The Climate Effect of Digitalization in Production and Consumption in OECD Countries

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***Abstract*—How does increasing digitalization affect the environment? A number of studies predict that digitalization will ultimately reduce environmental degradation but seem to overestimate the emission-reducing effects of digitalization through increases in resource efficiency, while underestimating substantial rebound effects and negative environmental impact of the construction and maintenance of complex digital infrastructures. Additionally, the environmental benefits of decreasing consumption of one-time usage goods may be outweighed by the environmental costs of the production of ICTs and the increasing use of digital technologies.**

This paper analyzes the relationship between degrees of countries' level of digitalization and environmental indicators by use of a panel data set of 37 economies. It is the first paper to differentiate between emissions associated with a country's production and those connected to a country's consumption, accounting for emissions related to exports and imports. The level of digitalization in production is approximated by companies' investments in digital technologies. The chosen indicator to measure consumers' proclivity to digital technologies is online shopping behaviour. We address the problem of changes in unobserved heterogeneity by using the recently developed Group Fixed Effects estimator.

Results indicate that the beneficial environmental effects of digitalization on reducing climate gas emissions slightly outweigh the undesired environmental effects, both in production and consumption. Ultimately, we find that increases in digitalization have a net positive effect on the natural environment.

Keywords: ecological footprint, digitalization, environmental throughput, industry 4.0.

I. Introduction

There is a widely-held consensus among politicians and economists that increases in digitalization will have a net-positive effect on the environment. The German Department of Trade and Industry claims that digitalization improves an economy's ecological sustainability by increasing resource and energy use efficiencies (Energie, 2015). According to the Association of German Engineers, digitalization may result in increases in resource efficiency of up to 25% (Ressourceneffizienz, 2017). And the 'Global e-Sustainability Initiative', an international network of IT companies, argues that digitalization has the potential to decrease global carbon emissions by an impressive 20% (GeSI and Accenture, 2015).

Looking closer at these studies reveals that such predictions are founded upon weak empirical bases. Some publications simply postulate the likely potential of digitalization to decrease environmental pressures with little subsequent quantitative analysis (Forschung, 2014; Bundesregierung, 2014; Wissenschaft, 2013). Others, while based on more concrete empirical calculations, nevertheless overestimate positive effects and underestimate negative ones (GeSI and Accenture, 2015), for a discussion see Hilty and Bieser (2017).

The scientific literature on the environmental effects of ICT usually differentiates between effects on different levels. Most taxonomies have in common that they include first higher order effects (Røpke, 2012; Horner et al., 2016a; Pohl et al., 2019). The definition of first order effects is similar throughout the literature. It entails the energy, resource use and emissions associated with the production life cycle. This entails the production, use phase and disposal of ICT.

However, the entire environmental effects of ICT involve additional mechanisms (Arvesen et al., 2011; Hakansson and Finnveden, 2015). Such higher order effects are manifold. Which effects are incorporated into the analysis and how they are systemized varies throughout the literature. Some of these effects tend to have positive and some to have negative environmental consequences. A recent list of effects includes substitution effects, optimization effects, beneficial effects, direct rebound effects, indirect rebound effects, induction effects, sustainable lifestyles and practices, transformational rebound effects, induction effects and systemic transformation and structural economic change (POHL et al., 2019). Several authors do not further categorize these higher order effects (BÖRJESSON RIVERA et al., 2014; POHL et al., 2019). However, there exist also several categorizations amongst the higher order effects. BERKHOUT and HERTIN (2004) differentiate between indirect and systemic effects and HORNER et al. (2016a) between application and systemic effects. Many authors differentiate between two levels of higher order effects (i.e., second and third order). This categorization has first been introduced by BERKHOUT and HERTIN (2001). HILTY and AEBISCHER (2015) see the life cycle effects of production, use and disposal at the first order level, referring to them as *direct effects*. At the second order, so-called *enabling effects* include *process optimization*, *media substitution*, and *externalization of control*. Media substitution means that with increased digitalization information is distributed through new forms of media, for example replacing books by tablets or Kindles, or replacing audio playback devices with streaming services. Externalization of control captures all processes that are out of the hands of consumers or businesses using a specific technology, such as the need to regularly acquire new hardware due to software update cycles. Third order effects are labelled *systemic effects* and encompass rebound effects, emerging risks and transition towards sustainable patterns of production and consumption.

Accurately measuring the effect of digitalization on the environment using these different classifications of effects is a challenging task (HEIJUNGS et al., 2009; FINKBEINER et al., 2014; MILLER and KEOLEIAN, 2015). It would be possible to investigate the life-cycle impacts, as well as the productivity increases, on a microeconomic scale by estimating changes in environmental productivity for the production of specific goods and services, or by measuring the energy and resources used to produce and use ICTs. However, even this is a difficult task (HILTY, 2015). Estimating the effect of digitalization on labor productivity and economic growth is even more difficult, as various other factors come into play. Digitalization takes place within a certain historic situation of the world economy. The fact that economies undergo a multitude of transformations and macroeconomic shocks parallel to digitalization makes it even more complicated to measure each of the three mechanisms as along with the overall effect of digitalization. Indeed, it is difficult to clearly separate the environmental effects caused by digitalization from those effects caused by other key factors, like the continuing globalization of world trade, economic policies aimed at climate change and environmental threats, urbanization, and population growth, among others.

Due to these challenges in measuring the environmental effects of digitalization directly, an alternative method – complementary to the existing ones in the literature – is to compare economies within the same historic setting through a differences in differences approach. Do economies experiencing faster digitalization increase or decrease their environmental throughput compared to economies with slower digitalization over the same time period?

Nearly no studies exist on the macro level to allow for capturing both negative and positive effects of digitalization on biosphere use with an explicit differentiation between production and consumption effects. One of few existing studies providing such evidence is SCHULTE et al. (2016), who assess the effects of increasing ICT use on energy consumption in production through a cross-country panel data analysis. Our approach adds to the existing body of knowledge by explicitly differentiating between the environmental effects of increasing digitalization caused by production and consumption.

II. LITERATURE REVIEW

The life-cycle impacts of ICT use have been subject to a number of investigations. The production and application of ICTs themselves require a substantial input of raw materials and energy. However, existing studies on the natural resource costs associated with the production and employment of ICTs are limited.

According to a recent study by MALMODIN et al. (2018), the use of ICTs accounts for 0,5% of global material use. However, these numbers vary highly concerning the specific material being considered. Indeed, ICT accounts for 80-90% of depletion of certain materials, such as indium, gallium and germanium. Several studies have investigated ICT's effects on the demand for energy. ANDRAE (2015) estimate that the use of ICTs accounted for 8% of global energy use in 2010 and expect this share to rise strongly in the coming years. VAN HEDDEGHEM et al. (2014) estimate that the share of global energy consumption due to a certain subset of ICTs (communication networks, personal computers, and data centres) grew from 3.9% to 4.6% in 2012 alone. These numbers certainly show that such direct effects of ICTs must be considered when estimating whether growing levels of digitalization serve to increase or decrease environmental throughput over time.

Many examples of increases in environmental productivity through increased ICT use have been observed. More efficient movement of robots can decrease their energy use in manufacturing.[1] In one of the first studies on the subject, LENNARTSON and BENGTSSON (2016) find that improvements in robotic movement efficiency are associated with a decrease in energy consumption of up to 40%. COROAMA et al. (2012) find that replacing in-person business meetings with virtual conferences could decrease the carbon footprint of such meetings by 37% - 50%. Electronic invoicing can decrease energy use compared with traditional invoicing methods and switching to online newspapers and magazines rather than consuming conventional print publications can have a substantial and far-reaching positive environmental impacts as well (MOBERG et al., 2010). Various studies have investigated the environmental effects of online vs. offline retailing at the micro level (HORNER et al., 2016b; MANGIARACINA et al., 2015; LOON et al., 2015). Which one is more efficient depends on various factors such as population density and the specific conditions of delivery, implying that online shopping can actually be more environmentally harmful than traditional retail. The same is true for media substitution regarding online video streaming compared to renting DVDs (SHEHABI et al., 2014).

In addition, rebound effects can also be observed. In a nutshell, rebound effects refer to the phenomenon where an increase in production efficiency leads to a lowering of consumer prices. This, in turn, leads to higher demand, resulting in an expansion of total production. The corresponding increase in natural resource use may overcompensate the ecological efficiency gains, leading to a net-increase of biosphere use (BERKHOUT et al., 2000). An overview of the literature on rebound effects in regards to ICT usage is provided by GOSSART (2014). If digitalization helps to increase energy and resource productivities, the costs for energy and other resources decrease. Economically speaking, this means that the production function shifts downwards, a new equilibrium of lower price and higher quantity is reached, and consumers have more income to spend on other goods and services. This implies that the energy and natural resources saved through increased productivity can be used for other productive purposes, either to produce more of the same goods and services or to produce additional other goods and services. Many authors have found evidence for rebound effects in different areas of the digital economy, including COROAMA et al. (2012), MOKHTARIAN (2009), and ARNFALK et al. (2016) for virtual meetings and video conferencing, and BÖRJESSON RIVERA et al. (2014a) for production of ICT hardware. Another example is in the increasing efficiency of processing units. The so called "Koomey's law" states that the energy efficiency of processing units doubles every 1.5 years (KOOMEY et al., 2011). If the amount of processing units would stay the same, energy use by such units would decrease along a logarithmic pattern with a half-life of 1.5 years, quickly approaching very low levels. But at the same time, the amount of computations of the processing units produced and used grows over time. The bottom line is that the growth in the number of processing units is higher than the rate of increase in productivity. This impressive growth can at least partly be explained by technological developments. The newer, more efficient units allow for media substitution, resulting in more aggregate use. For example, with the larger and more energy-intensive processing units in the 1990s, it was simply not feasible to invent a functional smartphone.

In summary, the existing research suggests that digitalization has the potential to increase environmental productivity in many economic areas. But even if this holds true, the production and maintenance of a digital infrastructure (first order effects) and potential rebound and other higher order effects could outweigh the benefits described by the first mechanism, possibly leading to an increase in total environmental throughput after all. Only by an aggregated analysis that takes all mechanisms into account can we investigate whether digitalization increases or decreases environmental throughput.

III. METHODOLOGY

A. Estimation method

This analysis relies on the recently introduced *Group Fixed Effects* (GFE) estimator. It was developed by BONHOMME and MANRESA (2015) and has been used by few studies so far (GRUNEWALD et al., 2017; KOPP and DORN, 2018). Its development has been motivated by

[1]Note that this refers to robot steerage, not the introduction of robots.

problems with conventional panel fixed-effect analysis, which implicitly assumes unobserved heterogeneity between countries to stay constant over time. To tackle this issue, in the first stage the GFE assembles all countries into groups, according to the *changes* in the observables. In the second stage the panel estimation is exercised, supplemented by dummy variables for each of the groups instead of individual country effects. The GFE also solves the problem of low degrees of freedom in fixed-effect panel estimations, which require a big number of dummy variables (one dummy per section, e.g. country). Since the GFE bundles all countries within a relatively small number of groups (all literature reviewed that employs the GFE estimator relies on less than ten groups (BONHOMME and MANRESA, 2015; GRUNEWALD et al., 2017; KOPP and DORN, 2018)), the number of covariates decreases strongly.

Four control variables are included, following GRUNEWALD et al. (2017) and KOPP and DORN (2018): the share of the population living in urban areas, as well as the shares of the GDP being generated in the agriculture, the manufacturing, and service sectors, respectively. This leads to the following equation to be estimated, for both production and consumption analyses:

$$\begin{aligned} \ln CO_2 = &\alpha \ln Digi + \beta \ln GDP \\ &+ \gamma \ln GDP\_Digi + \Gamma X \\ &+ \sum_{i=1}^{4} GFE_i + c + \varepsilon, \end{aligned} \tag{1}$$

where CO_2 stands for climate gas emissions and $Digi$ for the level of digitalization.[2] GDP denotes each country's GDP. GDP_Digi is a cross term capturing interaction effects between GDP and the measure of digitalization on the outcome variable.[3] X is the vector of control variables (x_1, x_2, x_3, x_4) and Γ the vector of the respective coefficients $(\delta_1, \delta_2, \delta_3, \delta_4)$. GFE_i stands for the coefficients of the GFE-groups, of which one is omitted from the estimation due to collinearity. c is a constant and ε an error term. The dependent and the key explaining variables are described in the following sections.

[2]The identification of the digitalization effect is laid out in the next section.

[3]This allows for the possibility that the effect of one of the variables depends on the state of the other, i.e. that digitalization may affect biosphere use in richer countries systematically different than it does in less well-off countries.

B. Identification strategy

The effects of digitalization can be decomposed into those effects related to the production of goods and those related to the consumption of goods. The former includes increased technical efficiency due to the use of ICT in production processes, while the latter refers to changing consumption patterns, such as the switch from conventional analogous and offline practices to digital and potentially online ones. To allow for a differentiation between the effects of these two areas we approach the question from two sides, first from the production perspective and then from the consumption perspective.

To measure production-side effects, we measure all resources that are used in one country's industrial production and investigate how deeply resource use in that country is affected by the country's level of industrial digitalization. This level of digitalization is captured by the total yearly investments of all firms in information and communication technology. Environmental throughput is proxied by each country's CO_2 emissions.

The analysis on the consumption side considers all resources used during the production of the goods consumed in one certain country (even if produced abroad) and associates them with a measure of digitalization on the consumer side in one country. Defining an aggregate measure to account for all aspects of digitalization on the consumer side is complicated, as it encompasses several dimensions. This means, generally speaking, that new or additional products and services are consumed that were not previously imagined to complement or substitute existing ones. This also includes the purchasing process itself, which is involved in every purchasing act, and might therefore serve as an effective proxy for the consumers' openness to new technology and willingness to use them. This paper therefore proxies digitalization on the consumption side by the share of individuals who ordered consumer articles online during the last three months.[4] The environmental throughput caused by the consumption of goods in a country is proxied by the sub-index CO_2 *emissions* of the ecological footprint. The critical difference between the two measures of biosphere use is that the former captures the CO_2 emissions produced *within* the countries while the latter also accounts for *emissions imported and exported* through trade.

[4]As this decision is controversial some critical reflections and ideas on alternatives to this measure are provided in the "Outlook" section IV-C.

C. Data

On the production side the key explanatory variable, the digitalization in a country's production, is the sum of all investments made by all companies into ICT infrastructure and software that is used for more than one year. This variable is provided by the OECD (2017). The dependent variable is CO_2 emissions generated by all production processes carried out in one country, proxying the environmentally detrimental output caused by production. This variable, as well as the controls, were taken from the World Development Indicators, provided by the World Bank. Descriptive statistics of all variables entering the production side regression are provided in Table (I).

TABLE I: Summary statistics of all variables entering the production side regression.

	mean	sd	min	max
$\ln CO_2$	6.56	1.33	4.65	9.96
ln*ICTinvest*	2.73	0.39	1.03	3.48
ln*GDP*	23.10	1.20	21.03	26.04
Urban	77.56	7.58	57.92	88.91
Manu	17.52	4.15	9.06	27.80
Agri	2.95	2.08	0.55	11.68
Serv	61.39	6.05	44.60	76.38

318 observations

So on the production side the following model is estimated:

$$\begin{aligned}\ln CO2_P = & \alpha_P \ln ICT_{Invest} + \beta_P \ln GDP \\ & + \gamma_P \ln GDP\_ICT_{Invest} + \Gamma_P X_P \\ & + \sum_{i=1}^{4} GFE_i + c_P + \varepsilon_P,\end{aligned} \tag{2}$$

where subscript P indicates the production side coefficients.

On the consumption side the key explanatory variable is the share of people who used the internet to purchase goods or services during the last three months. The data were provided by EuroStat, the statistics service of the European Commission (EUROSTAT, 2018). We generated the dependant variable based on the carbon sub-index of the ecological footprint (EF), provided by the Ecological Footprint Network (LIN et al., 2016). Unlike other accounts of emissions the EF captures not only the ones produced in one country, but also accounts for the *ecological backpack* carried by all goods imported and exported. Since the database provides the EF in the form of "global hectares", it was converted back to CO_2 emissions, based on average sequestration capacity of forests, which is the measure used to construct the EF in the first place. The control variables are the same as for the production side. Descriptive statistics of all variables entering the consumption side regression are provided in Table (II). The values diverge slightly from the ones provided in table (I); because – due to different data availabilities – the countries included in the analysis vary slightly.

TABLE II: Summary statistics of all variables entering the consumption side regression.

	mean	sd	min	max
ln*EFP*	5.77	1.36	2.43	7.88
ln*OnlineShopping*	-1.57	0.85	-3.91	-0.33
ln*GDP*	22.00	1.52	18.03	24.39
Urban	72.62	12.84	49.69	97.82
Manu	13.72	4.48	4.08	24.83
Agri	2.36	1.68	0.25	9.03
Serv	62.75	7.03	42.92	78.31

177 observations

The consumption side is estimated as follows:

$$\begin{aligned}\ln CO2_C = & \alpha_C \ln OnlineShopping + \beta_C \ln GDP \\ & + \gamma_C \ln GDP\_OnlineShopping \\ & + \Gamma_C X_C \\ & + \sum_{i=1}^{4} GFE_i + c_C + \varepsilon_C,\end{aligned} \tag{3}$$

where subscript C indicates the consumption side coefficients.

The countries entering the analysis, their descriptives and group assignments are displayed in Table (V) in the appendix. For the production side, the panel covers the years 1990-2009 and for the consumption side 2008-2014. The number of observations per group is displayed in Table (IV) in the appendix.

IV. RESULTS, DISCUSSION, AND OUTLOOK

A. Results

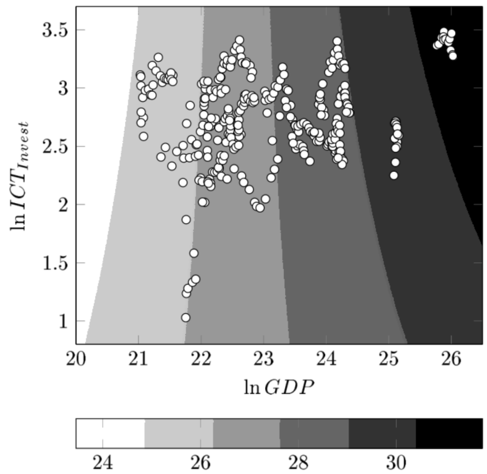
Results of both regressions are displayed in table (III). The inclusion of the interaction terms impedes a straightforward interpretation by simply observing the estimated coefficients. To facilitate an intuitive interpretation, figures (1) and (2) visualize the effect of digitalization within the range of the GDP and digitalization levels in the data in the form of heatmaps.

TABLE III: Regression results.

VARIABLES	(1) $\ln CO_2$	(2) $\ln EFP$
ln*ICTinvest*	-3.835***	
	(0)	
ln*GDP_ICTinvest*	0.171***	
	(0)	
ln*OnlineShopping*		-2.055***
		(6.88e-05)
ln*GDP_OnlineShopping*		0.0826***
		(0.000356)
ln*GDP*	1.577***	-0.190
	(0.000139)	(0.706)
lnGDP^2	-0.0195**	0.0247**
	(0.0456)	(0.0331)
Urban	0.0290***	0.00841***
	(0)	(0.00283)
Manu	0.00705*	0.0412***
	(0.0888)	(4.63e-06)
Agri	0.0669***	0.157***
	(0)	(4.83e-08)
Serv	-0.0231***	0.00433
	(2.88e-09)	(0.549)
Assignment1	-0.438***	0.742***
	(0)	(3.61e-09)
Assignment2	0.448***	0.879***
	(0)	(0)
Assignment3	0.734***	0.801***
	(0)	(0)
Assignment4	0.253***	0.424***
	(0)	(1.64e-05)
ε	-21.12***	-4.855
	(6.41e-06)	(0.395)
Observations	318	177
R^2	0.989	0.957

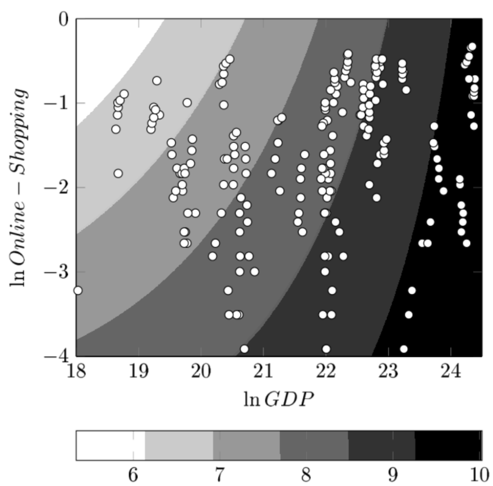
pval in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Fig. 1: Effects of ln*ICT-Investments* and ln*GDP* on CO_2 emissions produced within the country.



The shading indicates the size of the EF of the respective measure. The dots represent the distribution of ln*ICT-investments* and $\ln GDP$ of all countries in our sample.

Fig. 2: Effects of ln*Online-Shopping* and ln*GDP* on CO_2 emissions (including imported emissions).



The shading indicates the size of the EF of the respective measure. The dots represent the distribution of $\ln Online - Shopping$ and $\ln GDP$ of all countries in our sample.

B. Discussion

Figure (1) shows that the effects of digitalization in production on emissions depend on the level of GDP in a given country. In the lower quartile of the GDP distribution, increasing levels of digitalization lead to a reduction in environmental throughput, while for the upper quartile the opposite is true. At the sample mean the effect is more ambiguous.

On the consumption side (Figure 2) the effects appear clearer: digitalization leads to a reduction in environmental throughput. However, the effect grows weaker as GDP increases.

For both production and consumption, the effects of digitalization on environmental throughput appear to be relatively small compared with the effects of GDP. Nevertheless, the effect may still be substantial. To fully understand the marginal effects, we differentiate the parametrized equations with respect to their respective measurements of digitalization, ICT investments, and online shopping behaviour.

Differentiating equation (1) with respect to $Digi$ yields

$$\begin{aligned}\frac{\partial \ln CO_2}{\partial Digi} =& \alpha Digi^{-1} + \gamma \frac{1}{GDPDigi} GDP \\ =& \frac{\alpha + \gamma}{Digi}\end{aligned} \quad (4)$$

On the production side, equation (4) yields -0.22 at the sample mean. At this point in the data, an increase in ICT investments by 10% (that is, by 1.65) would decrease $\ln CO_2$ by 0.3664. This amounts to 5.6% of all CO_2 emissions caused in production, *ceteris paribus*.

The computation is the same on the demand side. At the sample mean, an increase in Online Shopping by 10% would decrease $\ln CO_2$ caused through a country's consumption by 3.4%, *ceteris paribus*.

C. Outlook

The global effects of digitalization are widespread and far-reaching in scope, encompassing multiple industries and sectors (Hilty et al., 2014; Williams, 2011; Börjesson Rivera et al., 2014b). This work specifically focuses upon two aspects central to digitalisation. On the production side, we focus on the life cycle impacts reflected through the ever-increasing use of digital hardware, proxied by firms' ICT investments. On the consumption side, digitalization manifests itself in a general proclivity and openness of consumers towards digitalization (second and third order effects), which can be measured effectively through online shopping behaviour.

However, one potential caveat of this study that must be taken into account is the potentially questionable validity of online shopping behaviour as a proxy for consumer openness towards digital services. To account for this potential weakness, the next step is to expand upon the study by testing our results for robustness by adding more dimensions on the consumer side, in order to provide a more complete picture of consumer-side digitalization. This can be achieved by executing our existing analysis with an index composed of data on more second-order effects, including media substitution, process optimization, and externalization of control. These can include data on internet penetration rates, average internet speed, share of Netflix subscriptions vs. DVD rentals, quantity of decentralised energy systems/smart grids, sales of Amazon Kindles, *inter alia*. These data would then need to be normalized and aggregated to an index.

V. Conclusion

To the best of the authors' knowledge, this paper is one of the first to analyze the impact of increased digitalization on environmental throughput at the macroeconomic level. It is the first paper that differentiates between consumption and production side effects. We make use of a unique dataset linking national CO_2 emissions to digitalization in production and net CO_2 levels after trading to data on digitalization levels in consumption. To answer the research questions, we apply the newly developed Group Effects estimator.

The results of this study provide the first evidence of its kind that the CO_2-decreasing benefit of digitalization might outweigh its environmental costs. Indeed, there is evidence that the net effect of digitalization on CO_2 emissions and environmental throughput are in fact positive. However, supplemental research is required to test the robustness of these results against a wider range of digitalization measures on the consumption side.

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VI. APPENDIX

TABLE IV: Observations per group.

	N production	N consumption
1	52	41
2	73	152
3	46	35
4	117	77
5	75	52

VI Appendix

TABLE V: Mean values of key variables.

	CO_2	*ICTinvest*	*assignment prod.*	*EF*	*OnlineShopping*	*assignment cons.*	*GDP*
Australia	1367	18.54	4	1838			1.3e+10
Austria	289	11.32	2	391	0.36	2	5.5e+09
Belgium	399			544	0.30	2	7.1e+09
Bulgaria	197			267	0.10	5	9.0e+08
Canada	2318	16.75	2	3126			2.5e+10
Croatia	91			120	0.13	4	1.0e+09
Czechrepublic	526			728	0.17	3	3.8e+09
Denmark	232	20.51	5	306	0.57	4	4.5e+09
Estonia	82			106	0.17	1	3.6e+08
Finland	282	11.09	4	268	0.41	1	3.6e+09
France	1513	15.49	5	1963	0.39	2	3.4e+10
Greece	312			423	0.13	4	4.0e+09
Hungary	210			273	0.20	3	2.6e+09
Ireland	187	10.15	3	247	0.34	4	3.3e+09
Italy	1829	12.48	2	2359	0.11	2	3.2e+10
Japan	4973	13.27	5	6403			8.1e+10
Latvia	31			42	0.14	5	4.0e+08
Lithuania	62			79	0.11	5	6.8e+08
Luxembourg	37			49	0.51	2	7.0e+08
Malta	10			13	0.32	5	1.3e+08
Montenegro	10			13	0.04		6.8e+07
Netherlands	694			880	0.52	2	1.2e+10
Newzealand	130	20.56	4	160			1.7e+09
Norway	279			292	0.55	1	8.4e+09
Poland	1478			1948	0.20	2	8.8e+09
Portugal	201			276	0.12	3	3.5e+09
Romania	461			626	0.04	4	3.6e+09
Serbia	243			324	0.03		7.6e+08
Slovakia	168			237	0.23	2	1.7e+09
Slovenia	71			101	0.19	2	8.4e+08
Southkorea	1996	11.17	3	2641			1.2e+10
Spain	1282	13.78	4	1680	0.20	3	2.0e+10
Sweden	241	22.65	1	322	0.52	5	6.6e+09
Switzerland	163	16.66	1	229	0.62		7.2e+09
Turkey	1554			2061	0.05	4	1.6e+10
Unitedkingdom	2076	23.58	4	2669	0.63	2	3.1e+10
Unitedstates	20518	29.54	2	26680			1.8e+11

Blank spots in the table refer to non-observed values in the respective dataset.