times of uncertainty, so firms will tend to model themselves on other organizations in their industry that are perceived to be more successful (DiMaggio & Powell, 1983). In fact, only coercive and normative institutional pressures are suitable for research on the country level (Mignerat & Rivard, 2009). Governmental interventions (coercive pressures) positively affect IT adoption within a country through subsidies and barrier reduction, investments in education, and the implementation of facilitating regulations and norms (Silva & Figueroa, 2002). Further, patterns across countries in the adoption rates of computer-aided production management tools are caused by the actions of different national professional associations (normative forces) (Swan et al., 1999; 2000). Given this, institutions are a fundamental element in frameworks that examine the adoption of new technologies across countries.

2.2 IT adoption

IT adoption is the choice to integrate hardware and/or software technology (Thong, 1999) and concerns managerial and technical staff decision-making in both the internal and external environment of the firm, which must occur before the given technology can be implemented (Grover & Goslar, 1993; Nguyen et al., 2015). Andrews et al. (2018) applied this classification of internal and external factors in their market incentives and firm capabilities framework on digital technologies adoption in Europe. Although drivers are initially classified as incentives or capabilities, incentives could operate via the side of capabilities and vice versa (Adalet McGowan & Andrews, 2015).

IT adoption drivers for firms relate to capabilities, incentives, and urban density. Firm capabilities and IT adoption were restrained by low managerial quality, lack of IT skills and poor matching of workers to jobs (Andrews et al., 2018). The first of these factors, management quality, has a causal relationship with overall organisational capital. And, higher organisational capital is associated with disporportionately higher digital adoption rates in knowledge-intensive industries compared to other industries (Bloom et al., 2012). Regarding the second factor, IT skills, complementarity exists between employees' IT skills and technology adoption (Machin & Van Reenen, 1998; Autor et al., 2003; Bartel et al., 2007). This becomes an obstacle to IT adoption when human capital lags behind. Moreover, specific IT competences and increased participation in lifelong learning enhance IT adoption (Andrews et al., 2018). Finally, the factor skill mismatch plays an important role. Lower skill mismatch is associated with disproportionately higher IT adoption rates (Andrews et al., 2018).

On the incentives side, IT adoption is influenced by market access, competition, and reallocation of labor and capital (Andrews et al., 2018). Regarding the first incentive on market access, improved acces that comes with a lack of entry barriers enhances IT adoption in the case of young firms (Andrews et al., 2018). This is because young firms possess a comparative advantage in commercialising new technologies (Henderson, 1993). The reason why the second incentive with regards to IT adoption, competition, is significant is twofold. Stronger competition resulting from international trade shocks strengthens firms' incentives to adopt better technologies (Perla et al., 2015; Bloom et al., 2011; Hollenstein, 2004; Behera et al., 2015). For this reason, it is no coincedence that IT adoption lags behind in market services that are more sheltered from foreign and domestic competitive pressures (Andrews et al., 2016). More specifically, as with any field of trade, open digital markets bring in greater competition benefiting final IT adopters through lower prices and a greater variety of products (Andrews et al., 2018). Finally, the incentive on labor and capital reallocation plays a key role in IT adoption based on two legislative arguments. Laws that impose heavy or unpredictable costs on hiring and firing slowed down the reallocation process (Bassanini et al., 2009; Andrews & Cingano, 2014), leading to lower productivity-enhancing investments by firms such as the adoption of IT solutions (Bartelsman et al., 2009; Andrews & Criscuolo, 2013). At the same time, reasonable degrees of employment protection are likely to boost IT adoption since it increases worker commitment and firm's willingness to invest in firm-specific human capital (Andrews et al., 2018).

In addition to this capabilities and incentives framework, IT adoption is also stimulated through increased urban density. The urban density theory explains the relationship between IT adoption costs and population density: IT adoption in more dense regions is easier and cheaper as a consequence of better telecommunications infrastructure (Forman et al., 2005). Alternatively, higher urban density positively affects IT skills through knowledge spillovers (Glaeser & Resseger, 2010). This urban density driver adds to the framework discussed above that is used to explore differences in IT adoption at industry and country level in Europe.

2.3 Hypotheses

The aim of this thesis is to examine differences in IT adoption at industry and country level in Europe with a specific focus on the real estate and construction industry. The theoretical framework presented above established a set of drivers that are expected to cause differences in IT adoption in industries and countries. First, industry size is an important driver for IT adoption. The same applies for industry competitiveness. Next, a large share of adults participating in lifelong learning stimulates IT adoption. Further, stricter protection of employees through legislation positively affects IT adoption. Moreover, strong institutions that facilitate regulations and norms enhance IT adoption. Finally, increased urban density is an important driver of IT adoption. Based on this, the following hypotheses were formulated:

- Hypothesis 1: *IT adoption is positively related with increased industry size*;

- Hypothesis 2: *IT adoption is positively related with increased industry competitiveness;*

- Hypothesis 3: *IT adoption is positively related with increased lifelong learning;*

- Hypothesis 4: *IT adoption is positively related with stricter protection of employees;*

- Hypothesis 5*:* *IT adoption is positively related with strong institutions*;

- Hypothesis 6: *IT adoption is positively related with increased urban density.*

3. DATA & METHODOLOGY

3.1 Data

Data were collected from various sources. First, data on IT adoption rates were drawn from the Eurostat "*community survey on ICT usage and e-commerce in enterprises"* (Eurostat, 2019a). This survey includes information on digital technologies adoption rates by industry, country and year. The adoption rates in the Eurostat survey refer to the use of the digital technologies Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM). Second, data on industry settings were collected from the Eurostat Structural Business Statistics (SBS) dataset (Eurostat, 2019b). The SBS dataset covers information on the structure, conduct and performance for industries on NACE Rev. 2 class level. Third, data on national employment protection were retrieved from the OECD database. This database entails indicators for employment protection legislation (EPL). Fourth, data on structural and policy settings on country level were obtained from the World Bank (2018). The World Development Indicators (WDI) dataset includes information on population dynamics and the Worldwide Governance Indicators (WGI) dataset comprises various indicators that summarize the quality of governance across countries and over time.

The data selection of industries and countries has proceeded as follows. Primarily, the dataset contained 25 industries of the non-farm business sector (NACE Rev. 2, codes 10-83) for all EU members and accession countries on an annual basis since 2002. However, because of the limited availability of SBS and WGI data on industry performance and country institutions, the sample was restricted: excluded were Bulgaria, Cyprus, Malta, Montenegro, North Macedonia, Serbia, Romania and Turkey. For this same reason, ten industries were excluded from the sample and the time dimension of the sample was restricted to the years 2010, 2012-2015, and 2017. Data coverage for all industries and countries is displayed in Appendix A. Finally, after dropping cases with missing values, a sample with information on IT adoption by ten industries in 26 countries with 1.220 observations was constructed. The industries and countries that were included in the analysis are listed in Table 1.

Table 1 Sample characteristics

Countries		**NACE Rev. 2 industries (10 persons employed or more)**
Austria	Italy	*Accommodation and food service*
Belgium	Latvia	*Administrative and support service*
Croatia	Lithuania	*Construction*
Czechia	Luxembourg	*Electricity, gas, steam and air supply*
Denmark	Netherlands	*Information and communication*
Estonia	Norway	*Manufacturing*
Finland	Poland	*Professional, scientific and technical activities*
France	Portugal	*Real estate*
Germany	Slovakia	*Transportation and storage*
Greece	Slovenia	*Wholesale and retail motor vehicles*
Hungary	Spain	
Iceland	Sweden	
Ireland	United Kingdom	

3.2 Operationalization

The factors that were discovered in the theoretical framework were operationalized into measurable variables. IT adoption was examined based on the adoption rates (in percentages) of the digital technologies ERP and CRM. Because these IT solutions most likely reflect both demand and supply factors, findings concerning their adoption drivers could apply to a broader set of IT technologies (Andrews et al., 2018). In addition, an important selection criterion was to maximize cross-industry and cross-country data coverage.

The first dependent variable, ‘IT adoption ERP’, measured the percentage of firms that use ERP software to share information between different functional areas. ERP software integrates and automates several functions, such as planning, purchasing, inventory, sales, marketing, finance, and human resources into one system in order to streamline processes and information across the firm (Gartner, 2017). In fact, the implementation of an ERP system is one of the most effective ways towards traceability, since it facilitates integration between modules, data storing/retrieving processes and management analysis functionalities, combined with the typical functionalities of stand-alone applications (Rizzi & Zamboni, 1999). Shang and Seddon (2000) classify ERP benefits into five groups as follows: *Operational*, relating to cost reduction, cycle time reduction, productivity improvement, quality improvement, and customer services improvement; *Managerial*, relating to better resource management, improved decision making and planning, and performance improvement; *Strategic*, concerning supporting business growth, supporting business alliance, building business innovations, building cost leadership, generating product differentiation, and building external linkages; *IT infrastructure*, involving building business flexibility, IT cost reduction, and increased IT infrastructure capability; *Organisational*, relating to supporting organizational changes, facilitating business learning, empowering, and building common visions. Unfortunately, many directors and managers view ERP as simply a software system and the implementation of ERP as primarily a technological challenge. The ultimate goal should however be to improve the business, not to implement software. The implementation should be business driven and directed by business requirements and not the IT department (Umble et al., 2003). The link between ERP benefits and business objectives is therefore a relative one rather than absolute in terms of what can be achieved (Al-Mashari et al., 2003).

The second dependent variable, ‘IT adoption CRM’, measured the percentage of firms that use CRM systems to capture, store and make available clients information to other business functions. CRM refers to the acquisition, analysis and use of information on customers in order to improve the efficiency of business processes (Bose, 2002). In other words, CRM applications attempt to focus on the customer first, specifically one customer at a time, to build a long-lasting mutually beneficial relationship. CRM benefits to the firm are: extended capability to the customer for self-service and internet applications; attraction of existing and new customers through personalized communications and improved targeting; integrated customer and supplier relationships; constructed metrics to analyze common and unique customer patterns (Injazz & Popovich, 2003). Although CRM software suppliers may tempt firms with promises of all powerful applications, there are no error-free solutions (Hackney, 2000). Yet, failed CRM projects are often the result of firms lacking a thorough understanding of what CRM initiatives entail. Because of this, possible risks such as project failure, inadequate return on investment, unplanned project budget revisions, unhappy customers, loss of employee confidence, and diversion of key management time and resources must be well thought out (Schweigert, 2000). Similar to ERP systems, the implementation of CRM requires changes to the organizational culture whereby strong leadership and commitment is the most essential element of success (Al-Mashari et al., 2003). While ERP and CRM systems can overlap in some areas, their core functionalities are diverse, and firms can adopt one without the other. Accordingly, industry and country factors were operationalized into independent variables based on the approach popularized by Andrews et al. (2018).

Industry variables were used to include industry size and comeptition characteristics. First, the variable 'Industry employment' which is total employment was used as an indicator for the size of an industry. This was measured in number of persons without distinction according to full-time or part-time work. Next, productivity is often used as a proxy for the competitiveness of an industry (European Commission, 2017). The variable 'Apparent labor productivity' was defined as value added at factor costs divided by the number of persons employed and is presented in thousands of euros per person employed. Both industry variables related to the NACE Rev. 2 statistical classification of economic activities.

Country variables were selected to take account of structural and institutional factors. First, because lifelong learning activities facilitate IT adoption, the variable 'Lifelong learning' was included. This independent variable represented the share of adults in a country participating in lifelong learning. Furthermore, the variable 'Employment protection legislation' was used to measure how certain degrees of employment protection enhance IT adoption because of worker commitment and increased firm-specific human capital (Andrews et al., 2018). This OECD indicator determines the strictness of regulation on dismissals and the use of temporary contracts. However, these index numbers did not cover all the years in the analysis. Because the data on employment protection legislation showed almost no changes, it was assumed to be constant over time and the average of every country over the period 2009-2014 was used. The original EPL index numbers are included in Appendix B. Further, the urban density theory (Forman et al., 2005) and the fact that urban density affects skills via spillovers (Glaeser & Resseger, 2010), were both accounted for by the variable 'Population density'. This variable measured the population density of a country as the midyear population divided by land area in square kilometers. Finally, institutions have a great effect on the possible output of digital technologies (Schumpeter, 1983; Perez, 2002; Scarbrough & Corbett, 1992). The variable 'Voice and accountability' was obtained from the World Bank WGI dataset and captured the perceptions of the extent to which a country's citizens were able to participate in selecting their government, together with freedom of expression, freedom of association, and a free media. Nozeman and Van der Vlist (2014) showed that this accountibility index is highly correlated to the JLL Transparency Index on institutional features.

The theoretical framework in the previous section pointed out how improved managerial quality and lower skill mismatch drive IT adoption. However, it was not possible to operationalize these factors into measurable variables because of limited data availability. Table 2 contains an overview of the used variables, definitions, data coverage and sources.

Table 2 Variable definitions

	Definition	**Coverage**	**Source**
IT adoption			
ERP	Percentage of firms who have Enterprise Resource Planning software package to share information between different functional areas	2010; 2012-15; 2017	Eurostat - DESI
CRM	Percentage of firms who have Customer Relationship Management software to capture, store and make available clients information to other business functions	2010; 2012-15; 2017	Eurostat - DESI
Industry size			
Industry employment	Total employment of industries measured in number of persons without distinction according to full-time or part-time work	2010-2017	Eurostat - SBS
Industry competitiveness			
Apparent labor productivity	Labor productivity of industries calculated by value added at factor costs divided by the number of persons employed presented in thousands of euros per person employed	2010-2017	Eurostat - SBS
Country settings			
Lifelong learning	Share of adults participating in lifelong learning within countries	2010-2015, 2017	OECD - PIAAC
Employment protection legislation	Strictness of employment protection (Collective and individual dismissal, regular contracts, Version 3)	2009-2014	OECD - IEPL
Population density	Midyear population divided by land area in square kilometers	2010-2017	World Bank - WDI
Country institutions			
Voice and accountability	The extent to which a country's citizens were able to participate in selecting their government, together with freedom of expression, freedom of association, and a free media	2010-2018	World Bank - WGI

3.3 Descriptive statistics

The full summary statistics of the dataset are presented in Table 3. A wide variability across industries and countries existed in both the dependent and independent indicators. Table 3 shows that in some industries, not a singular firm used ERP or CRM software. It is striking that these industries, real estate and construction, both relate to Iceland. Highest adoption rates relate to the German real estate industry (77%) and Belgian Information and communication industry (81%). According to the summary statistics, little divergence between the total ERP and CRM adoption rates is evident. On the contrary, large differences in ERP and CRM adoption rates between industries can be observed via the mean. Adoption rates for both digital technologies are highest for the Information and communication industry, and lowest for the construction industry. Also, the average degree to which adoption rates deviate from the mean differed a lot across industries. The biggest differences occurred within the Administration and support service industry (ERP) and the real estate industry (CRM). Notable variability also occurred in a number of independent variables. Apparent labor productivity varied from 4.10 thousand euros in the Lithuanian accommodation industry to 542.10 thousand euros in the electricity, gas, steam, and air supply industry in Spain. Also, the share of adults participating in lifelong learning in a country varied widely from 2.3% in Croatia to 32.6% in Denmark. Apparent labor productivity varied from 4.10 thousand euros in the Lithuanian accommodation industry to 542.10 thousand euros in the electricity, gas, steam, and air supply industry in Spain. Also, the share of adults participating in lifelong learning in a country varied widely from 2.3% in Croatia to 32.6% in Denmark.

Table 3 Summary statistics

Variable	Number of Observations	Mean	Std.Dev.	Min	Max
Total IT adoption					
ERP	1.220	28.11	15.11	0	77
CRM	1.220	29.67	15.28	0	81
IT adoption per industry (ERP)					
Accommodation and food service	118	21.02	21.02	1	69
Administration and support service	128	22.00	22.00	2	58
Construction	127	16.90	9.87	2	45
Electricity, gas, steam and air supply	110	33.20	14.88	5	71
Information and communication	123	42.90	13.93	9	72
Manufacturing	129	35.96	14.39	8	67
Professional and technical activities	126	27.91	11.87	3	61
Real estate	102	24.71	15.54	0	77
Transportation and storage	124	20.33	9.68	3	46
Wholesale and retail motor vehicles	133	34.24	13.14	8	68
IT adoption per industry (CRM)					
Accommodation and food service	118	31.83	13.37	5	70
Administration and support service	128	27.10	10.88	7	52
Construction	127	14.92	8.45	0	36
Electricity, gas, steam and air supply	110	30.30	12.34	9	62
Information and communication	123	54.44	12.77	30	81
Manufacturing	129	25.76	10.93	6	53
Professional and technical activities	126	32.48	12.05	11	64
Real estate	102	27.74	14.72	4	63
Transportation and storage	124	19.37	7.70	4	40
Wholesale and retail motor vehicles	133	33.06	11.66	12	61
Independent variables					
Industry employment	1.220	543.65	965.59	1.43	7594
Apparent labor productivity	1.220	64.76	74.96	4.10	524.10
Lifelong learning	1.220	11.78	7.54	2.30	32.60
Employment protection legislation	1.220	2.51	0.32	1.71	3.14
Population density	1.220	129.85	113.23	3.43	508.50
Voice and accountability	1.220	1.125	0.31	0.31	1.69

The variables were prepared for multivariate regression analysis by removing observations with missing values on key variables. In addition, the variables Industry employment, Apparent labor productivity, Lifelong learning and Population density were not normally distributed and were prepared for statistical analysis by log-transformation. The entire data preparation process is included in Appendix C. Figure 1 shows the distribution of the variables before log-transformation.

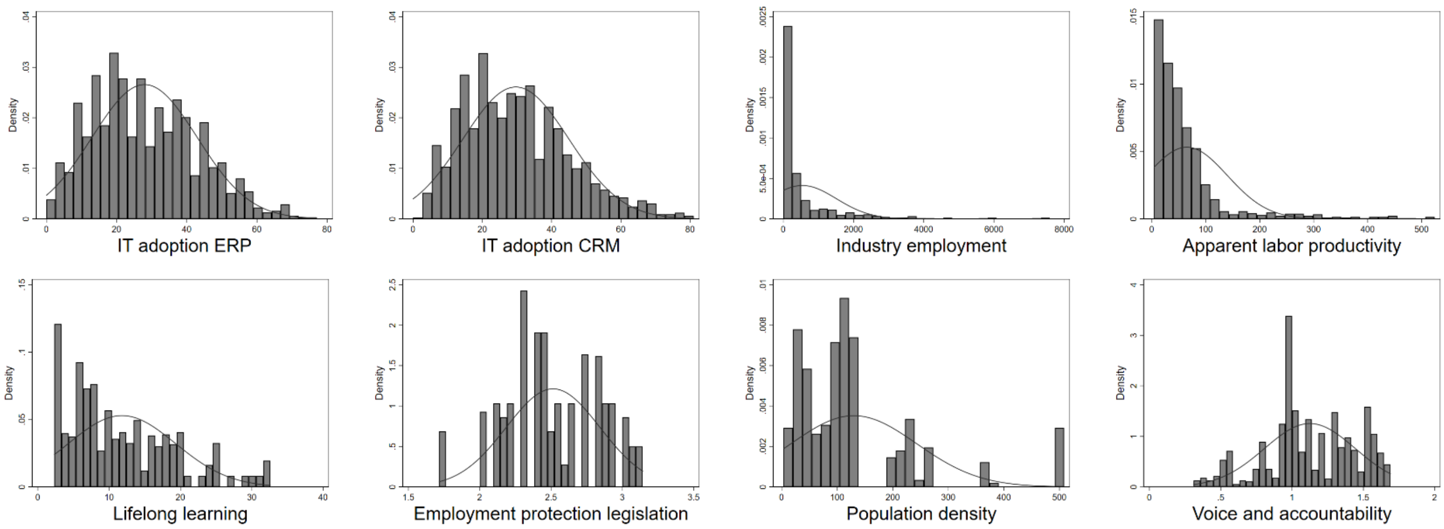

Figure 1 Histograms for assessing normality

The ordinary least squares (OLS) method is based on four assumptions (Burt et al., 2009): parameters are linear, residuals are normally distributed, independent variables are not highly correlated with each other, and the variance of error terms is constant across parameters (homoscedasticity). First, the scatterplots in Figure 2 were used to assess linearity between dependent and independent variables. Multiple linear relationships were evident. Apparent labor productivity for industries showed a strong positive linear relationship with both ERP and CRM as a dependent variable. To a lesser extent this was the case for the variable Employment protection legislation. All other independent variables showed positive but relatively weak relationships with the dependent variables ERP and CRM. Second, normal probability plots of all residuals were examined without finding considerable issues. Besides, because of the large sample size, a possible violation of this assumption could not have caused complications in the analysis (Burt et al., 2009). Third, to check for multicollinearity, the correlation matrix in Table 4 for both dependent variables was generated. The variables Voice and accountability and Lifelong learning appeared to be highly correlated (0.655). In order to monitor possible problems with multicollinearity, additional variance inflation factors (VIF) were generated for every regression model. Finally, the variances of the error terms were examined and tested for homoscedasticity. First, the Breusch-Pagan/Cook-Weisberg test, with the null hypothesis that the error variances are all equal, was used to detect heteroscedasticity. No significant results were found and the null hypothesis was accepted. In addition, all residuals were plotted and visually inspected without finding any clear patterns. The residual plots are included in Appendix D.

When more than one dependent variable is used, it is necessary to find out how highly correlated the dependent variables are. In this case, the correlation between ERP and CRM is 0.69. This is a moderate degree of correlation which underlines the conceptual relation between the two dependent variables. Nevertheless, it is still required to run separate regressions for both ERP and CRM adoption rates.

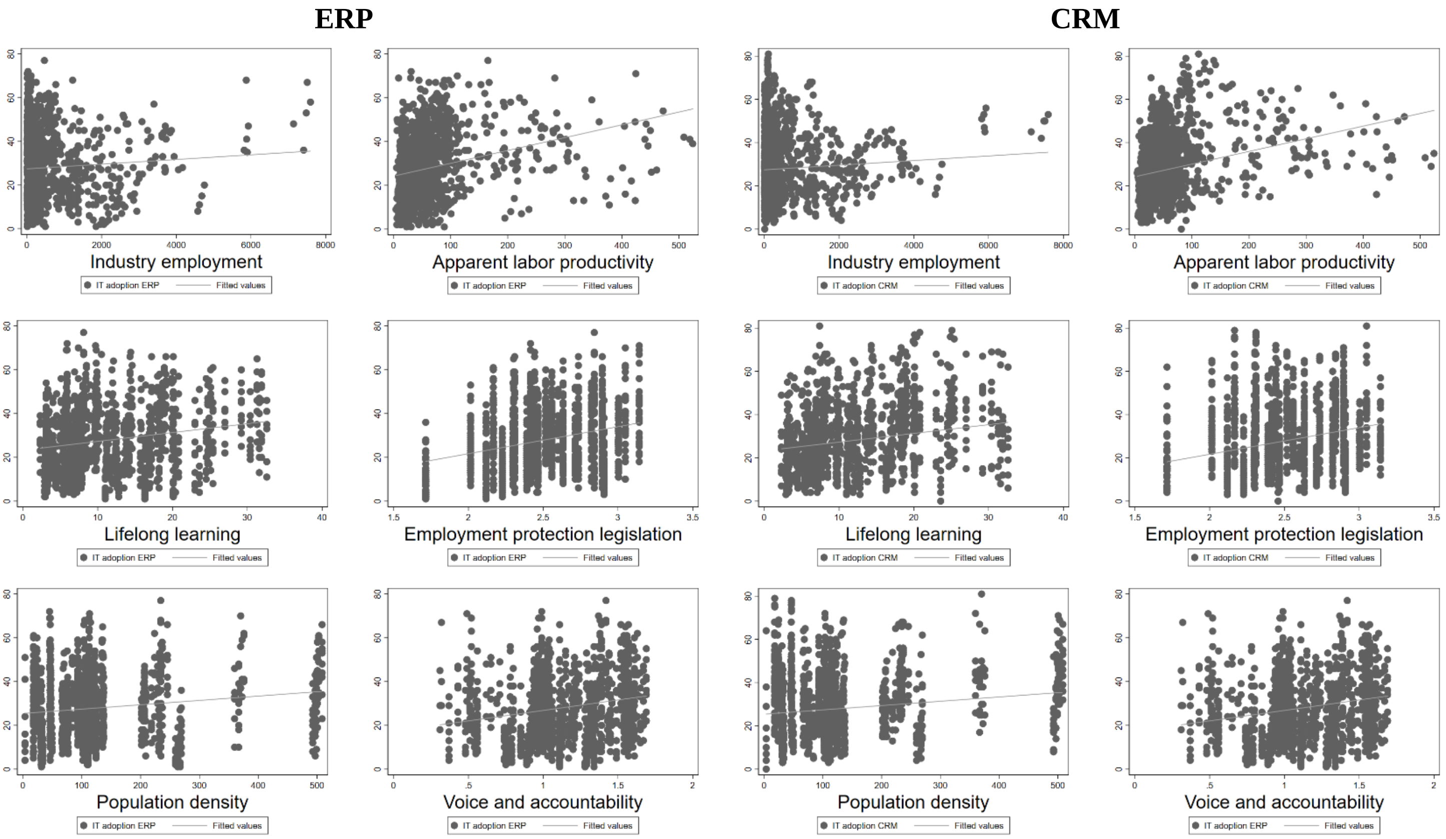

Figure 2 Scatterplots linearity dependent and independent variables

Table 4 Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) IT adoption ERP	1.000						
(2) Industry employment	0.069	1.000					
(3) Apparent labor productivity	0.291	-0.119	1.000				
(4) Lifelong learning	0.203	-0.063	0.280	1.000			
(5) Employment protection legislation	0.271	0.143	-0.076	-0.158	1.000		
(6) Population density	0.150	0.266	0.082	0.047	0.394	1.000	
(7) Voice and accountibility	0.203	0.114	0.268	0.655	-0.067	0.359	1.000
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) IT adoption CRM	1.000						
(2) Industry employment	0.051	1.000					
(3) Apparent labor productivity	0.318	-0.119	1.000				
(4) Lifelong learning	0.321	-0.063	0.280	1.000			
(5) Employment protection legislation	0.109	0.143	-0.076	-0.158	1.000		
(6) Population density	0.158	0.266	0.082	0.047	0.394	1.000	
(7) Voice and accountibility	0.372	0.114	0.268	0.655	-0.067	0.359	1.000

3.4 Methodology

A multivariate regression method was used to test the hypotheses that were discussed in section 2.3 Hypotheses. Multivariate regression analysis can measure the extent to which multiple independent variables predict the adoption of two groups of digital technologies (Hargittai, 1999; Kiiski & Pohjola, 2002; Guillén & Suárez, 2005; Çilan et al., 2009; Vicente & López, 2011). Similar regressions are run for both dependent variables ERP and CRM. The effect of independent industry and country variables on these dependent IT adoption variables is examined based on the following multivariate regression specifications:

$$Adoption = \alpha + DUM_i + DUM_c + DUM_t + \varepsilon \quad (1)$$

where *Adoption* refers to the percentage of firms in an industry that use the examined IT solution (ERP or CRM). In this baseline model, fixed effects are included with three groups of dummy variables: DUM_i refers to the set of dummies indicating the relevant NACE Rev. 2 industry, DUM_c represents the dummies indicating a country, and DUM_t took account of time effects with year dummies. α is a statistical symbol representing the intercept or constant. ε refers to the random error term that represents the influence of other variables that were not included in the model.

Next, industry settings were added to the model in order to test the effect of industry size and industry competitiveness on IT adoption. Industry size was indicated by the total employment of industries, measured in number of persons without distinction according to full-time or part-time work. Industry competitiveness was defined by the labor productivity of industries which is value added at factor costs divided by the number of persons employed. The effect of these independent industry variables on IT adoption are examined based on the following specification:

$$Adoption = \alpha + DUM_i + DUM_c + DUM_t + \beta_1 INs + \varepsilon \quad (2)$$

where *INs* refers to the vector of industry settings that include the logarithms of Industry employment and Apparent labor productivity. β_1 represents the regression coefficients for these independent variables.

Country settings were then added to the model to examine the effects of lifelong learning activities and employment protection. Lifelong learning is indicated as the share of adults within a country participating in lifelong learning activities. Employment protection is measured as the strictness of employment protection legislation in a country. The effect of these independent country variables on IT adoption are examined based on the following specification:

$$Adoption = \alpha + DUM_i + DUM_c + DUM_t + \beta_1 INs + \beta_2 COs + \varepsilon \quad (3)$$

where *COs* refers to the vector of country settings including the logarithm of Lifelong learning, and Employment protection legislation. Also, β_2 represents the regression coefficients for these independent variables.

Accordingly, country institutions were separately added to the model to examine the effect of the institutional environment in a country on IT adoption. Institutions are indicated based on a voice and accountability index that captures the perceptions of the extent to which a country's citizens were able to participate in selecting their government, together with freedom of expression, freedom of association, and a free media. Separately adding Voice and accountability to the model enables further examining of the highly correlated relationship with the independent variable Lifelong learning. The effect of institutions on IT adoption are examined based on the following specification:

$$Adoption = \alpha + DUM_i + DUM_c + DUM_t + \beta_1 INs + \beta_2 COs + \beta_3 COi + \varepsilon \qquad (4)$$

where *COi* refers to the country institutional environment indicated by Voice and accountability. β_3 represents the regression coefficient for this independent variable.

Country urban density effects are taken account of in an extra model to examine the relationship between urban density and IT adoption. In this extra model, country effects are omitted to prevent multicollinearity problems. Urban density for a country is measured as the population density which is the midyear population divided by land area in square kilometers. The effect of urban density on IT adoption is examined based on the following specification:

$$Adoption = \alpha + DUM_i + DUM_t + \beta_1 INs + \beta_2 COs + \beta_3 COi + \beta_4 COu + \varepsilon \qquad (5)$$

where *COu* refers to the urban density indicated by the logarithm of Population density. β_4 represents the regression coefficient for this independent variable.

Important issue with identifying causal effects of the drivers on ERP and CRM adoption is reverse causality. For example, does ERP and CRM adoption increase due to increased labor productivity, or is adoption just easier for very productive firms because they are more likely to have the financial means? Possible solution to this problem would be to use an instrumental variables approach. However, this is not an option due to the lack of suitable instruments in the dataset. When interpreting regression results, the presence of a certain degree of reverse causality should be taken into account.

4. RESULTS

4.1 Regression results

Table 5 shows the regression results for the pooled models. Model 1 uses industry, country and time dummies to predict the dependent variables ERP and CRM. The model reaches adjusted *R*-squared scores of 0.75 (ERP) and 0.81 (CRM), meaning that this baseline model with only fixed effects explains most of the variation in ERP and CRM adoption rates. Another study on this topic reaches an adjusted *R*-squared of only 0.70 in their complete model (Vicente & López, 2011). Therefore, the adjusted *R*-squared in this baseline specification is very high.

Model 2 includes industry settings on size and competitiveness. Ln Industry employment is significant at the 1% (ERP) and 10% (CRM) level. The coefficients show conflicting signs: increasing industry employment diminishes ERP adoption and increases CRM adoption. Possible explanation for this is that because the objective of CRM adoption is to optimize the relationship with customers (Injazz & Popovich, 2003), and it is assumed that larger industries have more end users, the feasibility of CRM implementation would also rise. On the other hand, because ERP software focuses on streamlining processes and information across the firm (Gartner, 2017), the number of (potential) customers is less important. Other studies do not examine de relationship between industry size and these specific measures for IT adoption. However, coefficients have the same size and remain significant across models 2 to 4. Ln Apparent labor productivity is significant at the 1% level. Both ERP and CRM adoption rates grow with increasing industry competitiveness which is in line with other studies (Behera et al., 2015). In case of a 1% increase in labor productivity, ERP and CRM adoption increase with 0.04% to 0.05%.

Model 3 adds variables on lifelong learning activities and employment protection. Ln Lifelong learning is insignificant in almost all models. Lifelong learning is significant as an interaction variable with knowledge intensity in other studies (Andrews et al., 2018). Yet, lifelong learning does not interact with other variables in the available dataset. Employment protection legislation coefficients are significant at a 1% level for both ERP and CRM in all models. All signs are positive which is in line with previous studies (Andrews et al., 2018). But, the effect on ERP adoption is larger compared to CRM adoption in Models 3 and 4. In Model 3, a 1 point increase in strictness of employment protection increases ERP adoption with 18.16% while this is 9.72% for CRM. This large difference could relate to the fact that ERP systems, in contrast to CRM solutions, are integrated across the entire supply chain and therefore demand more specific IT knowledge or human capital (Rizzi & Zamboni, 1999).

Model 4 is used to separately examine the effect of country institutions. Voice and accountability is significant at the 1% (ERP) and 5% (CRM) level and is positively related to both indicators for IT adoption. This positive relationship between strong institutions and IT adoption is also demonstrated by other studies (Silva & Figueroa, 2002; Swan et al., 1999, 2000). Again, the effect on dependent variable ERP is larger compared to CRM. A 1 point increase of Voice and accountability increases ERP adoption with 18.42% and CRM with 7.75%. This may also be due the dependency of ERP implementation on sufficient available human capital (Rizzi & Zamboni, 1999), if assumed that strong institutions boost human capital. The mean

VIF that indicates multicollinearity increases from 5.27 in Model 3 to 8.26 in Model 4 because Voice and accountability is highly correlated with Lifelong learning. This is probably due to the close relationship between government policies and lifelong learning initiatives (Andrews et al., 2018). However, the mean VIF remains below the critical value of 10 that applies as a rule of thumb (Hair et al., 2006).

Model 5 is an extra model that excludes country dummies in order to examine the effect of urban density on IT adoption. Population density is only significant at the 1% level in case CRM is used as the dependent variable. The sign of the coefficient is negative and implies that a 1% increase in urban density diminishes CRM adoption with 0.01% which contradicts other studies (Forman et al., 2005; Glaeser & Resseger, 2010). In addition, replacing industry effects with the independent variable Population density lowers the adjusted *R*-Squared from 0.76 and 0.82 to 0.59 and 0.69.

4.2 Real estate and construction

Model 4 is considered the most complete (pooled) model. The residuals of this regression form the input for the Chow test with the null hypothesis that the intercepts and slopes are identical between the real estate and construction industry and other industries. The Chow F statistics (91.36 for ERP and 128.74 for CRM) are significantly different from zero at the 95% level. The null hypothesis of the Chow test is rejected and in addition to the pooled model, separate regressions for the real estate and construction industries are run. These separate regressions are useful in examining how the effects of IT adoption drivers are different for the real estate and construction industry compared to other industries. An extensive elaboration of the Chow test is included in Appendix E.

Table 6 shows the regression results for the separate models. Country and time effects are fixed in models 1 to 4. The models do not lose notable power in terms of adjusted *R*-squared. Several models show striking differences in regression results compared to the pooled models. The coefficients for Ln Industry employment lose significance in all models for both ERP and CRM. This implies that increased industry size does not enhance IT adoption in real estate and construction industries. Also, this might point at the presence of very large firms in the observations for real estate and construction industries which causes a disproportionate effect (Andrews et al., 2018). Furthermore, in Model 2 a 1% increase of labor productivity causes instead of 0.05% and 0.04% in the pooled models a 0.08% and 0.10% increase of ERP and CRM adoption in the unrestricted models. This implies that IT adoption in real estate and construction industries is more dependent on industry competitiveness compared to IT adoption in other industries. In Model 3, the coefficient of Employment protection legislation for CRM turns insignificant. However, in the remaining models these coefficients are significant which suggests that employment protection is an important driver of IT adoption in real estate and construction industries. Other coefficients show no striking deviations from the pooled models. This also applies for Voice and accountability in Model 4, where only the coefficient for CRM turns insignificant. In line with the pooled regression, adding Voice and accountability to the model considerably increases the mean VIF. In this case, the mean VIF exceeds

Table 5 Regression pooled all industries

	Model 1 (baseline)				Model 2				Model 3				Model 4				Model 5			
	ERP		**CRM**		**ERP**		**CRM**		**ERP**		**CRM**		**ERP**		**CRM**		**ERP**		**CRM**	
Variable	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.
Ln Industry employment					-2.31***	0.69	1.07*	0.61	-2.31***	0.69	1.07*	0.61	-2.27***	0.68	1.09*	0.61	-0.52**	0.24	0.64***	0.22
Ln Apparent labor productivity					4.81***	0.89	4.10***	0.79	4.80***	0.90	4.10***	0.79	4.72***	0.89	4.07***	0.79	4.40***	0.62	7.39***	0.55
Ln Lifelong learning									1.05	1.31	0.09	1.15	2.47*	1.33	0.69	1.18	0.47	0.62	0.58	0.55
Employment protection legislation									18.16***	1.86	9.72***	1.64	21.73***	1.69	20.00***	1.50	13.04***	0.62	7.40***	0.55
Voice and accountability													18.42***	3.82	7.75**	3.39	5.42***	1.29	8.72***	1.14
Ln Population density																	0.46	0.41	-1.44***	0.36
Constant	28.12***	2.13	16.54***	1.87	-9.19*	4.54	3.51	4.00	-27.80***	10.06	-14.53	8.86	-61.9***	10.34	-43.93***	9.19	-30,62***	2.75	-14.65***	2.43
Country fixed effects	YES		YES		YES		YES		YES		YES		YES		YES		NO		NO	
Industry fixed effects	YES		YES		YES		YES		YES		YES		YES		YES		YES		YES	
Year fixed effects	YES		YES		YES		YES		YES		YES		YES		YES		YES		YES	
Observations	1.220		1.220		1.220		1.220		1.220		1.220		1.220		1.220		1.220		1.220	
Mean model VIF	3.23		3.23		8.65		8.65		5.27		5.27		8.26		8.26		2.22		2.22	
R-squared	0.76		0.82		0.76		0.82		0.77		0.82		0.77		0.82		0.60		0.70	
Adjusted *R*-squared	0.75		0.81		0.75		0.82		0.76		0.82		0.76		0.82		0.59		0.69	

Note: Dependent variables are ERP (percentage of firms that use Enterprise Resource Planning software to share information between different functional areas) and CRM (percentage of firms that use Customer Relationship Management software to capture, store and make available clients information to other business functions).
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6 Regression separate real estate and construction industries

	Model 1 (baseline)				Model 2				Model 3				Model 4				Model 5			
	ERP		**CRM**		**ERP**		**CRM**		**ERP**		**CRM**		**ERP**		**CRM**		**ERP**		**CRM**	
Variable	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.	Coef.	St. Err.
Ln Industry employment					-2.68	2.19	-2.31	1.99	-2.68	2.19	-2.31	2.00	-2.55	2.15	-2.24	1.99	-0.51	0.54	-0.04	0.48
Ln Apparent labor productivity					7.94***	2.13	9.50***	1.94	7.94***	2.14	9.51***	1.95	8.03***	2.10	9.55***	1.94	5.66***	1.33	10.23***	1.18
Ln Lifelong learning									0.29	2.92	-0.45	2.66	2.11	2.94	0.49	2.71	-2.66*	1.46	-2.65**	1.30
Employment protection legislation									14.11***	5.16	6.31	4.70	24.31***	3.75	19.83***	3.47	14.36***	1.94	8.89***	1.72
Voice and accountability													23.73***	8.47	12.36	7.83	7.86***	2.77	6.55*	2.52
Ln Population density																	2.21***	0.84	0.31	0.75
Constant	25.68***	5.63	16.08	5.25	16.35	16.83	13.28	15.35	-36.52	26.43	-19.32	24.10	-91.01***	24.89	-61.78***	23.00	-44.99***	5.93	-39.39***	5.26
Country fixed effects	YES		YES		YES		YES		YES		YES		YES		YES		NO		NO	
Industry fixed effects	NO		NO		NO		NO		NO		NO		NO		NO		NO		NO	
Year fixed effects	YES		YES		YES		YES		YES		YES		YES		YES		YES		YES	
Observations	229		229		229		229		229		229		229		229		229		229	
Mean model VIF	4.73		4.73		9.07		9.07		7.87		7.87		11.99		11.99		2.19		2.19	
R-squared	0.72		0.76		0.74		0.78		0.74		0.78		0.75		0.79		0.57		0.66	
Adjusted *R*-squared	0.68		0.72		0.70		0.75		0.70		0.75		0.71		0.75		0.54		0.64	

Note: Dependent variables are ERP (percentage of firms that use Enterprise Resource Planning software to share information between different functional areas) and CRM (percentage of firms that use Customer Relationship Management software to capture, store and make available clients information to other business functions).
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

the critical value of 10. Model 5 shows a positive coefficient for Ln Population density with ERP as a dependent variable. This implies that increased urban density stimulates ERP adoption in real estate and construction industries. This might be due to the fact that urban density is expected to enhance knowledge spillovers (Glaeser & Resseger, 2010), and ERP implementation is dependent on sufficient IT knowledge and human capital (Rizzi & Zamboni, 1999).

4.3 Robustness

Two methods assess the robustness of the regression results. First, indicators that are highly correlated with independent variables act as replace variables to check the robustness to changes in the independent variables: Ln Value added replaces Ln Industry employment as the indicator of industry size, Ln Wage adjusted labor productivity measures industry competitiveness instead of Ln Apparent labor productivity, and Regulatory quality replaces Voice and accountability to take account of country institutions. Appendix F shows the correlations between the independent variables and replace variables. Table 7 presents the regression results with replace variables for the real estate and construction industry.

Table 7 Replaced independent variables

	Model 4			
	ERP		**CRM**	
Variable	Coef.	St. Err.	Coef.	St. Err.
Ln Value added	-3.76	2.51	-3.25	2.33
Ln Wage adjusted labor productivity	9.10***	2.83	9.79***	2.62
Ln Lifelong learning	1.62	2.99	1.04	2.78
Employment protection legislation	27.08***	3.96	22.47***	3.67
Regulatory quality	9.92*	5.76	11.18*	5.34
Constant	-70.96**	26.86	-55.76**	24.89
Country fixed effects	YES		YES	
Industry fixed effects	NO		NO	
Year fixed effects	YES		YES	
Observations	229		229	
Mean model VIF	13.32		13.32	
R-squared	0.74		0.77	
Adjusted *R*-squared	0.69		0.73	

Note: Dependent variables are ERP (percentage of firms that use Enterprise Resource Planning software to share information between different functional areas) and CRM (percentage of firms that use Customer Relationship Management software to capture, store and make available clients information to other business functions).
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The regression outputs show that the coefficients of the replace variables have the same sign as the independent variables in Table 6. Also, in almost all cases the significance level is unchanged and only a small difference in adjusted *R*-squared exists. Because of this, the model is robust against changes in independent variables. Second, given the relatively small size of the real estate and construction industry sample (229 observations), it is important to rule out possible influence of outliers. Therefore, regressions are run excluding one country at a time. Table 8 lists the countries that cause loss of statistical significance when dropped. The results are broadly robust to this further robustness check because the loss of significance occurs in only a few cases.

Table 8 Robustness to dropping one country at a time

	ERP	**CRM**
Ln Industry employment		Luxembourg
Ln Apparent labor productivity	Robust	Robust
Ln Lifelong learning		
Employment protection legislation	United Kingdom	Croatia, Hungary, Netherlands, United Kingdom
Voice and accountability	Hungary	

Note: This table displays the robustness of results presented in Table 6, Model 4. Countries listed in this table are those which estimation results are sensitive to, i.e. dropping these countries implies the loss of statistical significance. Grey areas indicate that estimation results were not significant in the first place.

4.4 Implications

Several limitations emerged which must be taken into account in future research. At first, data availability limited the amount of information on IT adoption. With regard to the drivers of IT adoption, only six independent variables were included. Hence, some of the factors discussed in literature were not covered. Furthermore, the time dimension of the dataset was limited. This prevented further research into the evolution of divergence in IT adoption across industries and Europe. Also, major differences occurred in data coverage. Converting the raw data into a balanced dataset caused the loss of a large number of variables. Future research on this subject based on a single (non-public) source could solve these problems.

Next, this study did not examine how fixed effects explain most of the divergence in IT adoption in Europe. To better understand how these invariable characteristics determine IT adoption, further research should aim at examining inherent industry and country characteristics in more detail. For example, what does the business activities of a real estate developer look like and what are the potential benefits of IT adoption? This might be completely different for a housing corporation. At the same time, the relative costs for firms to adopt a new IT solution might differ greatly per country. It could be relevant to map these relative investment costs by doing research into for example the presence of suppliers and quality of digital infrastructures.

Further, this study assumed that IT adoption is the endogenous factor. However, one could also say that IT adoption is an exogenous factor that affects for instance industry size, transparency or competitiveness. In other words, IT adoption can be seen both as an outcome of competitiveness and a potential for competitiveness. It is important to critically reflect on this when interpreting the results.

The findings seem to be consistent with literature on IT adoption. Comparable studies show that industry size and competitiveness, employment protection, country institutions and urban density are important factors for IT adoption (Behera et al., 2015; Andrews et al., 2018; Silva & Figueroa, 2002; Swan et al., 1999, 2000; Forman et al., 2005; Glaeser & Resseger, 2010). This study is the first to show how the effect of these drivers differ for the real estate and construction industries compared to other industries in Europe.

Multivariate regression results show that country, industry and time effects explain most of the variation in ERP and CRM adoption. The baseline model with only country, industry and year dummies reaches very high adjusted *R*-Squared scores of 0.75 (ERP) and 0.81 (CRM). In the most complete regression model, the adjusted *R*-Squared increases only to 0.76 (ERP) and 0.82 (CRM). However, the regression outputs provide sufficient information to reflect on the hypotheses. First, increased industry employment diminishes ERP adoption and increases CRM adoption. Therefore, this finding cannot confirm the hypothesis that IT adoption is positively related with increased industry size. Second, both ERP and CRM adoption rates grow with higher apparent labor productivity, which confirms the hypothesis that IT adoption is positively related with increased industry competitiveness. Third, the share of adults in a country that participate in lifelong learning activities has no significant effect on IT adoption. Because of this, the hypothesis that IT adoption is positively related with increased lifelong learning is rejected. Fourth, a 1 point increase in strictness of employment protection increases ERP adoption with 18.16% and CRM adoption with 9.72%. So, these results confirm the hypothesis that IT adoption is positively related with stricter protection of employees. Fifth, the regression outputs show that a 1 point increase of the Voice and accountability index rises ERP adoption with 18.42% and CRM adoption with 7.75%. This confirms the hypothesis that IT adoption is positively related with strong institutions. Finally, an extra model that ignores country effects examines the relation between urban density and IT adoption. The independent variable Population density has a small negative effect on CRM adoption while there is no significant relationship with ERP adoption. Therefore, this finding rejects the hypothesis that IT adoption is positively related with increased urban density.

Results of the Chow test show the need for separate regressions for the real estate and construction industry. The output of these separate regressions provide insight in how the effect of IT adoption drivers are different in the real estate and construction industry compared to other industries. First, increased industry competitiveness has a much bigger effect on IT adoption in the real estate and construction industry compared to other industries: a 1% increase in apparent labor productivity causes a 0.07% and 0.10% increase of ERP and CRM adoption in the real estate and construction industry instead of 0.05% and 0.04% for all industries together. Second, the results suggest that in contrast to the pooled models, the adoption of ERP systems in real estate and construction industries is higher in densely populated countries.

The results of this research can be used to improve policies aimed at stimulating IT usage. Since current policies are only based on aggregates of IT investment, these results can help to develop specific measures for the real estate and construction industry. In addition, suppliers of IT solutions that consider to enter European markets may find these results helpful.

5. CONCLUSION

This study examined differences in IT adoption in Europe with a specific focus on real estate and construction industries. Literature identified a number of drivers that affect IT adoption and subsequently a dataset was constructed from Eurostat, OECD and World Bank data. IT adoption was indicated by adoption rates of ERP and CRM systems. The effect of the drivers on these two dependent variables across industries and countries were examined based on descriptive statistics and multivariate regression analysis. The sample used for empirical analysis contained 1.220 observations with information on IT adoption and covered ten industries in 26 countries for the years 2010, 2012-2015, and 2017. The central research question used in this research is: *What drives differences in IT adoption at industry and country level in Europe?*

The findings show that industry competitiveness, employment protection, institutions, and urban density are important drivers for ERP and CRM adoption. Country, industry, and time effects explain most of the variation in ERP and CRM adoption. However, results of a Chow test show that the effect of various IT adoption drivers is different for real estate and construction industries. Increased competitiveness enhances ERP and CRM adoption to a larger extent in real estate and construction industries compared to other industries. Also, in contrast to other industries, increased urban density stimulates ERP adoption in real estate and construction industries. Finally, findings show that the effect of employment protection and strong institutions is larger for ERP adoption compared to CRM adoption. This disparity most likely stems from the divergent characteristics of ERP and CRM solutions that relate to dependency on IT knowledge and human capital.

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APPENDICES

Appendix A

Appendix A.1 Data coverage countries

Country	Eurostat DESI	WB WDI	WB WGI	OECD PIAAC	OECD IEPL
Belgium	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Bulgaria	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	X
Czechia	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Denmark	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Germany	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Estonia	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Ireland	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Greece	2010, 2013-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Spain	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
France	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Croatia	2010, 2012-2014, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2015
Italy	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Cyprus	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	X
Latvia	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2012, 2013
Lithuania	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2014, 2015
Luxembourg	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Hungary	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Malta	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	X
Netherlands	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Austria	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Poland	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Portugal	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Romania	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	X
Slovenia	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2014
Slovakia	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Finland	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Sweden	2010, 2012-2014, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
United Kingdom	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2014

Iceland	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Norway	2010, 2012-2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	2009-2013
Montenegro	X	2010 - 2017	2010-2018	2010-2015, 2017	X
North Macedonia	2010, 2012-2015	2010 - 2017	2010-2018	2010-2015, 2017	X
Serbia	2014, 2017	2010 - 2017	2010-2018	2010-2015, 2017	X
Turkey	2012, 2015, 2017	2010 - 2017	2010-2018	2010-2015, 2017	X

Appendix A.2 Data coverage industries

NACE Rev. 2 Industry (10 persons employed or more)	Eurostat DESI	Eurostat SBS
Manufacturing	2010, 2012-2015, 2017	2010-2015, 2017
Electricity, gas, steam, air conditioning and water supply	2010, 2012-2015, 2017	2010-2015, 2017
Construction	2010, 2012-2015, 2017	2010-2015, 2017
Wholesale and retail motor vehicles	2010, 2012-2015, 2017	2010-2015, 2017
Transportation and storage	2010, 2012-2015, 2017	2010-2015, 2017
Accommodation and food service	2010, 2012-2015, 2017	2010-2015, 2017
Food and beverage service	X	X
Information and communication	2010, 2012-2015, 2017	2010-2015, 2017
Real estate	2010, 2012-2015, 2017	2010-2015, 2017
Professional, scientific and technical activities	2010, 2012-2015, 2017	2010-2015, 2017
Administrative and support service	2010, 2012-2015, 2017	2010-2015, 2017
ICT sector	2010, 2012-2015, 2017	X
Financial and insurance	2010, 2012, 2013	X
Retail trade	2010, 2012-2015, 2017	X

Appendix B

Appendix B Original values EPL

Time / Country	2009	2010	2011	2012	2013	2014	2015	Average EPL
Austria	2,442177	2,442177	2,442177	2,4421768	2,442177			2,442177
Belgium	2,994898	3,130952	3,130952	2,9948978	2,994898			3,04932
Czechia	2,751134	2,751134	2,751134	2,6604307	2,660431			2,714853
Denmark	2,274943	2,274943	2,320295	2,3202949	2,320295			2,302154
Estonia	2,327664	2,066327	2,066327	2,0663266	2,066327			2,118594
Finland	2,166667	2,166667	2,166667	2,1666667	2,166667			2,166667
France	2,822563	2,822563	2,822563	2,8225625	2,822563			2,822563
Germany	2,841837	2,841837	2,841837	2,8418367	2,841837			2,841837
Greece	2,85034	2,85034	2,444444	2,4444444	2,410431			2,6
Hungary	2,264739	2,264739	2,264739	2,2647393	2,074263			2,226644
Iceland	2,45805	2,45805	2,458050	2,4580498	2,45805			2,45805
Ireland	1,978458	1,978458	1,978458	2,0691609	2,069161			2,014739
Italy	3,032313	3,032313	3,032313	3,0323131	2,889456			3,003742
Latvia				2,9070296	2,90703			2,90703
Lithuania						2,415533	2,415533	2,415533
Luxembourg	2,735261	2,735261	2,735261	2,7352607	2,735261			2,735261
Netherlands	2,884354	2,884354	2,884354	2,8843536	2,937925			2,895068
Norway	2,309524	2,309524	2,309524	2,3095238	2,309524			2,309524
Poland	2,39059	2,39059	2,390590	2,3905897	2,39059			2,39059
Portugal	3,511905	3,307823	3,307823	2,8996599	2,685374			3,142517
Slovakia	2,634921	2,634921	2,634921	2,1649661	2,255669			2,465079
Slovenia	2,702948	2,702948	2,668934	2,6689343	2,668934	2,387188		2,633314
Spain	2,659864	2,659864	2,557823	2,5578232	2,355442			2,558163
Sweden	2,517007	2,517007	2,517007	2,5170066	2,517007			2,517007
United Kingdom	1,758503	1,758503	1,758503	1,7585034	1,663265	1,591837		1,714853
Croatia							2,298186	2,298186

Appendix C

Appendix C Data preparation / Syntax

Description	**Code**	**Number of dropped observations**
Import dataset	use "C:\Users\casr\OneDrive - Cegeka\Master's	
	Thesis\Data\Dataset\Dataset\DatasetMerged_v14.dta"cd	
	"C:\Users\casr\OneDrive - Cegeka\Master's Thesis\Data\Dataset\Dataset"	
Preparing dataset		
Dropping missing/implausible values	drop if adoption == ":"	1.001
	drop if adoptioncrm == ":"	103
	drop if year == 2016	354
	drop if gor <= 0	5
	drop if missing(indus_empl)	99
	drop if missing(walp)	80
	drop if missing(epl_av)	221
Dropping variables incomplete data	drop vent_cap tax_in inso_reg bar_su bar_ent dig_tr qua_ms hpwp epl	
	lo_train hi_train no_it_sk it_tra ski_mm	
Destring string variables	destring adoption, replace	
	destring adoptioncrm, replace	
	destring life_ll, replace	
	destring account, replace	
	destring epl_av, replace	
	encode countr, generate(country) label(Country)	
	encode industr, generate(industry) label ("NACE Rev. 2 industry")	
	drop countr industr	
Creating dummy variables	tab industry, generate (dum_industry)	
	rename (dum_industry1 dum_industry2 dum_industry3 dum_industry4 dum_industry5 dum_industry6 dum_industry7 dum_industry8 dum_industry9 dum_industry10)(accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive)	
	destring ict, replace	
	tab country, generate (dum_country)	
	rename (dum_country1 dum_country2 dum_country3 dum_country4 dum_country5 dum_country6 dum_country7 dum_country8 dum_country9 dum_country10 dum_country11 dum_country12 dum_country13 dum_country14 dum_country15 dum_country16 dum_country17 dum_country18 dum_country19 dum_country20 dum_country21 dum_country22 dum_country23 dum_country24 dum_country25 dum_country26)(Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK)	
	tab year, generate (dum_year)	
	rename (dum_year1 dum_year2 dum_year3 dum_year4 dum_year5	
	dum_year6) (y2010 y2012 y2013 y2014 y2015 y2017)	

Log transforming data	generate ln_indus_empl = ln(indus_empl)
	hist ln_indus_empl, normal
	generate ln_alp = ln(alp)
	hist ln_alp, normal
	generate ln_pop_den = ln(pop_den)
	hist ln_pop_den, normal
	generate ln_life_ll = ln(life_ll)
	hist ln_life_ll, normal
	generate ln_indus_empl = ln(indus_empl)
	hist ln_indus_empl, normal
	generate ln_alp = ln(alp)
	hist ln_alp, normal
	generate ln_pop_den = ln(pop_den)
	hist ln_pop_den, normal
Examining data	
Scatterplots	twoway (scatter adoption indus_empl)(lfit adoption indus_empl)
	twoway (scatter adoption alp)(lfit adoption alp)
	twoway (scatter adoption life_ll)(lfit adoption life_ll)
	twoway (scatter adoption epl_av)(lfit adoption epl_av)
	twoway (scatter adoption pop_den)(lfit adoption pop_den)
	twoway (scatter adoption account)(lfit adoption account)
Histograms	hist adoption, normal
	hist adoptioncrm, normal
	hist indus_empl, normal
	hist alp, normal
	hist life_ll, normal
	hist epl_av, normal
Rvf plots	regress adoption indus_empl
	rvfplot, yline(0, lcolor(red))
	regress adoption alp
	rvfplot, yline(0, lcolor(red))
	regress adoption life_ll
	rvfplot, yline(0, lcolor(red))
	regress adoption epl_av
	rvfplot, yline(0, lcolor(red))
	regress adoption pop_den
	rvfplot, yline(0, lcolor(red))
	regress adoption account
	rvfplot, yline(0, lcolor(red))
Breusch-Pagan test	estat hettest accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands

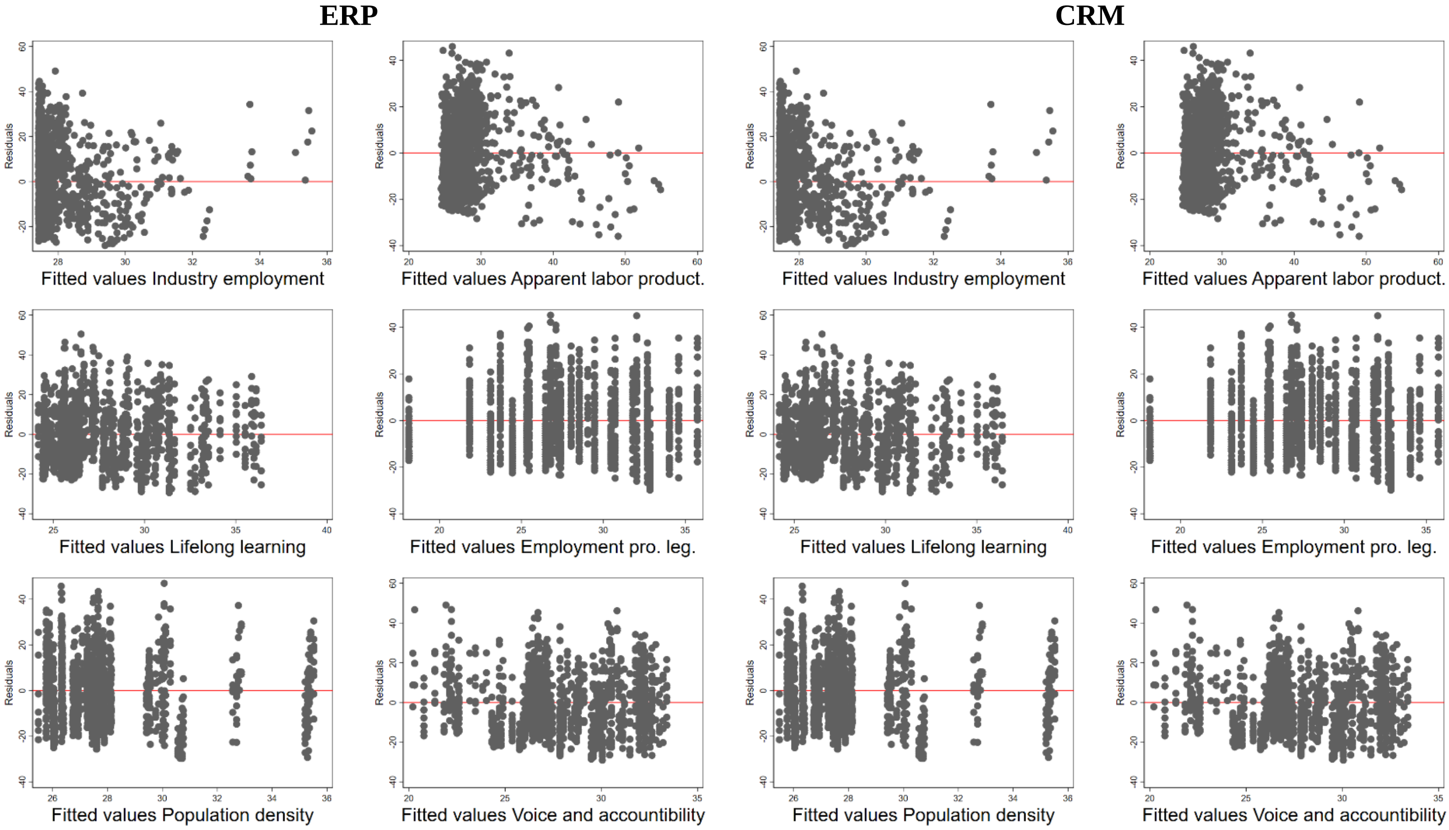
	Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 estat hettest ln_indus_empl ln_alp accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 estat hettest ln_indus_empl ln_alp ln_life_ll epl_av accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 estat hettest ln_indus_empl ln_alp ln_life_ll epl_av account accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 estat hettest ln_indus_empl ln_alp ln_life_ll epl_av account ln_pop_den accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive y2010 y2012 y2013 y2014 y2015 y2017
Correlation matrices	correlate adoption indus_empl alp life_ll epl_av pop_den account correlate adoptioncrm indus_empl alp life_ll epl_av pop_den account
Statistical analysis	
Model 1 Baseline (Pooled)	regress adoption accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif regress adoptioncrm accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 Vif

Model 2 (Pooled)	regress adoption ln_indus_empl ln_alp accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif regress adoptioncrm ln_indus_empl ln_alp accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif
Model 3 (Pooled)	regress adoption ln_indus_empl ln_alp ln_life_ll epl_av Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif regress adoptioncrm ln_indus_empl ln_alp ln_life_ll epl_av Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif
Model 4 (Pooled)	regress adoption ln_indus_empl ln_alp ln_life_ll epl_av account accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif regress adoptioncrm ln_indus_empl ln_alp ln_life_ll epl_av account accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif

Model 5 (Pooled)	regress adoption ln_indus_empl ln_alp ln_life_ll epl_av account ln_pop_den accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive y2010 y2012 y2013 y2014 y2015 y2017 vif regress adoptioncrm ln_indus_empl ln_alp ln_life_ll epl_av account ln_pop_den accommodation administration construction electricity ict manufacturing hightech realestate logistics automotive y2010 y2012 y2013 y2014 y2015 y2017 vif
Preparation for Chow test	drop if realestate == 1 drop if construction == 1 drop if accommodation == 1 drop if administration == 1 drop if electricity == 1 drop if ict == 1 drop if manufacturing == 1 drop if hightech == 1 drop if logistics == 1 drop if automotive == 1
Model used for Chow test (4)	regress adoption ln_indus_empl ln_alp ln_life_ll epl_av Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 regress adoptioncrm ln_indus_empl ln_alp ln_life_ll epl_av Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017
Model 1 Baseline (Real estate and Construction)	regress adoption Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif

	regress adoptioncrm Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif
Model 2 (Real estate and Construction)	regress adoption ln_indus_empl ln_alp Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif regress adoptioncrm ln_indus_empl ln_alp Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif
Model 3 (Real estate and Construction)	regress adoption ln_indus_empl ln_alp ln_life_ll epl_av Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif regress adoptioncrm ln_indus_empl ln_alp ln_life_ll epl_av Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif
Model 4 (Real estate and Construction)	regress adoption ln_indus_empl ln_alp ln_life_ll epl_av account Austria Belgium Croatia Czechia Denmark Estonia Finland France Germany Greece Hungary Iceland Ireland Italy Latvia Lithuania Luxembourg Netherlands Norway Poland Portugal Slovakia Slovenia Spain Sweden UK y2010 y2012 y2013 y2014 y2015 y2017 vif
Model 5 (Real estate and Construction)	regress adoption ln_indus_empl ln_alp ln_life_ll epl_av account ln_pop_den y2010 y2012 y2013 y2014 y2015 y2017 vif regress adoptioncrm ln_indus_empl ln_alp ln_life_ll epl_av account ln_pop_den y2010 y2012 y2013 y2014 y2015 y2017 vif

Appendix D



Appendix D RVF plots dependent and independent variables

Appendix E

Appendix E Chow test based on Model 4

	Pooled				Real estate and construction industries				Other industries			
	ERP		**CRM**		**ERP**		**CRM**		**ERP**		**CRM**	
	Resid.	Obs.	Resid.	Obs.	Resid.	Obs.	Resid.	Obs.	Resid.	Obs.	Resid.	Obs.
Residuals	63237,45	1.220	49878,85	1.220	9814,9	229	8383,19	229	49926,16	991	38692,31	991
Country fixed effects		YES		YES		YES		YES		YES		YES
Industry fixed effects		NO		NO		NO		NO		NO		NO
Year fixed effects		YES		YES		YES		YES		YES		YES
F value		F(43, 1176) = 91.11		F(43, 1176) = 128.74		F(43, 1176) = 91.11		F(43, 1176) = 128.74		F(43, 1176) = 91.11		F(43, 1176) = 128.74
Critical F value (95% significance level)		1,38		1,38		1,38		1,38		1,38		1,38
Chow F statistic		1,48		1,51		1,48		1,51		1,48		1,51

Appendix F

Appendix F Correlation matrix replace variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) IT adoption ERP	1.000									
(2) Industry employment	-0.093	1.000								
(3) Value added	0.098	0.885	1.000							
(4) Apparent labor productivity	0.363	-0.129	0.091	1.000						
(5) Wage adjusted labor productivity	0.231	-0.316	-0.158	0.636	1.000					
(6) Lifelong learning	0.159	-0.053	0.116	0.560	0.156	1.000				
(7) Employment protection leg.	0.384	0.118	0.107	-0.070	-0.166	-0.165	1.000			
(8) Voice and accountability	0.252	0.133	0.280	0.382	0.019	0.666	-0.041	1.000		
(9) Regulatory quality	0.111	0.055	0.240	0.473	0.171	0.675	-0.250	0.803	1.000	
(10) Population density	0.324	0.259	0.347	0.094	-0.098	0.036	0.393	0.360	0.211	1.000

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) IT adoption CRM	1.000									
(2) Industry employment	-0.085	1.000								
(3) Value added	0.145	0.885	1.000							
(4) Apparent labor productivity	0.673	-0.129	0.091	1.000						
(5) Wage adjusted labor productivity	0.427	-0.316	-0.158	0.636	1.000					
(6) Lifelong learning	0.330	-0.053	0.116	0.560	0.156	1.000				
(7) Employment protection leg.	0.190	0.118	0.107	-0.070	-0.166	-0.165	1.000			
(8) Voice and accountability	0.403	0.133	0.280	0.382	0.019	0.666	-0.041	1.000		
(9) Regulatory quality	0.336	0.055	0.240	0.473	0.171	0.675	-0.250	0.803	1.000	
(10) Population density	0.273	0.259	0.347	0.094	-0.098	0.036	0.393	0.360	0.211	1.000