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Tinbergen Institute Discussion Paper



Dynamics and Determinants of Energy Intensity in the Service Sector: A Cross-Country Analysis, 1980-2005

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Dynamics and Determinants of Energy Intensity in the Service Sector: A Cross-Country Analysis, 1980–2005

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Abstract

We present a detailed analysis of energy intensity developments across 23 service sectors in 18 OECD countries over the period 1980–2005. We find that the shift towards a service economy has contributed to lower overall energy intensity levels in the OECD, but this contribution would have been considerably larger if the service sector had realized the same degree of energy efficiency improvements as the manufacturing sector. In most OECD countries actual energy intensity levels in the service sector tend to decrease relatively slow, especially after 1995. If we control this trend for the impact of structural changes within the services sector – by means of a decomposition analysis – we find that in about one-third of the OECD countries, energy intensity levels in the service sector have increased over time. The impact of structural changes on aggregate energy intensity dynamics in the service sector has increased considerably after 1995, highlighting a relatively poor energy efficiency performance within a wide range of service sectors. We show that the introduction of Information and Communication Technology (ICT) plays a potentially important role here. Using spatial panel data regression analysis, we find a limited role for energy prices in explaining variation in energy productivity, casting doubt on the effectiveness of price instruments to enhance energy efficiency in the service sector. In contrast, climate conditions have a clear impact on energy productivity, especially the number of heating days.

Keywords: energy intensity, convergence, decomposition, sectoral analysis, service sector

JEL codes: O13, O47, O5, Q43

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1. Introduction

Climate change and energy security are among the major challenges facing the world economy in the 21st century. In view of these challenges, surprisingly little is known about energy efficiency in the service sector. Existing studies that study energy efficiency dynamics across countries traditionally focus on the energy intensive industries in the manufacturing sector (see, for example, Howarth et al. 1991, Eichhammer and Mannsbart 1997, Miketa and Mulder 2005, Mulder and De Groot 2007, Unander 2007, Park et al. 1993).² The typically held view is that the service sector is of less importance given its relatively limited use of energy. Furthermore, it is often assumed that the sectoral transition from manufacturing towards services in developed countries may serve to alleviate the environmental and security concerns related to the use of energy. This view on energy use in the service sector may, however, be challenged for at least two reasons. First, across the world the service sector is growing relatively fast (in absolute terms and as a share of GDP) as economic development proceeds, which obviously lead to a relatively fast growth of energy consumption in the service sector. Second, energy consumption patterns in the service sector change as a result of the fact that production processes within the service sector have undergone drastic changes, most notably in response to the advent of Information and Communication Technology (ICT). Depending on which trends prevail, future policies for that matter will have to take the service sector serious in efforts aimed at developing a sustainable future economic development.

Against this background, this paper presents a detailed analysis of the evolution of energy intensity (i.e., the ratio of energy input to economic output) in the service sector for 18 OECD countries over the period 1980–2005. Together, in 2005 these 18 countries are responsible for nearly 65% of world GDP and world energy consumption in the service sector. Typically, cross-country studies come at the price of limited sectoral detail, which may mask substantial heterogeneity in output and productivity growth within the aggregate sector (see, for example, Huntington 2010, Jorgenson 1984, Mulder and De Groot 2007). In contrast, using a new database, we combine our cross-country perspective with a high level of sector detail, distinguishing 23 subsectors in services. To the best of our knowledge, we are the first to analyze the energy intensity developments in the service sector with this degree of sectoral, cross-sectional and temporal coverage. We document and compare both levels and growth rates of energy intensity, and identify to what extent aggregate energy dynamics in the service sector can be explained from, respectively, technological progress and shifts in the underlying sector structure. Finally, we identify determinants of the observed energy intensity trends, with special attention for the role of ICT.

Tables 1 and 2 present some first evidence on the dynamics in the service sector, which substantiates the increasing relevance of the service sector in terms of energy consumption and energy dynamics. Table 1 shows the evolution of the relative weight of the service sector in the total economy over time, both in terms of value added and energy consumption. It can be seen that across the 18 OECD countries in our sample, in 2005 the service sector is responsible for about two-third of total value added and one-fifth of total energy consumption. Interestingly, Table 1 shows that the value added share has increased at a fairly

² Recent exceptions include Florax et al. (2011), Huntington (2010), and Mairet and Decellas (2009).

modest speed over time, whereas the energy share has increased considerably – even up to 25% in main Western European countries (EU6) and Japan.³

Table 1. Share of the service sector in the total economy

	Level						Change (in %)	
	Value added (in %)			Energy (in %)			Value added	Energy
	1980	1995	2005	1980	1995	2005	1995–2005	1995–2005
USA	65	68	68	14	16	18	0	13
JPN	55	58	60	11	18	23	5	25
OECD9	62	66	67	14	16	18	1	18
EU6	62	68	70	12	13	16	3	25
OECD18	—	66	67	—	16	18	1	15
EU15	—	67	69	—	15	17	2	11
EU4	—	70	66	—	22	19	–6	–15

Source: See Mulder and De Groot (2012) and Section 2 for details on the dataset.

Table 2 provides for the various (clusters of) countries and different time periods studied in this paper the average annual growth rates of energy intensity in the service sector, in comparison with energy intensity growth rates in the total economy and the manufacturing sector. The table clearly reveals that the decline in manufacturing energy intensity levels has been substantially larger than the decline in services energy intensity levels, especially in the period after 1995. The service sector shows a very modest decrease in energy intensity levels at best. An exception to this pattern is the service sector in Japan, which is even characterized by a persistent and considerable increase in energy intensity over time, especially in the period 1980–1995. Also, the group of four new EU member states (former Eastern Europe) is somewhat special in that they exhibit a relatively strong decrease in energy intensity between 1995–2005, presumably because of a catching-up effect following their turn to market economies (cf. Markandya et al. 2006, Mulder and De Groot 2012). Nevertheless, even in the EU4 sample, the decline in services energy intensity levels has been relatively small – less than half of the decrease in the manufacturing sector. Together with the relatively rapid increasing energy share of the service sector (Table 1), this trend – if continued – implies that the emergence of a service economy is not automatically good news from an energy consumption point of view.

³ The cluster of four formerly Eastern European countries (EU4) is an exception in that in those countries on average the relative size of the Service sector has declined between 1995 and 2005, especially in terms of energy consumption. This is due to exceptional growth of the manufacturing sector in these countries, following their turn to market economies at the beginning of the 1990s.

Table 2. Energy intensity growth rates across sectors and time periods

	Average annual growth rate									Growth difference Service and Manufacturing*		
	1980–2005			1980–1995			1995–2005			1980–2005	1980–1995	1995–2005
	SRV	MAN	TOT	SRV	MAN	TOT	SRV	MAN	TOT	SRV-MAN	SRV-MAN	SRV-MAN
USA	-1.8	-3.7	-2.4	-2.2	-2.0	-2.3	-1.3	-6.4	-2.6	-1.9	0.2	-5.0
JPN	1.8	-2.5	-0.8	2.5	-2.5	-0.6	0.8	-2.5	-1.0	-4.4	-5.1	-3.3
OECD9	-0.7	-2.8	-1.9	-1.3	-1.9	-1.9	-0.4	-4.3	-1.9	-2.1	-0.5	-3.8
EU6	-0.7	-1.5	-1.3	-1.4	-0.8	-1.1	0.3	-1.8	-1.5	-0.8	0.6	-2.1
OECD18	—	—	—	—	—	—	-0.6	-4.0	-1.9	—	—	-3.4
EU15	—	—	—	—	—	—	-0.9	-2.0	-1.8	—	—	-1.1
EU4	—	—	—	—	—	—	-2.4	-5.2	-1.4	—	—	-2.8

Source: See Mulder and De Groot (2012) and Section 2 for details on the dataset.

* A negative difference means that the decrease in the energy intensity growth rate in services is smaller than in manufacturing. SRV= Services; MAN = Manufacturing; TOT = Total Economy (SRV+MAN+Construction+Agriculture). We refer to Table 4 for the country groupings.

The setup of this paper is as follows. In Section 2 we describe our data. Section 3 presents stylized facts on levels and changes in energy consumption and energy intensity across countries, in both the aggregate service sector and its various subsectors. In Section 4 we present the results of a decomposition analysis that separates the role of technological progress from shifts in the underlying sector structure in driving aggregate energy intensity dynamics in the service sector. This exercise yields insights into the realized potential of energy saving technological progress during the period 1980–2005 – which is, for example, of great interest in view of maintained arguments that energy saving is particularly difficult in energy extensive sectors (see, for example, Florax et al. 2011). We complete our analysis in Section 5 with a panel data regression analysis aiming to identify key determinants of cross-sectional and temporal energy intensity dynamics in the service sector, with special attention for the potential role of the emergence of Information and Communication Technology (ICT) after 1995. Section 6 concludes.

2. Data description

We make use of a new dataset developed by Mulder and De Groot (2012), which is based on the EU KLEMS database (O’Mahony and Timmer 2009). The latter contains sector-specific measures of output, inputs and productivity, derived from a consistent framework of national accounts and supply-and-use tables, and processed according to agreed procedures by EU KLEMS consortium partners with cooperation of national statistical offices. Since the EU KLEMS database includes information on energy inputs, our analysis does not rely on an ad-hoc combination of energy data and economic data from different sources, which typically characterizes empirical cross-country studies in the field of energy economics (see, for example, Duro et al. 2010, Duro and Padilla 2011, Mairret and Decellas 2009, Miketa

and Mulder 2005, Mulder and De Groot 2007, Unander 2007). Another major advantage of this dataset is its high level of sector detail, which enables us to make a consistent comparison of sector-specific energy-intensity trends across countries.

In this study we consider 23 service sectors (9 main sectors and 14 subsectors), as listed in Table 3. In terms of geographical coverage, our dataset includes 18 OECD countries: 11 EU-15 countries (Austria, Belgium, Denmark, Finland, France, Germany, the Netherlands, Portugal, Spain, Sweden and the United Kingdom), four new EU member states (Czech Republic, Hungary, Poland and Slovakia), the USA, Japan and South Korea. Our study covers the period 1980–2005. However, because of data availability and the rise of ICT since 1995, we distinguish in our analysis the periods 1980–1995 (for nine countries) from the period 1995–2005 (for 18 countries). To ensure comparability of data across countries, we cluster countries in various groups, as listed in Table 4.

Table 3. Sector classification of the service sector

Sector	NACE rev1 code
WHOLESALE AND RETAIL TRADE	G
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	50
Wholesale trade and commission trade, except of motor vehicles and motorcycles	51
Retail trade, except of motor vehicles and motorcycles; repair of household goods	52
HOTELS AND RESTAURANTS	H
POST AND TELECOMMUNICATIONS	64
FINANCIAL INTERMEDIATION	J
Financial intermediation, except insurance and pension funding	65
Insurance and pension funding, except compulsory social security	66
Activities related to financial intermediation	67
RENTING, COMPUTER, R&D and OTHER BUSINESS	71 to 74
Renting of machinery and equipment	71
Computer and related activities	72
Research and development	73
Other business activities	74
PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECURITY	L
EDUCATION	M
HEALTH AND SOCIAL WORK	N
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	O
Sewage and refuse disposal, sanitation and similar activities	90
Activities of membership organizations nec	91
Recreational, cultural and sporting activities	92
Other service activities	93

Table 4. List of countries in the database

	Country	Code	Country groups used in this study				
			1980–2005		1995–2005		
			OECD9	EU6	OECD18	EU4	EU15
1	Austria	AUT	✓	✓	✓		✓
2	Belgium	BEL			✓		✓
3	Czech Republic	CZE			✓	✓	✓
4	Denmark	DNK	✓	✓	✓		✓
5	Finland	FIN	✓	✓	✓		✓
6	France	FRA	✓	✓	✓		✓
7	Germany	GER			✓		✓
8	Hungary	HUN			✓	✓	✓
9	Japan	JPN	✓		✓		
10	Korea	KOR	✓		✓		
11	The Netherlands	NLD			✓		✓
12	Poland	POL			✓	✓	✓
13	Portugal	PRT			✓		✓
14	Spain	SPA	✓	✓	✓		✓
15	Slovakia	SVK			✓	✓	✓
16	Sweden	SWE			✓		✓
17	United Kingdom	UK	✓	✓	✓		✓
18	United States	USA	✓		✓		

We measure energy intensity by the ratio of intermediate energy input to gross value added. Value added data originate from National Accounts and have been converted to constant 1997 US\$, using a new and comprehensive dataset of industry-specific Purchasing Power Parities (PPPs). In the EU KLEMS project these PPP series were constructed by double deflation of gross output and intermediate inputs within a consistent input-output framework. Energy data consist of expenditure-based intermediate inputs that encompass all energy mining products, oil refining products and electricity and gas products. Using detailed supply-and-use tables, energy expenditures at the sector-level have been deflated in the EU KLEMS project by the relative price index of each fuel (energy carrier). Finally, because these intermediate energy input series are provided in volume indices, Mulder and De Groot (2012) have matched these with final energy consumption data provided by the International Energy Agency (IEA), to obtain energy consumption in kilo tonnes of oil equivalent (ktoe). The latter allows us to not only assess energy intensity growth rates, but also energy intensity levels across countries and subsectors.

To analyze the role of ICT in driving energy intensity trends in the services sector (see Section 5), we make use of EU KLEMS information on ICT capital services per hour worked, in constant US\$. It has been derived from the share of ICT assets in total asset compensation, based on agreed procedures concerning capital compensation including imputation for negative rentals. Furthermore, we control in our analysis for the impact of energy prices as well as heating and cooling days. Energy prices are sector-specific and defined as expenditures on intermediate energy inputs per ktoe, in constant 1997 US\$. Data about heating and cooling degree days originate from the World Resources Institute (WRI).

3. Trends

Evolution of energy intensity over time

Figure 1 shows for the various (clusters of) countries the evolution over time of energy intensity levels in the aggregate service sector. From the figure it can be seen that the dominant pattern (in the USA, OECD9, EU6, OECD18) is a very modest decrease in energy intensity levels, especially since the 1990s, with a temporary modest increase in energy intensity levels during approximately the period 1996–2003. A clear exception to this pattern is the service sector in Japan, which is characterized by a persistent and considerable increase in energy intensity since the first half of the 1980s. Also, the group of four new EU member states (former Eastern Europe) is somewhat special in that they exhibit a relatively strong decrease in energy intensity between 1995–2005, presumably because of a catching-up effect following their turn to market economies (Markandya et al. 2006, Mulder and De Groot 2012).

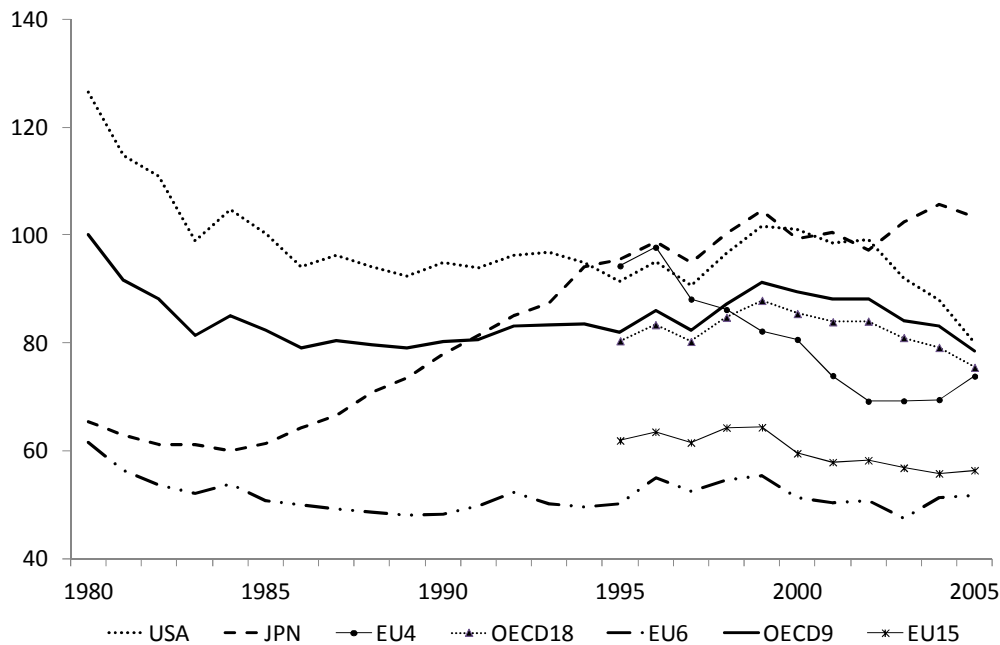


Figure 1. Energy intensity levels; index, relative to OECD9 in 1980 (OECD9 in 1980=100).

From Table 5 it can be seen that countries as diverse as Austria, Belgium, Finland, Japan, South Korea, the Netherlands, Spain and the UK exhibit positive growth rates of energy intensity in their service sector (i.e., increasing levels of energy intensity). This result is in sharp contrast with the aggregate economy level and the manufacturing sector, where most countries exhibit negative energy intensity growth rates and thus a decreasing energy-activity ratio (Mulder and De Groot 2012). Table 5 leads to a couple of observations. First, in the service sector changes in energy intensity levels differ substantially across countries, varying from an average annual increase of 3.0% in Austria to an average annual decrease of 3.6% in Denmark, measured over the period 1980–2005. Across all periods these cross-country

differences are considerably larger than in Manufacturing (cf. Mulder and De Groot 2012). Second, in contrast to manufacturing, in a range of countries growth in value added does not keep up with growth in energy use, resulting in increasing energy intensity levels in services. This trend is particularly strong in Austria, Finland and Japan, but also present in Spain and the United Kingdom. Third, in virtually all countries aggregate energy use in services increased over the past several decades, except for Denmark and after 1995 also for Hungary and Slovakia.

Table 5. Change in energy use, value added and energy intensity at the aggregate Services level; average annual growth rates

growth rate	Energy Intensity			Energy Use			Value Added		
	1980	1980	1995	1980	1980	1995	1980	1980	1995
	-2005	-1995	-2005	-2005	-1995	-2005	-2005	-1995	-2005
Austria	3.0	3.4	2.4	5.3	5.9	4.4	2.2	2.4	1.9
Belgium	0.8	2.9	-2.5	2.6	4.6	-0.3	1.9	1.6	2.3
Czech Republic	—	—	1.8	—	—	3.4	—	—	1.6
Denmark	-3.6	-3.1	-4.3	-1.3	-1.0	-1.8	2.3	2.1	2.5
Finland	1.5	1.7	1.3	3.6	3.2	4.1	2.0	1.5	2.8
France	-1.7	-2.7	-0.3	0.5	-0.4	1.7	2.2	2.4	2.0
Germany	-2.5	-3.1	-1.6	-0.3	-0.3	-0.1	2.3	2.8	1.5
Hungary	—	—	-6.6	—	—	-2.6	—	—	4.0
Japan	1.8	2.5	0.8	4.9	6.3	2.8	3.0	3.7	1.9
Korea	0.4	-2.4	4.4	6.3	5.0	8.4	5.9	7.5	3.7
The Netherlands*	0.4	1.7	-1.4	—	—	1.6	2.7	1.2	3.1
Poland	—	—	0.2	—	—	4.1	—	—	4.0
Portugal	-2.2	-2.9	-1.1	0.9	0.5	1.6	3.2	3.5	2.7
Spain	0.9	-2.1	5.5	4.0	0.4	9.7	3.1	2.6	3.9
Slovakia	—	—	-5.7	—	—	-2.6	—	—	3.2
Sweden	—	—	-3.1	—	—	-0.2	—	—	3.0
United Kingdom	1.0	1.6	0.1	4.1	4.1	4.2	3.1	2.5	4.1
USA	-1.8	-2.2	-1.3	1.3	0.8	2.1	3.2	3.0	3.5
OECD9	-0.7	-1.3	-0.4	2.1	1.7	2.7	3.1	3.0	3.1
EU6	-0.7	-1.4	0.3	2.0	1.0	3.4	2.7	2.4	3.1
OECD18	—	—	-0.6	—	—	2.3	—	—	2.9
EU15	—	—	-0.9	—	—	1.7	—	—	2.7
EU4	—	—	-2.4	—	—	1.0	—	—	3.5

Note: *Initial year 1987 instead of 1980, due to limited data availability.

Hypothetical development of energy intensity under various scenarios

Next, we take a closer look at the impact that the observed energy intensity dynamics in the service sector have for the energy intensity development of the total economy. To this aim we present in Figure 2, for four (key groups of) countries, three hypothetical development paths of energy intensity at the aggregate economy level under different assumptions regarding (i) the share of the service sector, and (ii) energy efficiency development in the service sector.

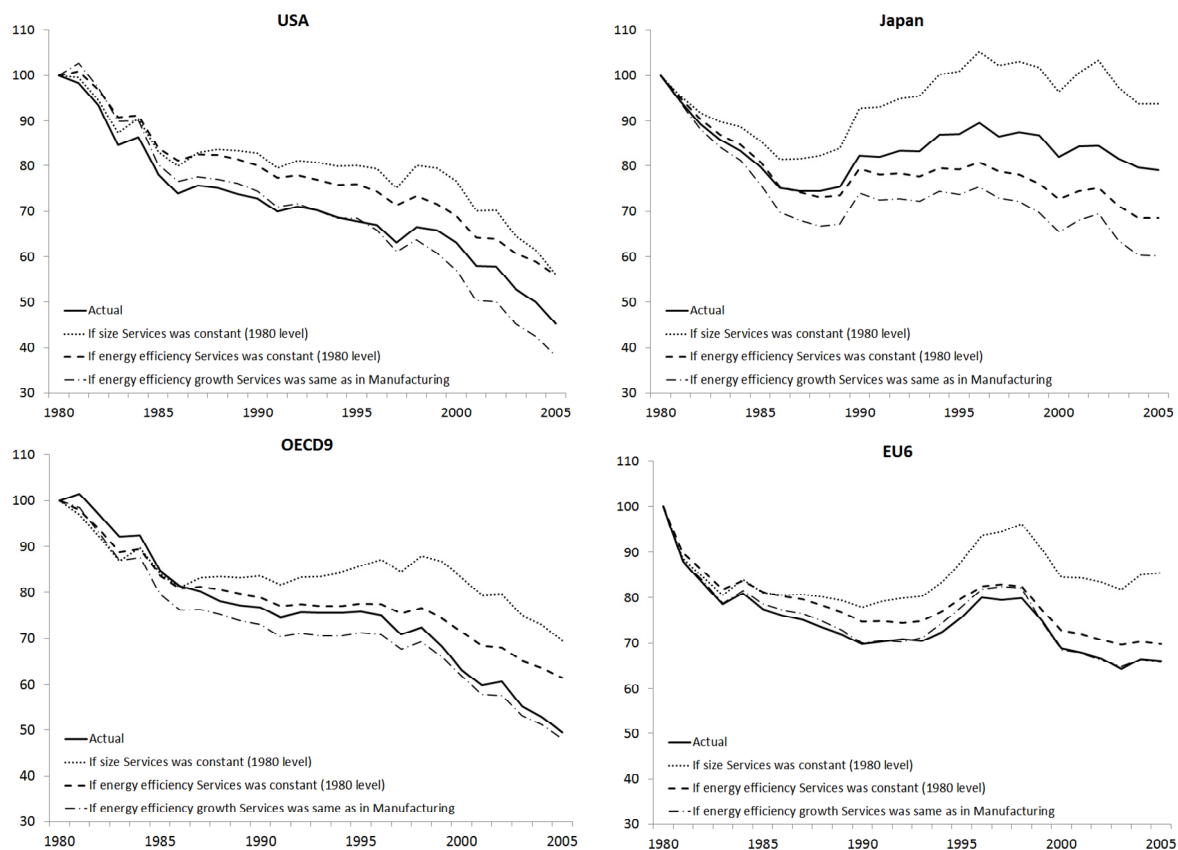


Figure 2. Aggregate (Total Economy) energy intensity trends under various scenarios

The bold line in the figure shows the actual (observed) total energy intensity level of the respective economies. As noted before (Table 2), it can be seen that energy intensity at the aggregate economy level has gradually decreased over time, especially in the USA and (thus) the OECD9 sample. The first of the remaining three hypothetical energy intensity lines shows the evolution of energy intensity levels in case the service sector would not have grown in size (measured in terms of value added) since 1980. The figure clearly shows that in all four country samples this would have led to a considerable higher overall level of energy intensity than the actual (observed) energy intensity level. Hence, the emergence of the service economy has substantially contributed to decreasing aggregate energy intensity levels in Western

economies. Hence, our data lend support to the idea that the sectoral transition from manufacturing towards services helps alleviating environmental and security concerns related to the use of energy. Obviously, this is due to the fact that the service sector is relatively energy extensive as compared to other sectors, most notably manufacturing and transport.

The second hypothetical line in Figure 5 shows what the evolution of overall energy intensity levels would have been in case the service sector would not have improved its energy efficiency since 1980. The figure clearly shows that, except for Japan, the assumption of no efficiency improvements in services would have led to higher overall energy intensity levels, but not as high as in the hypothetical case in which the service sector would not have grown beyond its 1980 size. This means that, except for Japan that features negative efficiency changes in the service sector, the rise of the service economy came along with a positive efficiency effect that contributed to a decrease in overall energy intensity levels. At the same time, the figure reveals that this efficiency effect was considerably smaller than the aforementioned structural effect. This insight is underlined by the third hypothetical line in Figure 2, which shows the evolution of overall energy intensity in case the service sector would have realized the same energy efficiency improvements as the manufacturing sector. It can be seen that across all samples this would have led to a lower overall energy intensity level than we actually observe, especially in the USA and Japan. This of course raises the question as to why energy efficiency improvements in the service sector have been relatively so modest. We return to this question in Sections 4 and 5.

Relative positions of countries

Figure 3 ranks countries according to their relative energy intensity performance in the aggregate service sector in 1995 and 2005. It can be seen that EU15 member states lead this ranking, while Japan, South Korea and former Eastern European countries are to be found at the bottom of this ranking. As regards these latter countries, it is to be noted that the relative performance of Japan and South Korea has deteriorated over time, while the opposite is true for Slovakia, Czech Republic and especially Hungary; also Poland is an exception, with a relatively low energy intensity level (top-5).

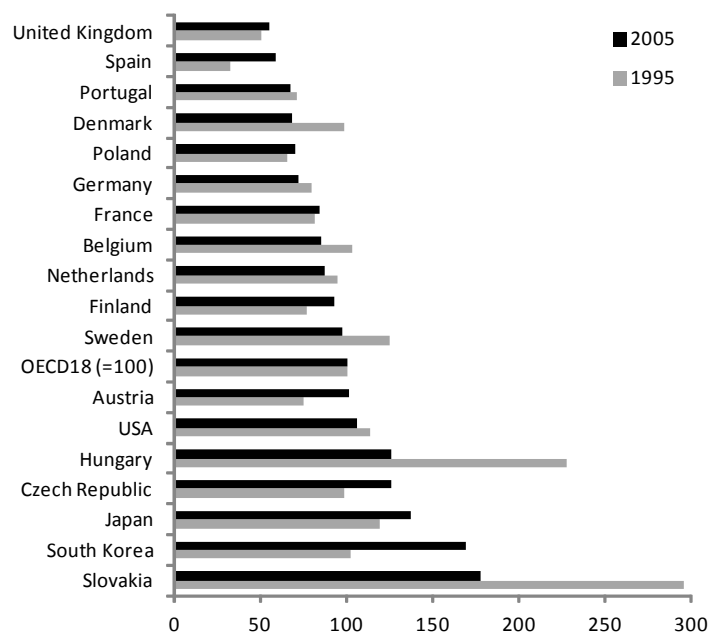


Figure 3. Energy intensity levels (Indexed; OECD18=100)

Dynamics of the service sector

Table 6 shows the evolution of the relative weight of the various subsectors in the total service sector over time, again both in terms of value added and energy consumption. It can be seen that in terms of energy consumption Wholesale and Retail Trade stands out as the dominant sector, although its relative weight has decreased considerably over time. In 2005 it was responsible for about one-third of all energy consumption in the service sector. In addition, the sectors Renting/Computer/R&D, Public Administration, Health and Social Work and Other Services each account for about 10% of total energy consumption in the Service sector; the remaining 30% is consumed by all other sectors. By and large, this pattern is alike in terms of value added, except for the sectors Financial Intermediation and Education, which pair a relatively small energy share to a relatively high value added share. Of course, this implies that these sectors exhibit relatively low levels of energy intensity (see also Figure 4).

Table 6. Shares service subsectors in total service sector - weighted average across countries

	Value added (in %)			Energy (in %)		
	1980	1995	2005	1980	1995	2005
Wholesale and retail trade	17	20	20	41	35	32
Hotels and restaurants	5	3	3	8	9	9
Post and telecommunications	3	4	6	1	3	4
Financial intermediation	9	10	11	3	4	4
Renting, computer, R&D, other business	10	11	13	10	9	10
Public administration and defence, compulsory social security	19	16	13	13	14	13
Education	15	14	12	5	5	6
Health and social work	16	15	15	8	10	11
Other community, social and personal services	6	7	6	9	10	11

Figure 4 ranks the various service sectors in terms of their relative energy intensity levels. It can be seen that relatively low levels of energy intensity are to be found in Education and sectors that deal with Financial Intermediation activities. Relatively high energy intensity levels within the service sector are to be found in the sectors Sewage and Refuse Disposal, Hotels and Restaurants and Automobile Retail. Overall, the highest relative decreases in relative energy intensity performance have been realized in the various Retail sectors.

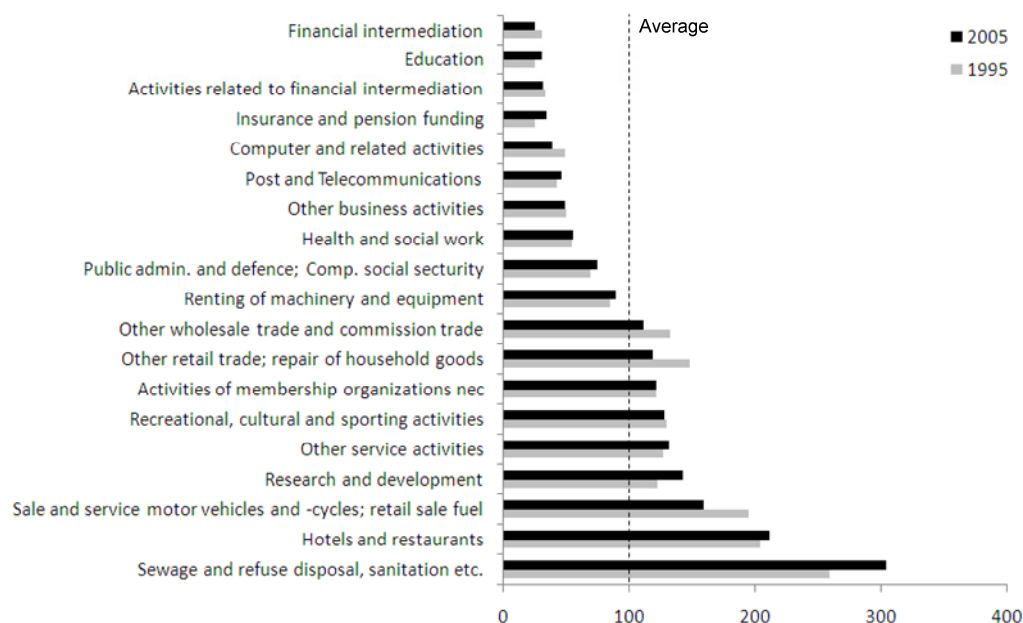


Figure 4. Relative energy intensity levels services sectors, average across all 18 countries (Indexed, average =100).

In Table 7 we translate the observed changes in aggregate energy intensity in the service sector (Table 5) into annualized growth rates for the 23 underlying subsectors, for the periods 1980–1995 and 1995–2005. For the aggregate service sector, the table shows that between 1980 and 2005 energy intensity decreased on average with 1.8% per year in the USA, 0.7% in the OECD9 and EU6 regions; after 1995 the pace of change slowed down to 1.3% in the USA and 0.7% in the OECD9 region, while the trend reversed in the EU6 region with 0.3% annual increase. In contrast, in Japan aggregate energy intensity in services increased, on average with 1.8% per year between 1980 and 2005 and 0.8% between 1995 and 2005. In the EU4 region energy intensity decreased with an average of 2.4% per year between 1995 and 2005.

In contrast to the aggregate economy and the manufacturing sector (see Mulder and De Groot 2012), underlying data reveal a slowdown of energy intensity decreases after 1995. In the USA most subsectors exhibit negative growth rates of energy intensity, especially in the trade and non-commercial service sectors. In Japan and the EU the picture is more diverse. In Japan especially the non-commercial service sectors exhibit relatively large positive growth rates of energy intensity. We refer to the Appendix for a listing of growth rates for individual service sectors per country, differentiated for the periods 1980–2005, 1980–1995 and 1995–2005.

Table 7. Energy intensity growth rates by service subsector.

	USA		JPN		OECD9		EU6		OECD18	EU15	EU4
	1980	1995	1980	1995	1980	1995	1980	1995	1995	1995	1995
	-2005	-2005	-2005	-2005	-2005	-2005	-2005	-2005	-2005	-2005	-2005
SERVICES	-1.8	-1.3	1.8	0.8	-0.7	-0.4	-0.7	0.3	-0.6	-0.9	-2.4
WHOLESALE AND RETAIL TRADE	-3.8	-2.9	0.0	-0.8	-2.9	-1.7	-1.4	0.4	-1.9	-1.5	-5.3
Sale and repair motor vehicles and -cycles; retail sale of fuel	-4.6	-5.1	5.0	-0.2	-2.3	-2.7	-0.2	1.2	-2.1	0.6	1.0
Other wholesale trade and commission trade	-4.3	-1.5	-1.9	0.3	-3.5	-0.8	-2.0	-0.3	-1.8	-3.3	-8.2
Other Retail trade; repair of household goods	-3.2	-4.2	1.8	-0.5	-2.2	-2.5	-1.1	1.0	-2.2	-0.1	-4.6
HOTELS AND RESTAURANTS	-0.3	-1.1	3.5	4.1	0.5	0.4	1.0	1.1	0.3	-0.2	-2.1
POST AND TELECOMMUNICATIONS	-2.6	-3.3	1.5	4.2	2.5	1.7	-1.3	-2.9	0.7	-3.7	-9.7
FINANCIAL INTERMEDIATION	-1.3	-1.7	-1.3	0.0	-1.0	-1.2	-0.3	-1.8	-0.8	-0.3	0.4
Financial intermediation, except insurance and pension funding	-2.6	-2.8	-1.5	-0.9	-1.8	-2.2	-1.1	-3.6	-2.1	-2.4	-3.5
Insurance and pension funding, except comp. social security	1.0	1.0	-0.6	2.3	5.0	1.9	3.8	1.0	3.0	6.4	10.1
Activities related to financial intermediation	—	—	—	—	-1.4	-1.4	-1.2	-1.9	-0.5	-0.7	-11.7
RENTING, COMPUTER, R&D and OTHER BUSINESS	-1.4	0.4	1.0	-1.3	-1.2	-0.2	-2.5	-2.0	-0.3	-1.7	-6.8
Renting of machinery and equipment	2.7	3.6	-13.1	-18.8	2.1	0.8	4.4	1.0	0.5	-0.9	-1.5
Computer and related activities	-3.2	-1.4	3.1	-1.1	-1.5	-2.5	-2.3	-2.7	-2.6	-2.9	-2.8
Research and development	-1.9	2.0	2.5	3.9	-0.5	2.6	-0.2	3.0	1.4	-0.7	0.5
Other business activities	-1.8	0.2	2.2	0.9	-1.8	-0.2	-3.4	-2.5	-0.2	-1.5	-7.8
PUBLIC ADMIN. AND DEFENCE; COMP. SOCIAL SECURITY	0.8	0.9	3.0	-0.6	1.2	0.7	0.6	1.6	0.7	0.8	-0.3
EDUCATION	-0.9	1.0	3.8	3.4	1.1	2.9	0.8	3.9	1.8	1.5	2.5
HEALTH AND SOCIAL WORK	-0.3	-1.0	2.4	0.6	1.1	1.2	0.2	1.5	0.2	-1.9	0.5
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	-2.5	-0.9	3.4	1.6	-0.9	-0.1	-0.8	-0.3	0.1	0.2	2.3
Sewage and refuse disposal, sanitation and similar activities	1.0	0.8	9.0	2.1	0.3	-0.1	-1.8	0.0	1.5	3.0	3.3
Activities of membership organizations n.e.c.	-2.8	-0.3	-0.3	-0.5	-2.1	0.0	-0.3	1.6	0.0	-0.1	-1.4
Recreational, cultural and sporting activities	-2.1	-1.1	4.1	1.2	0.1	-0.3	-1.1	-0.9	-0.2	-0.6	-0.1
Other service activities	-3.2	-1.7	1.6	2.1	-1.1	0.0	1.8	-0.4	0.3	-0.5	2.4

Sigma convergence

We conclude this section with a brief analysis of the evolution of cross-country differences in energy intensity levels over time for the main service sectors. This analysis builds on recent work on cross-country convergence of energy- or emission intensities (see, for example, Aldy 2006, Markandya et al. 2006, Liddle 2009, Miketa and Mulder 2005, Mulder and De Groot 2007, and Romero-Avila 2008). Convergence can be understood both in terms of levels and growth rates, which translates into a distinction between so-called σ -convergence and β -convergence (e.g., Barro 1991, Barro and Sala-i-Martin 1992). The former refers to a decreasing variance of cross-country differences in productivity or intensity levels, while the latter refers to a tendency of countries with relatively high (low) initial intensity (productivity) levels to grow relatively fast, building upon the proposition that growth rates tend to decline as countries approach their steady state (see Section 5).⁴

To measure cross-country differences in energy intensity we calculate for each sector the unweighted cross-country standard deviation of the log of energy intensity over time. Decreasing variance in energy intensity levels among countries is then taken as evidence for σ -convergence. Our analysis comprises the aggregate service sector and nine service subsectors (at 2-digit level). The results are depicted in Figure 5. The figure shows that, in general, in the service sector cross-country variation in energy intensity levels has decreased over time, indicating σ -convergence. When measured at the aggregate service sector level (top-left graph), the cross-country variance decreases relatively rapid until 1995. For the OECD9 sample it tends to stagnate between 1995 and 2003. As regards the subsectors, the figure reveals that by 2005 the highest degree of cross-country variation in energy intensity is to be found in the sectors Post and Telecommunication, whereas cross-country differences in energy intensity levels are relatively small in the sectors Wholesale and Retail Trade, Renting etc., Public Administration and Defense, and Education. Moreover, the figure shows that in most subsectors cross-country variation in energy intensity levels has decreased over time. This pattern of σ -convergence is particularly strong in the subsectors Wholesale and Retail Trade, Public Administration and Education. In contrast, there is evidence of σ -divergence in the sectors Hotels and Restaurants, Post and Telecommunication, Financial Intermediation, and Health and Social Work. In the sector Other Social Services cross-country variation in energy intensity levels remains more or less constant over time. In Table 8 we summarize these trends in percentage changes.

⁴ Note that β -convergence is a necessary but not a sufficient condition for σ -convergence to occur (cf. Galton's fallacy; see Quah 1993), implying that in cases where we find evidence for σ -convergence, we know for sure that β -convergence is also present.

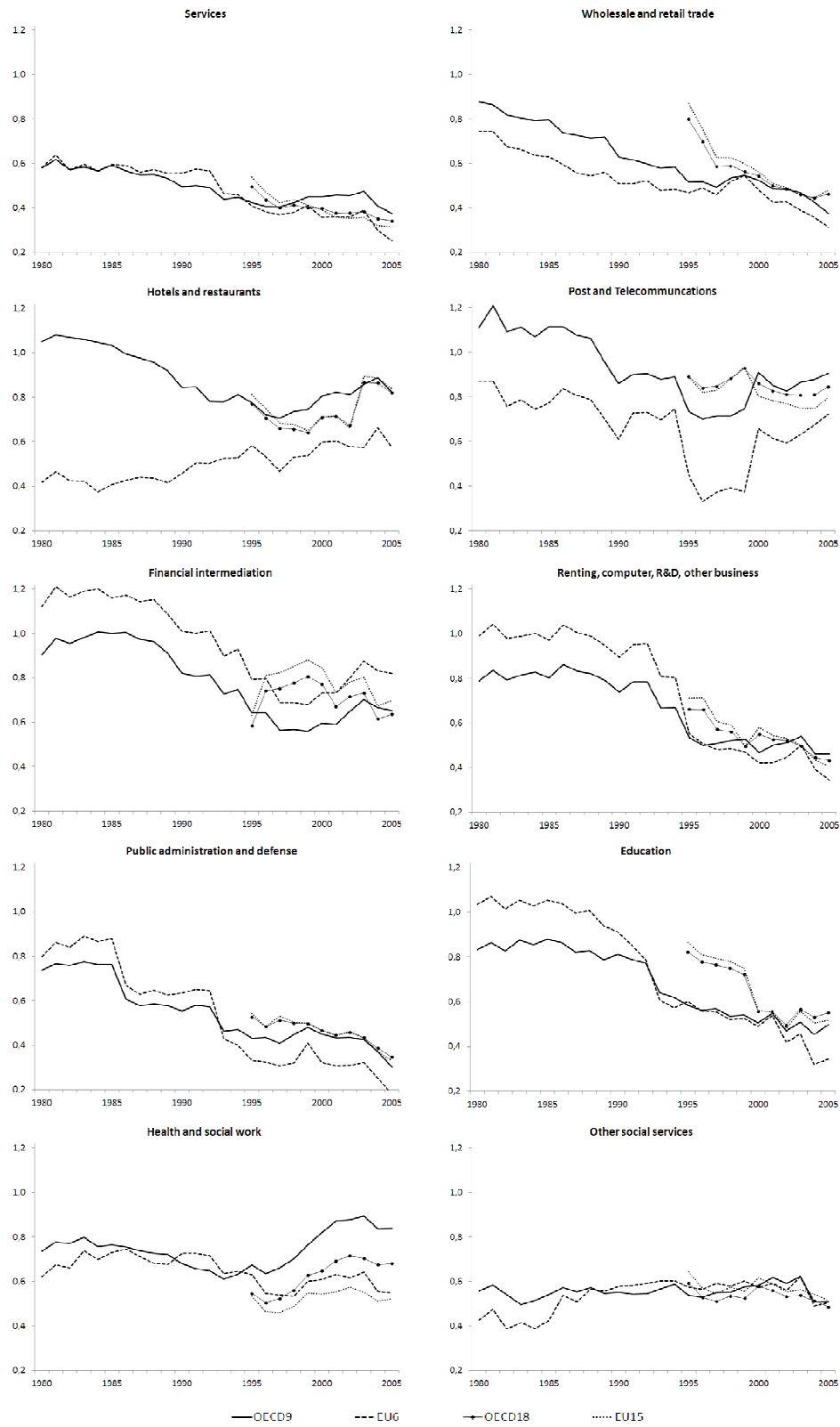


Figure 5. σ -convergence analysis, measured as standard deviation of $\log(\text{energy intensity})$

Table 8. Percentage change of σ in different time-periods and for different country groupings

	OECD9			EU6			OECD18	EU15	EU4
	1980– 2005	1980– 1995	1995– 2005	1980– 2005	1980– 1995	1995– 2005	1995– 2005	1995– 2005	1995– 2005
SERVICES	-0.35	-0.27	-0.11	-0.57	-0.30	-0.38	-0.31	-0.42	-0.46
WHOLESALE AND RETAIL TRADE	-0.57	-0.41	-0.27	-0.58	-0.37	-0.33	-0.42	-0.45	-0.46
Sale and repair motor vehicles and -cycles; retail sale of fuel	-0.56	-0.36	-0.32	-0.43	0.21	-0.53	0.01	0.08	0.13
Other wholesale trade and commission trade	-0.41	-0.40	-0.02	-0.40	-0.37	-0.05	-0.37	-0.40	-0.61
Other Retail trade; repair of household goods	-0.56	-0.32	-0.36	-0.73	-0.39	-0.55	-0.44	-0.49	-0.44
HOTELS AND RESTAURANTS	-0.22	-0.26	0.06	0.38	0.40	-0.02	0.06	0.03	0.50
POST AND TELECOMMUNICATIONS	-0.18	-0.34	0.23	-0.17	-0.48	0.61	-0.05	-0.10	-0.24
FINANCIAL INTERMEDIATION	-0.28	-0.29	0.02	-0.27	-0.29	0.03	0.09	0.10	-0.73
Financial intermediation, except insurance and pension funding	-0.12	-0.24	0.16	-0.05	-0.20	0.19	0.04	0.05	-0.65
Insurance and pension funding, except comp. social security	-0.56	-0.60	0.12	-0.56	-0.61	0.13	0.15	0.13	0.04
Activities related to financial intermediation									
RENTING, COMPUTER, R&D and OTHER BUSINESS	-0.42	-0.32	-0.14	-0.65	-0.44	-0.38	-0.35	-0.43	-0.51
Renting of machinery and equipment	-0.04	-0.37	0.52	-0.57	-0.36	-0.33	0.18	-0.23	-0.39
Computer and related activities	-0.02	-0.12	0.10	-0.41	-0.27	-0.20	-0.01	-0.11	-0.38
Research and development	0.24	0.39	-0.11	-0.01	0.33	-0.26	-0.18	-0.25	-0.48
Other business activities	-0.48	-0.39	-0.16	-0.59	-0.44	-0.27	-0.50	-0.55	-0.66
PUBLIC ADMIN. AND DEFENCE; COMP. SOCIAL SECURITY	-0.59	-0.42	-0.30	-0.78	-0.58	-0.46	-0.34	-0.39	-0.43
EDUCATION	-0.40	-0.30	-0.15	-0.67	-0.42	-0.43	-0.33	-0.40	-0.49
HEALTH AND SOCIAL WORK	0.14	-0.08	0.24	-0.12	0.01	-0.13	0.25	-0.02	0.31
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	-0.09	-0.04	-0.05	0.19	0.35	-0.12	-0.18	-0.20	-0.59
Sewage and refuse disposal, sanitation and similar activities	-0.41	-0.52	0.23	-0.20	-0.55	0.80	0.04	0.09	-0.15
Activities of membership organizations n.e.c.	-0.03	-0.16	0.15	0.38	0.12	0.22	-0.02	-0.03	-0.79
Recreational, cultural and sporting activities	-0.01	0.03	-0.04	-0.10	0.09	-0.17	-0.17	-0.22	-0.34
Other service activities	-0.40	-0.12	-0.32	-0.50	0.31	-0.62	-0.35	-0.47	-0.48

4. Decomposition analysis

Changes in energy intensity at the aggregate service level result not only from energy efficiency improvements in individual service sectors (the so-called efficiency effect), but also from changes in the composition of the service sector (the structural effect). The efficiency effect is supposedly largely driven by energy-saving technology adoption while the structural effect is caused by the fact that some sectors are more energy intensive (e.g. sewage and refuse disposal) than others (e.g. financial intermediation). By using index number decomposition (or shift-share) analysis, we can identify the role of these two effects in driving aggregate energy intensity changes in the service sector. In the field of energy studies this methodology has been widely used to decompose aggregate changes in energy use, energy intensity, or emission intensity (see Ang and Zhang 2000 and Liu and Ang 2007 for reviews). To describe the essence of index number decomposition methodology algebraically, let i denote the sectors of the economy and let Y and E represent output (value added) and energy consumption. Aggregate energy intensity I in the service sector defined as the ratio of energy to output in the aggregate service sector, can then be calculated as:

$$I = \frac{E}{Y} = \sum_i \frac{E_i}{Y_i} \frac{Y_i}{Y} = \sum_i I_i S_i . \quad (1)$$

In this equation, I_i represents the energy intensity of sub-sector i ; S_i is the share of sub-sector i in total value added. The efficiency effect can then be determined as a within-sector intensity effect, derived by controlling aggregate energy intensity for adjustments in the sectoral structure. Since both the structure effect and the efficiency effect change over time, one has to establish appropriate weights in order to measure the contribution of each effect. Decomposition analysis in the field of energy studies have used a variety of weights, which translates into a range of slightly different applied decomposition approaches (see Ang et al. 2003, Ang 2004, Ang et al. 2004, Boyd and Roop 2004, and Zhang and Ang 2001, for reviews and details). In this study we use the so-called log mean Divisia index method (LMDI I), as introduced by Ang and Liu (2001), which in its additive form decomposes a change in aggregate energy intensity (ΔI_{tot}) between period 0 and T into an efficiency effect (ΔI_{eff}) and a structure effect (ΔI_{str}) according to:

$$\Delta I_{eff} = \sum_i w_i \ln \left(\frac{I_i^T}{I_i^0} \right), \quad (2)$$

$$\Delta I_{str} = \sum_i w_i \ln \left(\frac{S_i^T}{S_i^0} \right), \quad (3)$$

where w_i is the weighting function defined as $w_i = L(V_i^T, V_i^0)$, with $V_i = \sum I_i S_i$ and L the logarithmic average of two positive numbers a and b given by $L(a, b) = (a - b) / \ln(a / b)$.⁵

In Table 9 we present the results of our decomposition analysis, for each country (group) and two time periods (1980–2005 and 1995–2005). We differentiate between the average annualized energy intensity growth rates before decomposition (gross) and after decomposition (net), i.e. after correcting for the impact of structural changes. Table 9 shows that in most countries energy intensity changes in the service sector have been influenced more by (technology-driven) efficiency improvements within sectors than by structural shifts in the composition of the service sector. Nevertheless, in some countries – most notably France, Japan, South Korea, Portugal and United Kingdom – these shifts are substantial, and in general the impact of structural effects on aggregate energy intensity has increased considerably after 1995.

⁵ This choice is primarily motivated by the ability of LMDI to satisfy the factor-reversal test, i.e. it provides perfect decomposition results without a residual. Moreover, it can effectively handle zero values, the results are invariant to scaling, and it satisfies the time-reversal test, i.e. estimated values between period 0 and T and period T and 0 are equal (in absolute terms). In the two-factor case, LMDI is equivalent to the Fisher ideal index method, defined as the geometric average of the Laspeyres and Paasche indices (Ang 2004, Boyd and Roop 2004). For these reasons the LMDI and Fisher ideal index methods have emerged as the preferred methods in energy decomposition analysis (Ang 2004).

Table 9. Decomposition of average annual growth rate of energy intensity in the service sector.

	Average annual growth rate				% Contribution of Efficiency and Structure Effect			
	1980–2005		1995–2005		1980–2005		1995–2005	
	Gross	Net	Gross	Net	Efficiency Effect	Structure Effect	Efficiency Effect	Structure Effect
Austria	3.0	3.1	2.4	2.4	103	–3	100	0
Belgium	0.8	0.9	–2.5	–2.3	119	–19	–91	–9
Czech Republic	—	—	1.8	–0.1	—	—	21	79
Denmark	–3.6	–3.5	–4.3	–3.9	–100	0	–86	–14
Finland	1.5	1.4	1.3	1.3	98	2	104	–4
France	–1.7	–1.9	–0.3	–0.4	–779	879	–278	178
Germany	–2.5	–2.3	–1.6	–1.5	–92	–8	–85	–15
Hungary	—	—	–6.6	–6.8	—	—	–103	3
Italy	—	—	—	—	—	—	–98	–2
Japan	1.8	2.1	0.8	0.9	117	–17	161	–61
South Korea	0.4	–0.6	4.4	3.9	–182	282	98	2
The Netherlands	0.4	0.6	–1.4	–1.0	147	–47	–69	–31
Poland	—	—	0.2	–0.2	—	—	–368	468
Portugal	–2.2	–1.6	–1.1	–0.5	–71	–29	–32	–68
Spain	0.9	0.9	5.5	5.5	101	–1	101	–1
Slovakia	—	—	–5.7	–6.4	—	—	–112	12
Sweden	—	—	–3.1	–2.7	—	—	–87	–13
United Kingdom	1.0	1.1	0.1	0.5	105	–5	460	–360
USA	–1.8	–2.1	–1.3	–1.3	–115	15	–110	10
OECD9	–0.7	–0.9	–0.4	–0.3	–130	30	–74	–26
EU6	–0.7	–0.8	0.3	0.4	–111	11	114	–14
OECD18	—	—	–0.6	–0.5	—	—	–78	–22
EU15	—	—	–1.0	–0.9	—	—	–86	–14
EU4	—	—	–2.6	–3.2	—	—	–127	27

Most importantly, Table 9 shows that after controlling for structural changes in the service sector, in about one-third of the OECD countries in our sample, energy intensity levels increase over time. Even stronger, the results reveal that in various countries structural changes obscure a poor within-sector energy efficiency performance. For example, measured over the period 1980–2005, net energy intensity levels increase faster than gross energy intensity levels in Austria, Belgium, the Netherlands, Japan, and the United Kingdom. For the latter two countries this also holds for the period 1995–2005. In addition, measured over the period 1995–2005, in Belgium, Denmark, France, Germany, the Netherlands, Portugal, and Sweden the observed decrease in gross energy intensity levels slows down once we correct for the

impact of structural changes in sector composition. For Denmark, Germany and Portugal this also holds for the period 1980–2005. In contrast, structural effects contribute to further energy intensity increases in the Czech Republic and South Korea (both after 1995), and slow down net energy intensity decreases in France, Hungary, Slovakia and (before 1995) the USA. Poland appears to be exceptional in that controlling for structural changes turns a positive gross energy intensity growth rate into a negative net energy intensity growth rate, i.e. into decreasing net energy intensity levels.

Together, these trends imply that, during the period 1995–2005, on average in the full sample of countries (OECD18), the observed 0.6% average annual decrease in observed gross energy intensity levels slows down to 0.5% per year, once we control for changes in the (sub-)sector composition of the service sector. For the aggregate OECD9 region, net energy intensity levels decrease between 1995 and 2005 on average with 0.3% per year, as compared to a 0.4% annual decrease of observed gross energy intensity levels. For the EU15 sample, the average annual decrease amounts to, respectively, 0.9% (net) and 1.0% (gross). In the group of Eastern European countries (EU4), these numbers are, respectively, 3.2% (net) and 2.6% (gross). In contrast, within the EU6 region, during the same period (1995–2005) net energy intensity levels increase on average with 0.4% per year, as compared to a 0.3% annual increase of observed gross energy intensity. During the whole period 1980–2005, the 0.7% average annual decrease of gross energy intensity levels at the OECD9 and EU6 samples, changes into, respectively, a 0.9% and 0.8% average annual reduction, once we correct for structural effects. These figures underline, once more, that especially after 1995, in many OECD countries the within-sector energy efficiency performance is worse than the observed gross energy intensity growth rates suggest – with a clear exception for Eastern European countries.

In order to examine the role of individual service subsectors in driving the aggregate results presented above, we identify for each individual subsector the percentage contribution of the total efficiency effect and the total structure effect to the aggregate service sector energy intensity growth rate. The results are presented in Tables 10a–c, again for the periods 1980–2005 and 1995–2005, and the same selection of (samples of) countries. The bottom line of the tables confirms that changes in aggregate service sector energy intensity result mainly from within-sector (technology-driven) efficiency changes, but that after 1995 and especially in Japan, the structure effects start to play a prominent role. Also, it confirms that in the USA, as well as in the EU6 and EU4 regions, structural changes contributed to increased energy intensity levels, whereas the opposite is true in Japan and the other regions.

The sectoral breakdown provided in Tables 10a–c shows that the efficiency effect is mainly realized within the various Wholesale and Retail sectors, as well as in Post and Telecommunication, Financial Intermediation and Other Business Activities. In Japan these achievements are undone by decreasing within-sector efficiency in the sectors Hotel and Restaurants, Public Administration and Defense, Education and Health and Social Work. Hence, these latter sectors predominantly drive the previously observed striking increase in aggregate service sector energy intensity in Japan. But also in some other regions within the OECD, Public Administration and Defense as well as Education feature considerable increases in within-sector energy intensity levels. It is also to be noted that the efficiency effect in the

sectors Post and Telecommunication and Financial Intermediation differs substantially across the various countries and regions. As regards the structural effect, the sectoral breakdowns provided in Tables 10a–c show that, in general, energy intensity increases are especially driven by the emergence of the sectors Post and Telecommunications and Financial intermediation. In contrast, energy intensity levels have mainly decreased under influence of a shift towards the sectors Hotel and Restaurants, Public Administration and (to a lesser extent) Education. Furthermore, it is to be noted that the rise of the sector Retail and Trade had a considerable mixed impact on energy intensity trends, depending on the country and region. Finally, the substantial overall impact of structural changes on decreasing energy intensity in Japan appears to mainly be caused by a shift towards the sectors Retail and Trade, Hotels and Restaurants, Public Administration and Education. We refer to the Appendix for more detailed country figures.

Table 10a. Percentage contribution of the efficiency effect (EFF) and the structure effect (STR) by sector to the annual growth rate of service sector energy intensity (TOT) in the period 1980–2005. GDP-weighted cross-country averages.

	USA			Japan			OECD9			EU6		
	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT
Sale, maintenance, repair motor vehicles and -cycles; retail sale of fuel	-22.8	12.2	-10.6	1.8	-0.5	1.3	-23.5	6.4	-17.1	-1.4	-11.6	-13.0
Other wholesale trade and commission trade	-39.3	12.5	-26.9	-8.4	5.4	-3.0	-82.7	31.7	-51.0	-75.9	21.7	-54.3
Other retail trade; repair of household goods	-31.1	4.7	-26.4	12.1	-10.2	1.9	-50.1	8.2	-41.9	-22.6	4.5	-18.1
Hotels and restaurants	-1.6	-7.1	-8.7	29.0	-19.4	9.6	6.8	-18.3	-11.5	11.3	-14.8	-3.5
Post and Telecommunications	-2.6	1.3	-1.4	3.5	7.4	11.0	6.9	7.0	13.9	-6.8	19.9	13.1
Financial intermediation, except insurance and pension funding	-4.2	4.8	0.6	-1.6	2.4	0.8	-7.3	9.9	2.6	-4.4	2.3	-2.1
Insurance and pension funding, except compulsory social security	0.3	-0.8	-0.4	-0.4	0.3	-0.1	6.1	-6.5	-0.4	27.7	2.8	30.4
Activities related to financial intermediation	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.6	0.4	-1.3	3.3	2.0
Renting of machinery and equipment	2.9	-1.3	1.7	-3.9	4.0	0.1	5.0	-0.2	4.8	8.4	-4.5	3.9
Computer and related activities	-1.0	2.2	1.2	3.7	-0.4	3.3	-2.2	6.2	4.0	-6.9	6.7	-0.2
Research and development	-0.7	0.8	0.1	2.4	1.6	4.0	-0.7	2.9	2.2	-0.5	-0.6	-1.1
Other business activities	-6.7	2.1	-4.6	3.7	2.7	6.3	-16.8	11.3	-5.5	-50.9	30.6	-20.3
Public administration and defence; Compulsory social security	5.6	-14.7	-9.0	20.7	-1.5	19.1	21.9	-26.7	-4.8	12.1	-31.7	-19.6
Education	-0.7	-0.6	-1.2	12.2	-4.4	7.9	5.4	-3.5	1.9	10.6	-15.3	-4.7
Health and social work	-0.9	-2.1	-3.0	19.9	2.5	22.5	13.4	-1.4	12.0	3.1	-5.7	-2.6
Sewage and refuse disposal, sanitation and similar activities	1.2	-2.5	-1.4	2.1	-0.9	1.2	0.8	-1.9	-1.1	-5.8	3.4	-2.4
Activities of membership organizations n.e.c.	-6.1	1.8	-4.4	-0.1	-0.8	-0.9	-9.1	2.3	-6.8	-0.6	-0.9	-1.5
Recreational, cultural and sporting activities	-3.1	2.3	-0.8	16.3	-5.0	11.3	0.6	3.9	4.5	-9.3	3.8	-5.5
Other service activities	-4.4	-0.4	-4.8	4.4	-0.8	3.6	-4.3	-1.7	-6.0	2.6	-3.3	-0.7
SERVICES	-115.3	15.3	-100.0	117.4	-17.4	100.0	-130.0	30.0	-100.0	-110.5	10.5	-100.0

Table 10b. Percentage contribution of the efficiency effect (EFF) and the structure effect (STR) by sector to the annual growth rate of service sector energy intensity (TOT) in the period 1995–2005. GDP-weighted cross-country averages.

	USA			Japan			OECD9			EU6		
	EFF Effect	STR Effect	TOT Effect	EFF Effect	STR Effect	TOT Effect	EFF Effect	STR Effect	TOT Effect	EFF Effect	STR Effect	TOT Effect
Sale, maintenance, repair motor vehicles and -cycles; retail sale of fuel	-32.3	23.2	-9.0	-0.2	0.8	0.6	-37.7	23.8	-13.8	14.6	-15.2	-0.6
Other wholesale trade and commission trade	-15.9	-4.5	-20.4	3.1	-10.7	-7.6	-25.1	-12.8	-37.9	-20.4	25.3	4.9
Other retail trade; repair of household goods	-51.4	25.5	-25.9	-9.6	-63.1	-72.7	-86.5	18.3	-68.1	32.2	-12.2	20
Hotels and restaurants	-7.1	-8.1	-15.2	82.5	-45.4	37.2	8.2	-27.3	-19.1	22.1	-15.9	6.2
Post and Telecommunications	-4.6	3.8	-0.8	25.1	28.2	53.2	10.6	25.7	36.3	-33.7	63.8	30.1
Financial intermediation, except insurance and pension funding	-7.5	7.0	-0.5	-2.5	1.7	-0.8	-16.4	14.9	-1.4	-28.3	14.9	-13.4
Insurance and pension funding, except compulsory social security	0.5	-1.4	-0.9	3.5	-5.0	-1.5	3.9	-6.4	-2.5	19	-21.1	-2.1
Activities related to financial intermediation	—	—	—	—	—	—	-0.4	1.2	0.8	-3.9	9.6	5.7
Renting of machinery and equipment	6.9	-4.4	2.5	-13.9	13.4	-0.5	3.8	2.4	6.2	4.3	1.2	5.5
Computer and related activities	-1.0	2.7	1.7	-4.4	3.1	-1.3	-7.8	12.2	4.3	-13.4	25.5	12.1
Research and development	1.1	0.2	1.3	11.4	1.7	13.0	6.7	-0.2	6.5	11.3	-11.0	0.3
Other business activities	1.0	1.4	2.5	4.7	4.9	9.6	-3.1	12.1	9.0	-59.2	49.5	-9.7
Public administration and defence; Compulsory social security	9.3	-26.7	-17.5	-13.7	-11.2	-24.9	23.8	-65.7	-41.9	55.0	-63.2	-8.2
Education	1.0	-1.1	-0.1	29.6	-11.2	18.4	22.7	-11.3	11.4	82.3	-42.1	40.2
Health and social work	-5.4	-0.7	-6.1	14.0	48.5	62.6	26.5	-0.4	26.1	39.9	-24.2	15.7
Sewage and refuse disposal, sanitation and similar activities	1.4	-4.7	-3.3	2.1	-2.0	0.1	-0.5	-3.8	-4.3	-0.1	3.5	3.4
Activities of membership organizations n.e.c.	-1.0	-2.6	-3.5	-0.2	-0.8	-1.0	0.1	-5.9	-5.8	5.9	-7.8	-1.9
Recreational, cultural and sporting activities	-2.4	1.4	-1.0	14.9	-9.2	5.6	-2.9	2.8	0.0	-12.7	9.6	-3.1
Other service activities	-2.7	-1.0	-3.7	14.4	-4.3	10.1	0.1	-5.8	-5.7	-1.1	-4.1	-5.2
SERVICES	-110.1	10.1	-100.0	160.8	-60.8	100.0	-73.8	-26.2	-100.0	113.8	-13.8	100

Table 10c. Percentage contribution of the efficiency effect (EFF) and the structure effect (STR) by sector to the annual growth rate of service sector energy intensity (TOT) in the period 1995–2005. GDP-weighted cross-country averages.

	OECD18			EU15			EU4		
	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT
Sale, maintenance, repair motor vehicles and -cycles; retail sale of fuel	-19.0	12.4	-6.6	2.5	-1.4	1.1	1.9	2.2	4.1
Other wholesale trade and commission trade	-40.3	-3.0	-43.2	-63.1	13.0	-50.1	-79.1	31.6	-47.4
Other retail trade; repair of household goods	-49.5	8.6	-40.9	-1.7	-4.2	-5.9	-24.1	2.5	-21.5
Hotels and restaurants	3.6	-17.0	-13.4	-1.5	-6.2	-7.7	-4.2	-7.3	-11.5
Post and Telecommunications	2.8	17.2	20.0	-13.3	16.9	3.5	-13.4	6.9	-6.6
Financial intermediation, except insurance and pension funding	-9.5	9.6	0.1	-5.2	4.6	-0.6	-2.8	3.5	0.6
Insurance and pension funding, except compulsory social security	4.4	-4.7	-0.2	8.8	-6.4	2.4	4.6	2.7	7.2
Activities related to financial intermediation	-0.1	0.6	0.4	-0.3	1.3	0.9	-1.3	0.7	-0.6
Renting of machinery and equipment	1.3	2.4	3.7	-0.9	1.4	0.6	-0.3	0.3	0.0
Computer and related activities	-5.1	8.3	3.2	-3.5	6.8	3.3	-0.7	2.3	1.5
Research and development	2.5	-0.1	2.4	-0.9	-2.1	-3.0	0.3	-3.9	-3.7
Other business activities	-2.3	5.7	3.5	-10.7	4.9	-5.8	-20.1	2.3	-17.8
Public administration and defence; Compulsory social security	14.1	-39.4	-25.3	10.1	-17.8	-7.7	-1.3	-0.1	-1.4
Education	12.2	-9.2	3.0	12.6	-13.1	-0.5	7.1	-2.7	4.4
Health and social work	2.8	0.1	2.9	-22.1	-3.8	-25.9	1.5	-9.8	-8.3
Sewage and refuse disposal, sanitation and similar activities	4.8	-6.2	-1.4	6.4	-3.8	2.6	4.9	0.2	5.0
Activities of membership organizations n.e.c.	-0.2	-3.6	-3.7	-0.1	-2.1	-2.2	-0.8	0.0	-0.8
Recreational, cultural and sporting activities	-1.4	1.4	0.1	-2.8	1.9	-0.9	-0.1	-0.1	-0.2
Other service activities	0.9	-5.3	-4.3	-0.7	-3.4	-4.1	1.4	-4.5	-3.2
SERVICES	-77.8	-22.2	-100.0	-86.4	-13.6	-100.0	-126.6	26.6	-100.0

5. Regression analysis

In the final part of our analysis, we delve deeper into the fundamental question what factors may drive the observed temporal and spatial variation in energy intensity in the service sector. We follow the tradition in the economic growth literature known as Barro-regressions (after Barro, 1991) in which we try to explain variation in productivity levels (the inverse of the intensity levels that we used before) from a series of ‘plausible’ explanatory variables. The explanatory variables that we consider are (i) ICT intensity, (ii) energy prices, and (iii) indicators for climate conditions. We exploit the panel structure of our data by using country- and/or time fixed effects to control for unobserved heterogeneity across countries and global trends over time. This helps us to clarify to what extent there is evidence for two intuitively plausible explanations for the relatively poor performance of the service sector in terms of energy efficiency improvements. The first explanation builds on the hypothesis that the low share of energy costs in total production costs that is characteristic for most service sectors gives firms little incentive to save on energy costs (see, e.g., De Groot et al. 2001). A natural implication of this would be that energy prices bear little relation with energy efficiency improvements. A second explanation focuses on the transformation in many service sectors resulting from the emergence of ICT in the course of the 1990s. This may have resulted in a transformation towards more energy-intensive production processes and could be an explanation for the relatively slow increase in energy productivity in the service sector.

Our proxy for ICT intensity is defined as ICT capital services per hour worked. Figure 6 shows that ICT intensity has increased considerably in most OECD18 countries since 1995, and furthermore, that it varies substantially across countries. Figure 7 shows the variation of energy ICT intensity across sectors. It clearly reveals that the Post and Telecommunication sector, Financial Intermediation and Renting, Computer, R&D and Other Business stand out as ICT intensive (sub-) sectors, both within the service sector as well as compared to the manufacturing sector and the aggregate economy.

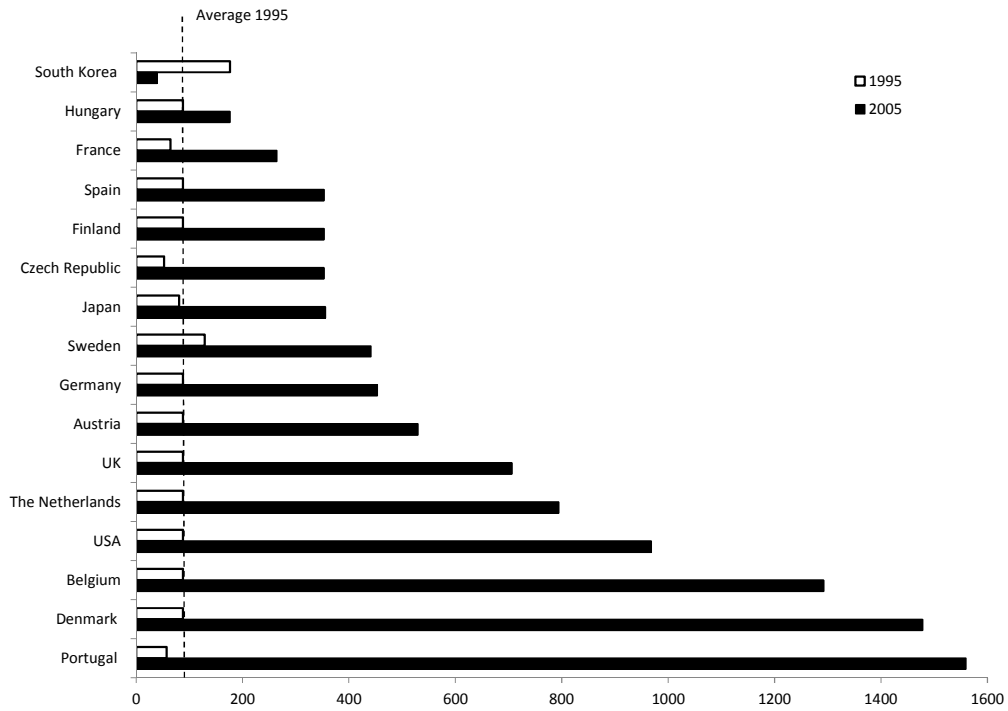


Figure 6. ICT intensity across OECD18 countries, 1995 and 2005 (Indexed; Average OECD18 in 1995 = 100)

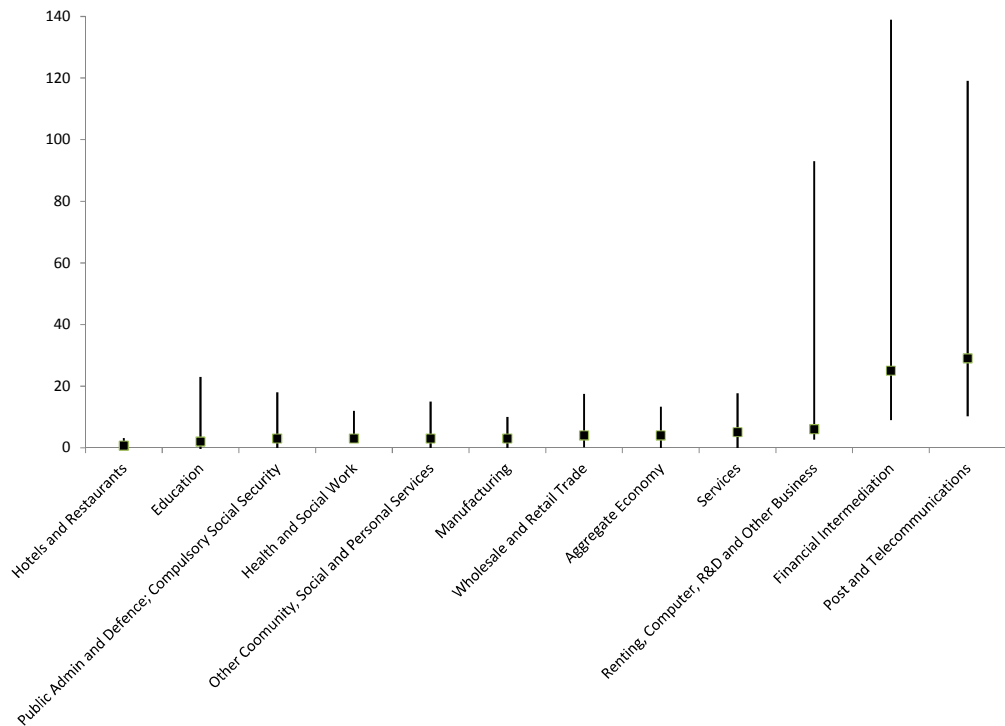


Figure 7. ICT intensity in 2005 per sector (minimum, maximum and medium value for OECD countries)

In order to determine the effect of the various explanatory variables on the growth of energy intensity, we estimate the following equation for all (sub-)sectors in our sample for the period 1980–2005:⁶

$$g_{it} = \alpha_i + \beta_1 \cdot \ln(EP_{it-1}) + \beta_2 \cdot P_{it} + \beta_3 \cdot ICT_{it} + \beta_4 \cdot HEAT_{it} + \beta_5 \cdot COOL_{it} + \gamma_t + \varepsilon_{it} \quad (1)$$

where g_{it} is the growth of energy productivity in country i at time t (defined as the dlog of energy productivity in the final and initial year of the period considered), α_i are country-fixed effects, EP_{it-1} is initial energy productivity, P_{it} is the energy price, ICT_{it} is the ICT intensity, $HEAT_{it}$ and $COOL_{it}$ are the number of heating and cooling days, respectively, and γ_t are period fixed effects. In our estimation strategy, we have used two different samples (OECD9 and the complete sample of countries), and we have estimated equation (1) without any fixed effect, with only country fixed effects, and with country and period fixed effects. Finally, we have estimated the equation on a year-to-year basis and also for 5-year periods to eliminate business cycle effects (as is rather common in the literature, cf. Islam 1995). The results reported in Table 12 are for the complete sample for 5-year periods, and with inclusion of country- and period fixed effects. Other results are available upon request.

We see from Table 12 clear evidence for β -convergence in terms of energy productivity in all sectors: across all sectors we find a statistically significant tendency of countries with relatively low initial productivity levels to grow relatively fast. This effect is about equally strong in the service sectors as in the manufacturing sector and the aggregate economy. Looking at the country specific fixed effects (see the Appendix for the country fixed effects), we see relatively good performance across (almost) all sectors in Finland, Denmark and Sweden. The Czech Republic, Japan, Korea, and Portugal stand out negatively.

Regarding the impact of ICT, our regression results analysis yield various important results. First, looking at the time fixed effects we observe a clearly declining trend in energy productivity over time (which is much stronger than in the manufacturing industry). There may of course be various reasons driving this common trend across countries, but the introduction of ICT is a natural candidate. Second, if we look at the additional results in Table 12, we see that the results for the impact of ICT intensity are mixed. In most sectors, there is hardly any statistically significant relationship between ICT and energy productivity. Exceptions are wholesale retail trade, the aggregate service sector and the total economy. In these sectors, relatively fast introduction of ICT (in deviation from the common trend which is captured by the time fixed effects) is associated with relatively high energy productivity. This may be caused by a vintage effect, implying the adoption of relatively energy-extensive ICT equipment. Third, also for energy prices, we find no clear relationship between energy productivity levels and a relatively fast increase of energy prices (note again that global trends in energy prices and structural cross-country variation in prices is captured by the fixed effects). This may just reflect the fact that energy prices vary little across time and countries, but it may also be the result of limited responsiveness of economic actors to energy

⁶ We leave out sector-indices.

prices. The latter would confirm the hypothesis that in the service sectors firms have little incentives to invest in energy saving, presumably because its low share of energy costs in total production costs.

Table 12. Regression results per sector

Sector	TRA	HOT	TEL	FIN	OBU	ADM	EDU	HEA	SOC	SRV	MAN	TOT
Constant	1.42*** 0.31	1.68*** 0.58	1.79*** 0.51	2.69*** 0.94	2.46*** 0.59	1.11** 0.43	1.92** 0.79	1.68*** 0.62	1.83*** 0.39	1.80*** 0.48	1.04** 0.47	1.78*** 0.50
Initial productivity	-0.68*** 0.12	-0.66*** 0.15	-0.39*** 0.13	-0.58*** 0.19	-0.62*** 0.17	-0.48*** 0.12	-0.48** 0.22	-0.46*** 0.15	-0.58*** 0.15	-0.56*** 0.15	-0.66*** 0.22	-0.62*** 0.20
ICT intensity	0.06*** 0.02	-0.12 0.12	0.00 0.00	0.00 0.01	0.00 0.00	0.03 0.02	0.01 0.02	-0.01 0.05	0.01 0.02	0.04** 0.02	0.03 0.05	0.05* 0.03
Energy price	0.50*** 0.15	0.20 0.20	-0.07 0.34	0.23 0.25	0.07 0.14	0.11 0.07	0.21 0.14	0.07 0.12	0.03 0.14	0.22 0.16	0.45 0.31	0.12 0.35
Heating days	1.76 1.58	0.16 0.27	-0.23* 0.13	-0.69 0.68	-0.91*** 0.30	-0.36 1.43	-3.81** 1.63	-1.53 1.90	-0.22 0.44	-7.55 5.46	-2.49** 1.11	-14.70* 7.92
Cooling days	-16.70*** 6.02	-5.31* 2.88	0.09 0.48	-4.67 3.1	3.37 3.05	55.91** 25.41	39.61 25.9	14.76 9.63	-0.29 2.52	34.31 62.74	2.07 10.61	32.97 83.38
Period fixed effects												
1980–1985	-0.07	0.14	0.02	0.08	0.05	0.06	0.03	-0.03	0.07	0.08	0.00	0.09
1985–1990	0.00	0.04	0.06	-0.07	-0.06	-0.05	0.18	0.18	0.07	0.06	0.04	0.07
1990–1995	0.10	-0.06	0.08	-0.04	0.08	0.00	-0.03	-0.11	-0.01	0.04	-0.04	-0.01
1995–2000	0.09	-0.08	-0.09	0.00	-0.02	0.02	-0.02	-0.01	-0.04	0.00	0.03	-0.02
2000–2005	-0.12	-0.03	-0.08	0.02	-0.05	-0.03	-0.16	-0.03	-0.09	-0.19	-0.03	-0.13
Adjusted R ²	0.52	0.24	0.14	0.15	0.31	0.38	0.29	0.20	0.27	0.35	0.37	0.32
# obs	69	69	66	69	69	69	69	69	69	66	60	55

Notes: statistical significance is indicated with stars: ***, **, and * stand for statistical significance at the 1, 5 and 10%, respectively. White standard errors are reported in brackets below the estimates. All equations have been estimated with period- and country-specific fixed effects. The sectors are labeled as follows: TRA: Wholesale and retail trade; HOT: Hotels and restaurants; TEL: Post and telecommunications; FIN: Financial intermediation; OBU: Renting, computer, R&D and other business; ADM: Public admin and defence; compulsory social security; EDU: Education; HEA: Health and social work; SOC: Other community, social and personal services; SRV: Services; MAN: Manufacturing; TOT: Aggregate economy. The period fixed effects are centered around zero. Country fixed effects are reported in Table A4 in the Appendix.

Finally, in contrast, for the climate related variables we see several statistically significant relationships between energy productivity and the number of heating and cooling days. In relatively cold areas, the energy productivity is relatively low as is to be expected. This pattern is particularly strong in education (where energy use is almost largely related to heating of buildings). The pattern is also clearly present at the aggregate service sector level and for the aggregate economy. For cooling we see a more mixed pattern. Many cooling days may be associated with relatively high energy productivity because of less need for heating. But it may also lower energy productivity if, for example, air-conditioning is required.

6. Conclusions

Based on a unique dataset, this paper has provided an extensive analysis of the dynamics of energy intensity in the service sector. It aims to fill a gap in the existing literature that has hitherto mainly focused on the energy intensive manufacturing sector. We show that although energy-intensity is indeed low in the service sectors compared to the manufacturing sector, the service sector becomes increasingly important as a consumer of energy and tends to remain behind in terms of energy efficiency improvements. The latter may be caused by technological developments within the service sector that may turn them less energy efficient, but the service sector is also known for its (relative) lack of attention for energy savings as seems to be confirmed by the results in this paper. As such, the paper calls for enhanced attention for the potential of energy savings in the service sectors. In view of the low share of energy in total costs, the policies that will be called for are most likely to be of different nature than traditional tax and subsidy programs (see, e.g. De Groot et al. 2001 and Florax et al. 2011). This is further reinforced by the results of this paper which reveal that energy prices can hardly explain variation in energy productivity levels. In some sectors, we see a positive effect of ICT intensity on energy productivity. This may be the resultant of smart energy systems or rapid developments in the energy efficiency of ICT (a vintage effect). Future research can elaborate on this analysis by further expanding the coverage across time and countries. Also a deeper investigation of the determinants of temporal and spatial variation in energy efficiency in the service sector, including attention for the impact of variation in policy mixes, is called for.

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Appendix

Table A.1a Average annual growth rates energy intensity by sector for the periods 1980–2005, 1980–1995 and 1995–2005.

	AUT	BEL	CZE	DNK	FIN	FRA	GER	HUN	JPN	KOR	NLD	POL	PRT	SPA	SVK	SWE	UKD	USA
WHOLESALE AND RETAIL TRADE																		
1980–2005	2.7	-1.4	—	-3.1	1.6	-3.3	-1.1	—	0.0	-2.8	-0.6	—	-5.1	0.3	—	—	2.0	-3.8
1980–1995	4.0	3.2	—	-2.3	1.5	-4.9	-0.9	—	0.5	-5.7	1.6	—	-8.6	-3.3	—	—	2.0	-4.4
1995–2005	0.8	-8.3	0.0	-4.3	1.9	-1.0	-1.5	-12.8	-0.8	1.4	-2.3	-2.0	0.3	5.8	-10.5	-4.9	2.2	-2.9
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel																		
1980–2005	2.6	3.3	—	3.6	0.9	-0.4	1.2	—	5.0	-2.7	1.2	—	-7.4	-2.1	—	—	0.6	-4.6
1980–1995	4.4	2.7	—	7.3	1.4	0.0	2.4	—	8.5	-5.4	3.8	—	-8.6	-5.6	—	—	-2.2	-4.3
1995–2005	-0.1	4.1	9.7	-1.9	0.2	-0.9	-0.6	-0.6	-0.2	1.4	-0.9	-3.2	-5.6	3.1	-2.0	-5.0	4.7	-5.1
Other wholesale trade and commission trade																		
1980–2005	1.9	-3.8	—	-4.8	2.4	-4.3	-3.1	—	-1.9	-2.7	-0.5	—	-4.7	-0.4	—	—	3.1	-4.3
1980–1995	2.9	3.3	—	-4.5	2.1	-5.7	-2.1	—	-3.4	-5.4	1.7	—	-8.6	-3.1	—	—	3.9	-6.2
1995–2005	0.4	-14.5	0.2	-5.3	2.8	-2.1	-4.7	-21.4	0.3	1.4	-2.3	-1.0	1.2	3.5	-4.6	-4.9	2.0	-1.5
Other retail trade																		
1980–2005	3.9	1.7	—	-2.9	0.3	-3.2	0.4	—	1.8	-2.9	0.1	—	1.6	2.9	—	—	1.5	-3.2
1980–1995	5.5	2.4	—	-2.4	0.3	-5.0	-0.3	—	3.3	-5.8	2.3	—	0.9	-0.8	—	—	1.2	-2.5
1995–2005	1.6	0.6	-8.3	-3.7	0.3	-0.6	1.4	7.3	-0.5	1.4	-1.6	-3.3	2.8	8.3	-17.8	-5.0	1.8	-4.2
HOTELS AND RESTAURANTS																		
1980–2005	1.9	2.8	—	0.7	0.4	3.1	-1.8	—	3.5	-5.2	2.1	—	-0.6	-0.7	—	—	0.0	-0.3
1980–1995	1.8	0.7	—	2.3	0.8	4.3	-1.8	—	3.1	-9.4	4.1	—	1.4	-1.8	—	—	-1.2	0.1
1995–2005	2.0	6.0	-1.9	-1.8	-0.3	1.4	-1.9	-3.2	4.1	1.1	0.5	-3.1	-3.6	1.0	5.2	-0.7	1.8	-1.1
POST AND TELECOMMUNICATION																		
1980–2005	6.8	0.9	—	-6.9	-8.6	-0.5	-2.1	—	1.5	-2.1	-6.3	—	-7.2	0.1	—	—	-1.7	-2.6
1980–1995	2.5	2.6	—	-5.5	-5.1	2.0	-3.0	—	-0.2	-1.9	-6.2	—	-9.9	-3.4	—	—	0.1	-2.1
1995–2005	13.3	-1.6	-5.4	-8.9	-13.9	-4.4	-0.9	-7.0	4.2	-2.3	-6.3	-14.1	-3.2	5.4	-4.0	-6.1	-4.3	-3.3

Table A.1b Average annual growth rates energy intensity by sector for the periods 1980–2005, 1980–1995 and 1995–2005.

	AUT	BEL	CZE	DNK	FIN	FRA	GER	HUN	JPN	KOR	NLD	POL	PRT	SPA	SVK	SWE	UKD	USA
FINANCIAL INTERMEDIATION																		
1980–2005	6.8	0.3	—	-8.0	3.8	-0.5	-0.1	—	-1.3	-0.9	1.3	—	-0.1	-2.5	—	—	0.7	-1.3
1980–1995	4.5	3.7	—	-8.7	3.7	-1.2	-3.1	—	-2.1	-2.4	4.7	—	3.9	-1.2	—	—	3.5	-1.1
1995–2005	10.2	-4.9	-1.2	-7.0	4.0	0.6	4.4	-3.5	0.0	1.5	-1.4	5.6	-6.0	-4.5	-2.7	-3.3	-3.3	-1.7
Financial intermediation, except insurance and pension funding																		
1980–2005	7.1	—	—	-6.6	4.6	-1.8	—	—	-1.5	-0.8	1.2	—	—	-3.7	—	—	1.1	-2.6
1980–1995	4.1	—	—	-5.9	5.1	-2.9	—	—	-1.8	-2.4	5.0	—	—	-1.9	—	—	6.3	-2.5
1995–2005	11.8	—	-1.6	-7.7	3.8	-0.2	1.3	-3.7	-0.9	1.5	-1.9	4.6	-6.4	-6.4	-7.0	-1.3	-6.7	-2.8
Insurance and pension funding, except compulsory social security																		
1980–2005	4.3	—	—	-8.8	0.7	14.6	—	—	-0.6	-0.8	1.0	—	—	-3.6	—	—	-0.8	1.0
1980–1995	5.4	—	—	-10.9	-14.4	19.4	—	—	-2.6	-2.4	1.6	—	—	-4.9	—	—	-3.4	1.0
1995–2005	2.6	—	11.0	-5.7	23.4	7.4	13.2	-12.6	2.3	1.5	0.5	15.6	-4.4	-1.5	9.3	-1.8	3.3	1.0
Activities related to financial intermediation																		
1980–2005	5.7	—	—	-14.0	0.9	-14.9	—	—	—	—	2.6	—	—	-0.1	—	—	4.1	—
1980–1995	5.6	—	—	-19.5	-5.2	-20.9	—	—	—	—	9.8	—	—	0.0	—	—	6.3	—
1995–2005	5.7	—	—	-5.8	9.9	-6.0	9.0	7.1	—	1.5	-3.3	-21.6	1.1	-0.3	—	0.7	0.8	—
PUBLIC ADMINISTRATION AND DEFENCE																		
1980–2005	1.5	10.5	—	-3.3	4.5	-2.0	-2.5	—	3.0	7.0	3.8	—	4.9	4.6	—	—	3.8	0.8
1980–1995	1.3	12.5	—	-4.0	4.3	-3.1	-4.7	—	5.4	9.9	7.1	—	9.3	3.2	—	—	4.6	0.7
1995–2005	1.9	7.5	2.8	-2.3	4.8	-0.4	0.8	0.3	-0.6	2.7	1.1	1.1	-1.7	6.6	-8.6	-2.0	2.5	0.9
EDUCATION																		
1980–2005	9.1	7.6	—	-3.5	2.1	-0.2	-2.5	—	3.9	1.9	0.9	—	1.0	3.4	—	—	1.3	-0.9
1980–1995	13.0	7.1	—	-3.6	3.9	-3.5	-3.6	—	4.2	-0.5	2.2	—	-0.8	-2.1	—	—	1.9	-2.1
1995–2005	3.2	8.3	3.0	-3.4	-0.6	4.9	-0.8	-2.3	3.4	5.6	-0.1	10.5	3.7	11.7	-4.2	-0.9	0.5	1.0

Table A.1c Average annual growth rates energy intensity by sector for the periods 1980–2005, 1980–1995 and 1995–2005.

	AUT	BEL	CZE	DNK	FIN	FRA	GER	HUN	JPN	KOR	NLD	POL	PRT	SPA	SVK	SWE	UKD	USA
RENTING, COMPUTER, R&D, OTHER BUSINESS																		
1980–2005	3.5	1.1	—	-6.2	-4.5	-2.1	-3.7	—	1.0	1.0	0.5	—	-0.5	-1.5	—	—	0.5	-1.4
1980–1995	3.9	1.1	—	-6.6	-4.2	-2.4	-6.4	—	2.6	0.1	2.8	—	2.8	-5.3	—	—	1.9	-2.6
1995–2005	2.8	1.2	-4.8	-5.4	-4.9	-1.6	0.4	-7.6	-1.3	2.4	-1.4	-3.6	-5.4	4.2	-13.1	-4.0	-1.6	0.4
Renting of machinery and																		
1980–2005	0.1	—	—	-14.3	3.3	9.4	—	—	-13.1	7.6	0.4	—	—	0.4	—	—	-1.4	2.7
1980–1995	-1.0	—	—	-20.0	12.5	12.9	—	—	-9.4	0.7	1.6	—	—	-2.5	—	—	-1.6	2.2
1995–2005	1.8	—	3.5	-5.8	-10.6	4.2	-3.2	3.8	-18.8	17.9	-0.5	-20.7	-3.1	4.7	8.6	-11.3	-0.9	3.6
Computer and related activities																		
1980–2005	-1.2	—	—	-12.1	-5.8	-1.5	—	—	3.1	0.3	-2.0	—	—	-4.4	—	—	-0.8	-3.2
1980–1995	2.6	—	—	-10.5	-6.2	-1.2	—	—	5.8	-1.2	-1.1	—	—	-5.1	—	—	-0.7	-4.4
1995–2005	-6.9	—	2.9	-14.7	-5.1	-2.0	-4.9	4.4	-1.1	2.7	-2.8	-4.9	6.2	-3.4	-6.0	-1.0	-0.9	-1.4
Research and development																		
1980–2005	-0.5	—	—	-3.0	-0.9	0.1	—	—	2.5	0.3	2.5	—	—	-3.3	—	—	1.8	-2.0
1980–1995	-2.5	—	—	-3.6	-1.4	-2.6	—	—	1.5	-1.2	10.8	—	—	-11.5	—	—	0.4	-4.6
1995–2005	2.5	—	-2.2	-2.0	-0.2	4.1	-5.2	-5.3	3.9	2.7	-4.1	6.0	1.2	9.0	-1.2	-7.7	4.0	2.0
Other business activities																		
1980–2005	5.4	—	—	-3.9	-4.8	-3.8	—	—	2.2	0.3	1.0	—	—	-1.1	—	—	1.2	-1.8
1980–1995	5.3	—	—	-4.0	-8.6	-4.6	—	—	3.1	-1.2	2.3	—	—	-5.4	—	—	3.7	-3.1
1995–2005	5.5	—	-5.5	-3.7	0.8	-2.7	2.8	-9.9	0.9	2.7	0.0	-3.3	-6.9	5.3	-20.0	-2.3	-2.4	0.2
HEALTH AND SOCIAL WORK																		
1980–2005	3.4	4.7	—	-3.3	3.8	0.6	-4.1	—	2.4	2.9	-0.2	—	2.8	2.0	—	—	-0.9	-0.3
1980–1995	4.6	7.9	—	-2.9	3.7	-0.3	-1.7	—	3.6	-2.8	2.5	—	3.2	-0.8	—	—	-1.5	0.2
1995–2005	1.6	-0.2	2.1	-4.0	3.9	1.9	-7.7	-4.4	0.6	11.5	-2.3	1.0	2.1	6.2	4.8	-0.6	0.1	-1.0

Table A.1d Average annual growth rates energy intensity by sector for the periods 1980–2005, 1980–1995 and 1995–2005.

	AUT	BEL	CZE	DNK	FIN	FRA	GER	HUN	JPN	KOR	NLD	POL	PRT	SPA	SVK	SWE	UKD	USA
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES																		
1980–2005	3.0	1.3	—	-1.0	1.9	-1.7	-2.1	—	3.4	0.9	0.4	—	0.4	0.1	—	—	-0.8	-2.5
1980–1995	3.0	2.0	—	-0.1	2.9	-1.5	-3.3	—	4.6	-1.0	1.1	—	-0.8	-3.6	—	—	-0.6	-3.5
1995–2005	3.0	0.3	0.8	-2.4	0.4	-1.9	-0.2	2.8	1.6	3.7	-0.1	5.2	2.1	5.8	-6.0	-1.2	-1.2	-0.9
Sewage and refuse disposal, sanitation and similar activities																		
1980–2005	5.4	—	—	0.7	3.6	-16.3	—	—	9.0	11.4	-2.7	—	—	3.4	—	—	-2.2	1.0
1980–1995	6.3	—	—	-0.2	-0.2	-19.2	—	—	13.6	14.9	-4.8	—	—	1.1	—	—	-3.9	1.1
1995–2005	4.0	—	4.2	2.0	9.3	-11.8	4.7	1.3	2.1	6.1	-1.0	2.5	1.4	6.9	5.2	-1.5	0.3	0.8
Activities of membership organizations nec																		
1980–2005	1.4	—	—	-3.7	4.1	-1.5	—	—	-0.4	-3.6	0.2	—	—	-1.3	—	—	-0.6	-2.8
1980–1995	0.4	—	—	-3.4	3.4	-2.4	—	—	-0.3	-6.5	0.9	—	—	-3.7	—	—	-1.2	-4.4
1995–2005	2.8	—	-7.3	-4.0	5.1	-0.3	-3.2	-3.3	-0.5	0.7	-0.4	3.4	4.0	2.4	-20.3	-0.8	0.3	-0.3
Recreational, cultural and sporting activities																		
1980–2005	5.2	—	—	-0.3	0.3	-1.2	—	—	4.1	0.7	1.1	—	—	-2.5	—	—	-0.2	-2.1
1980–1995	6.6	—	—	2.2	-0.6	-1.0	—	—	6.0	-1.6	4.4	—	—	-7.4	—	—	1.4	-2.8
1995–2005	3.2	—	-0.3	-3.9	1.8	-1.5	0.2	2.2	1.2	4.1	-1.6	1.7	4.0	4.8	-4.5	-2.5	-2.5	-1.1
Other service activities																		
1980–2005	4.2	—	—	-3.8	-0.4	1.7	—	—	1.7	-0.2	2.5	—	—	2.6	—	—	1.6	-3.2
1980–1995	5.1	—	—	-6.4	12.1	3.8	—	—	1.3	-2.1	2.7	—	—	2.0	—	—	2.1	-4.1
1995–2005	2.7	—	5.9	-0.1	-19.2	-1.6	-1.8	4.0	2.1	2.8	2.3	-1.4	1.3	3.6	-15.1	-2.9	0.9	-1.7

Table A.2a Percentage contribution of the efficiency effect (EFF) and the structural effect (STR) by sector to the average annual growth rate of service sector energy intensity per country, for the period 1980–2005.

	Austria			Belgium			Denmark			Finland		
	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT
Sale, maintenance, repair motor vehicles and –cycles; retail sale of fuel	3.3	-2.1	1.3	-84.3	-85.5	-169.9	4.6	-7.5	-2.9	3.0	4.0	7.0
Other wholesale trade and commission trade	5.3	4.7	10.0				-19.0	7.7	-11.3	38.9	-1.7	37.2
Other retail trade; repair of household goods	11.7	0.0	11.7				-7.4	0.1	-7.3	1.4	0.9	2.3
Hotels and restaurants	8.8	-3.0	5.8	19.2	-3.2	15.9	0.7	-2.0	-1.3	0.4	-1.5	-1.1
Post and Telecommunications	6.2	2.3	8.5	4.9	9.6	14.5	-6.5	3.2	-3.3	-13.8	9.3	-4.5
Financial intermediation, except insurance and pension funding	3.3	0.5	3.8	0.8	7.3	8.1	-4.6	2.2	-2.4	14.0	-2.6	11.3
Insurance and pension funding, except compulsory social security	0.5	-0.3	0.2				-3.1	0.7	-2.4	0.4	0.2	0.6
Activities related to financial intermediation	0.3	0.2	0.4				-2.3	0.5	-1.8	0.0	0.4	0.5
Renting of machinery and equipment	0.0	2.1	2.1	19.6	56.2	75.8	-3.6	1.3	-2.3	2.2	-1.1	1.1
Computer and related activities	-0.3	2.0	1.7				-4.0	3.5	-0.5	-3.6	3.3	-0.3
Research and development	0.0	0.2	0.2				-0.9	-0.6	-1.5	-0.3	0.4	0.1
Other business activities	5.1	1.9	7.0	-9.9	3.1	-6.8	-15.7	4.3	-11.4			
Public administration and defence; Compulsory social security	7.0	-2.9	4.0	74.0	-8.1	65.9	-11.0	-5.8	-16.8	20.3	-4.0	16.3
Education	17.1	-2.2	14.9	30.2	-4.6	25.5	-12.9	-3.3	-16.3	8.6	-4.0	4.6
Health and social work	18.2	2.0	20.1	40.0	3.5	43.5	-17.5	-1.6	-19.1	25.0	-5.2	19.8
Sewage and refuse disposal, sanitation and similar activities	6.3	-4.6	1.8	14.5	6.1	20.6	0.7	-2.0	-1.3	3.3	0.4	3.8
Activities of membership organizations n.e.c.	2.7	-2.7	0.0				-1.3	-0.2	-1.4	13.6	-1.8	11.8
Recreational, cultural and sporting activities	5.0	-0.1	4.9				-0.3	0.6	0.3	1.1	0.4	1.5
Other service activities	2.1	-0.7	1.4	-1.3	-0.4	-1.7	-0.2	-0.4	-0.6			
SERVICES	102.6	-2.6	100.0	118.8	-18.8	100.0	-99.7	-0.3	-100.0	98.5	1.5	100.0

Table A.2b Percentage contribution of the efficiency effect (EFF) and the structural effect (STR) by sector to the average annual growth rate of service sector energy intensity per country, for the period 1980–2005.

	France			Germany			Japan			Korea		
	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT
Sale, maintenance, repair motor vehicles and –cycles; retail sale of fuel	-4.4	2.1	-2.4	-11.5	-2.3	-13.8	1.8	-0.5	1.3	-9.5	6.3	-3.3
Other wholesale trade and commission trade	-415.2	349.3	-65.9				-8.4	5.4	-3.0	-88.8	-32.8	-121.6
Other retail trade; repair of household goods	-138.1	103.6	-34.4				12.1	-10.2	1.9	-74.4	38.7	-35.7
Hotels and restaurants	52.5	-8.5	44.0	-3.7	-3.3	-7.1	29.0	-19.4	9.6	-330.6	2.8	-327.8
Post and Telecommunications	-4.3	50.3	46.1	-2.8	2.0	-0.9	3.5	7.4	11.0	-32.4	157.6	125.3
Financial intermediation, except insurance and pension funding	-11.9	17.0	5.1	-0.2	-1.5	-1.7	-1.6	2.4	0.8	-4.9	17.0	12.1
Insurance and pension funding, except compulsory social security	39.3	-35.0	4.3				-0.4	0.3	-0.1	-0.9	10.5	9.6
Activities related to financial intermediation	-16.5	20.5	4.1				0.0	0.0	0.0	—	—	—
Renting of machinery and equipment	19.3	-9.7	9.7	-14.9	7.7	-7.2	-3.9	4.0	0.1	30.9	-7.5	23.3
Computer and related activities	-10.1	10.0	-0.1				3.7	-0.4	3.3	0.6	12.9	13.5
Research and development	0.5	12.6	13.1				2.4	1.6	4.0	1.1	13.5	14.6
Other business activities	-152.1	139.0	-13.0				3.7	2.7	6.3	3.0	20.1	23.2
Public administration and defence; Compulsory social security	-84.1	73.5	-10.6	-15.2	-6.1	-21.3	20.7	-1.5	19.1	133.6	-53.7	79.8
Education	-3.5	20.6	17.1	-14.9	-7.3	-22.2	12.2	-4.4	7.9	51.9	-56.3	-4.4
Health and social work	12.1	37.7	49.8	-21.9	4.3	-17.5	19.9	2.5	22.5	134.0	109.5	243.5
Sewage and refuse disposal, sanitation and similar activities	-35.3	29.8	-5.6	-6.8	-1.6	-8.4	2.1	-0.9	1.2	15.8	1.8	17.6
Activities of membership organizations n.e.c.	-5.5	9.6	4.1				-0.1	-0.8	-0.9	-18.4	10.1	-8.3
Recreational, cultural and sporting activities	-25.6	60.3	34.7				16.3	-5.0	11.3	8.3	34.9	43.1
Other service activities	3.8	-3.7	0.1				4.4	-0.8	3.6	-1.0	-3.8	-4.7
SERVICES	-779.2	879.2	100.0	-91.8	-8.2	-100.0	117.4	-17.4	100.0	-181.8	281.8	100.0

Table A.2c Percentage contribution of the efficiency effect (EFF) and the structural effect (STR) by sector to the average annual growth rate of service sector energy intensity per country, for the period 1980–2005.*

1980–2005	Netherlands			Portugal			Spain			United Kingdom		
	EFF Effect	STR Effect	TOT Effect	EFF Effect	STR Effect	TOT Effect	EFF Effect	STR Effect	TOT Effect	EFF Effect	STR Effect	TOT Effect
Sale, maintenance, repair motor vehicles and –cycles; retail sale of fuel	12.9	–5.3	7.6	–99.6	–23.0	–122.7	–19.8	–16.2	–36.0	3.0	–0.9	2.1
Other wholesale trade and commission trade	–13.0	66.3	53.3				–6.7	–3.1	–9.8	49.7	–0.8	48.9
Other retail trade; repair of household goods	4.4	–30.9	–26.4				39.2	–1.7	37.5	14.9	4.6	19.4
Hotels and restaurants	49.1	–27.8	21.3	–3.0	–7.7	–10.7	–7.9	–7.3	–15.2	0.1	–6.7	–6.7
Post and Telecommunications	–21.2	17.0	–4.2	–5.2	3.9	–1.4	0.6	14.7	15.3	–6.5	14.5	7.9
Financial intermediation, except insurance and pension funding	5.5	5.9	11.4	0.0	1.5	1.5	–13.1	–1.4	–14.6	2.9	2.1	5.0
Insurance and pension funding, except compulsory social security	2.1	–1.2	0.9				–2.1	1.6	–0.5	–2.6	4.1	1.6
Activities related to financial intermediation	2.4	0.1	2.6				–0.1	0.9	0.8	3.8	0.6	4.4
Renting of machinery and equipment	0.3	3.3	3.6	–0.9	0.7	–0.2	0.7	1.9	2.6	–2.6	7.8	5.3
Computer and related activities	–3.6	14.1	10.5				–1.9	3.3	1.4	–1.8	9.0	7.2
Research and development	7.4	–3.5	3.9				–0.2	0.1	–0.1	1.2	0.0	1.3
Other business activities	13.7	18.7	32.4	–9.2	15.7	6.5	5.4	11.6	17.0			
Public administration and defence; Compulsory social security	90.6	–42.6	47.9	16.5	–0.3	16.2	58.6	–13.6	45.1	43.4	–35.5	7.9
Education	15.9	–50.5	–34.6	1.7	–1.1	0.6	38.6	7.2	45.8	8.5	–12.4	–3.9
Health and social work	–5.8	–19.5	–25.3	18.0	–2.2	15.8	23.7	–1.7	22.0	–9.1	–4.2	–13.4
Sewage and refuse disposal, sanitation and similar activities	–43.3	27.5	–15.8	1.1	–0.2	0.8	13.3	–0.4	12.9	–5.1	–0.4	–5.5
Activities of membership organizations n.e.c.	0.8	–3.0	–2.2				–1.2	1.0	–0.2	–0.2	–0.3	–0.6
Recreational, cultural and sporting activities	17.4	–4.5	13.0				–16.0	–1.1	–17.1	–0.5	1.9	1.4
Other service activities	11.8	–11.7	0.1	4.1	–0.5	3.6	1.0	–0.4	0.6			
SERVICES	147.5	–47.5	100.0	–71.4	–28.6	–100.0	100.8	–0.8	100.0	105.5	–5.5	100.0

* USA data are presented in main text; they are excluded here due to limited space.

Table A.3a Percentage contribution of the efficiency effect (EFF) and the structural effect (STR) by sector to the average annual growth rate of service sector energy intensity per country, for the period 1995–2005.

	Austria			Belgium			Czech Republic			Denmark		
	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT
Sale, maintenance, repair motor vehicles and –cycles; retail sale of fuel	-0.1	-1.0	-1.1	-135.5	-18.6	-154.2	43.6	-12.0	31.6	-2.1	-2.3	-4.4
Other wholesale trade and commission trade	1.5	3.8	5.4				2.3	99.4	101.7	-16.6	4.2	-12.3
Other retail trade; repair of household goods	6.8	2.0	8.8				-30.1	26.2	-4.0	-7.5	-1.3	-8.8
Hotels and restaurants	9.8	0.1	9.9	10.8	-3.6	7.2	-5.2	-19.4	-24.5	-1.9	-4.3	-6.1
Post and Telecommunications	16.3	2.0	18.3	-2.7	3.6	0.9	-8.8	7.0	-1.8	-6.2	3.4	-2.8
Financial intermediation, except insurance and pension funding	7.7	-0.2	7.4	-5.8	2.5	-3.4	-1.4	1.9	0.6	-4.0	1.8	-2.2
Insurance and pension funding, except compulsory social security	0.5	-1.1	-0.6				4.8	-2.1	2.7	-0.9	0.2	-0.7
Activities related to financial intermediation	0.3	0.6	0.9				—	—	—	-0.2	0.0	-0.2
Renting of machinery and equipment	0.9	2.0	2.9	6.6	16.3	22.9	0.7	0.9	1.7	-0.5	0.1	-0.4
Computer and related activities	-3.1	4.7	1.6				0.9	1.8	2.7	-4.6	3.4	-1.2
Research and development	0.2	0.1	0.4				-0.8	-2.0	-2.8	-0.3	0.1	-0.2
Other business activities	7.9	3.5	11.4				-21.8	3.5	-18.3	-7.7	0.2	-7.5
Public administration and defence; Compulsory social security	9.5	-7.9	1.6	24.1	-2.2	21.9	11.1	-3.6	7.5	-4.6	-4.9	-9.5
Education	12.2	-2.7	9.5	11.8	-2.6	9.3	9.9	1.2	11.1	-8.3	-3.1	-11.4
Health and social work	12.0	2.4	14.4	-0.7	-1.1	-1.8	8.5	-18.3	-9.8	-15.7	-2.7	-18.4
Sewage and refuse disposal, sanitation and similar activities	5.4	-3.9	1.5	1.0	-3.7	-2.8	5.8	-3.8	2.0	2.2	-6.6	-4.4
Activities of membership organizations nec	5.3	-3.3	2.0				-2.9	-0.3	-3.1	-1.0	-0.4	-1.5
Recreational, cultural and sporting activities	4.7	-0.6	4.1				-0.4	2.5	2.1	-5.6	-1.8	-7.5
Other service activities	1.7	-0.3	1.5				4.3	-3.7	0.6	0.0	-0.5	-0.5
SERVICES	99.8	0.2	100.0	-90.5	-9.5	-100.0	20.7	79.3	100.0	-85.5	-14.5	-100.0

Table A.3b Percentage contribution of the efficiency effect (EFF) and the structural effect (STR) by sector to the average annual growth rate of Services energy intensity per country, for the period 1995–2005.

1995–2005	Finland			France			Germany			Hungary		
	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT
Sale, maintenance, repair motor vehicles and –cycles; retail sale of fuel	0.6	10.4	11.0	-14.6	-36.6	-51.2	-1.4	2.4	1.1	-0.2	1.4	1.3
Other wholesale trade and commission trade	48.0	26.7	74.7	-215.0	174.7	-40.3	-38.1	2.2	-35.9	-90.4	6.5	-83.9
Other retail trade; repair of household goods	1.5	7.1	8.6	-29.9	-49.0	-78.9	9.9	-7.0	3.0	8.5	-0.2	8.3
Hotels and restaurants	-0.3	-1.7	-2.0	35.5	-21.0	14.6	-5.0	-2.6	-7.6	-2.3	-2.1	-4.4
Post and Telecommunications	-21.4	11.2	-10.1	-70.3	97.1	26.9	-1.8	4.6	2.8	-2.9	1.9	-0.9
Financial intermediation, except insurance and pension funding	18.5	-23.5	-4.9	-1.5	9.5	8.0	1.5	0.7	2.2	-0.9	0.1	-0.8
Insurance and pension funding, except compulsory social security	5.8	-0.3	5.6	27.5	-26.3	1.2	9.8	-8.3	1.5	-0.6	0.3	-0.3
Activities related to financial intermediation	0.6	0.4	1.0	-9.3	16.6	7.3	2.4	-1.6	0.8	0.2	0.3	0.5
Renting of machinery and equipment	-13.2	3.1	-10.1	15.1	-6.7	8.3	-1.3	1.2	-0.1	0.5	-0.3	0.2
Computer and related activities	-2.6	3.9	1.3	-14.6	19.9	5.4	-2.9	3.7	0.8	0.3	0.9	1.2
Research and development	-0.1	0.2	0.1	40.5	-33.9	6.6	-4.0	1.4	-2.6	-1.4	-0.4	-1.7
Other business activities	1.5	1.9	3.3	-126.2	72.3	-53.9	11.2	-3.4	7.8	-10.1	-0.6	-10.7
Public administration and defence; Compulsory social security	28.1	-11.7	16.4	-19.5	-40.0	-59.5	6.1	-12.5	-6.4	0.5	-1.8	-1.3
Education	-3.4	-8.4	-11.8	124.9	-52.7	72.2	-5.8	-8.6	-14.4	-2.4	0.0	-2.5
Health and social work	32.6	-15.9	16.7	55.3	-25.7	29.5	-64.4	17.4	-47.0	-4.4	0.1	-4.4
Sewage and refuse disposal, sanitation and similar activities	9.4	-1.5	7.8	-28.9	14.1	-14.8	2.7	-3.5	-0.7	0.7	0.0	0.8
Activities of membership organizations n.e.c.	19.8	-0.5	19.3	-1.3	-3.5	-4.8	-1.7	-0.5	-2.2	-0.4	-0.1	-0.5
Recreational, cultural and sporting activities	6.2	-4.9	1.3	-41.1	72.5	31.4	0.5	0.4	0.9	1.0	-1.7	-0.7
Other service activities	-27.8	-0.4	-28.2	-4.7	-3.2	-7.9	-2.6	-1.3	-3.9	1.0	-1.1	-0.1
SERVICES	103.9	-3.9	100.0	-278.1	178.1	-100.0	-84.8	-15.2	-100.0	-103.3	3.3	-100.0

Table A.3c Percentage contribution of the efficiency effect (EFF) and the structural effect (STR) by sector to the average annual growth rate of service sector energy intensity per country, for the period 1995–2005.

1995–2005	Japan			Korea			The Netherlands		
	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT
Sale, maintenance, repair motor vehicles and –cycles; retail sale of fuel	–0.2	0.8	0.6	0.4	0.0	0.4	–3.0	0.6	–2.4
Other wholesale trade and commission trade	3.1	–10.7	–7.6	2.5	–1.8	0.6	–18.5	18.3	–0.3
Other retail trade; repair of household goods	–9.6	–63.1	–72.7	2.6	–1.7	0.8	–13.8	–9.6	–23.4
Hotels and restaurants	82.5	–45.4	37.2	3.0	–1.2	1.7	3.6	–14.8	–11.2
Post and Telecommunications	25.1	28.2	53.2	–4.4	25.6	21.2	–4.5	6.0	1.5
Financial intermediation, except insurance and pension funding	–2.5	1.7	–0.8	0.9	0.5	1.3	–2.8	3.5	0.7
Insurance and pension funding, except compulsory social security	3.5	–5.0	–1.5	0.3	–0.2	0.1	0.3	–1.8	–1.5
Activities related to financial intermediation	—	—	—	0.1	0.2	0.4	–1.3	–0.1	–1.4
Renting of machinery and equipment	–13.9	13.4	–0.5	12.2	–12.6	–0.4	–0.1	0.3	0.1
Computer and related activities	–4.4	3.1	–1.3	0.6	1.3	1.9	–1.7	4.3	2.6
Research and development	11.4	1.7	13.0	1.0	0.4	1.4	–4.7	–1.4	–6.2
Other business activities	4.7	4.9	9.6	2.4	0.6	3.0	0.2	–1.0	–0.9
Public administration and defence; Compulsory social security	–13.7	–11.2	–24.9	6.6	–2.8	3.7	8.8	–13.6	–4.8
Education	29.6	–11.2	18.4	10.4	–2.4	8.0	–0.3	–12.6	–12.9
Health and social work	14.0	48.5	62.6	51.9	–6.0	45.9	–22.0	–6.3	–28.3
Sewage and refuse disposal, sanitation and similar activities	2.1	–2.0	0.1	1.8	0.2	2.0	–4.0	2.9	–1.1
Activities of membership organizations n.e.c.	–0.2	–0.8	–1.0	0.2	–0.2	0.0	–0.5	–1.7	–2.2
Recreational, cultural and sporting activities	14.9	–9.2	5.6	4.8	2.4	7.2	–7.7	0.8	–6.9
Other service activities	14.4	–4.3	10.1	1.2	–0.6	0.6	3.1	–4.6	–1.5
SERVICES	160.8	–60.8	100.0	98.5	1.5	100.0	–69.1	–30.9	–100.0

Table A.3d Percentage contribution of the efficiency effect (EFF) and the structural effect (STR) by sector to the average annual growth rate of service sector energy intensity per country, for the period 1995–2005.

	Poland			Portugal			Slovakia			Spain		
	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT
Sale, maintenance, repair motor vehicles and –cycles; retail sale of fuel	-120.8	49.7	-71.1	-24.6	-8.6	-33.2	-0.8	2.4	1.6	2.7	-0.4	2.3
Other wholesale trade and commission trade	-116.4	234.5	118.1	12.3	-6.4	5.9	-10.1	9.7	-0.3	7.4	0.2	7.6
Other retail trade; repair of household goods	-327.5	-106.1	-433.6	19.2	7.2	26.4	-59.6	12.8	-46.8	19.1	-0.6	18.5
Hotels and restaurants	-66.5	34.7	-31.9	-41.9	-23.1	-65.0	6.2	-14.2	-8.0	1.7	-1.9	-0.2
Post and Telecommunications	-403.0	172.0	-231.0	-3.9	5.9	2.0	-1.5	0.8	-0.7	4.7	2.3	6.9
Financial intermediation, except insurance and pension funding	54.7	96.0	150.7	-8.5	8.7	0.2	-2.5	-3.5	-5.9	-3.0	0.6	-2.4
Insurance and pension funding, except compulsory social security	187.7	113.6	301.3	-1.2	-0.7	-1.9	0.5	-0.5	0.0	-0.1	0.4	0.3
Activities related to financial intermediation	-57.4	12.5	-44.9	0.0	0.0	0.0	—	—	—	-0.1	-0.3	-0.3
Renting of machinery and equipment	-56.8	34.0	-22.8	-1.9	0.8	-1.1	0.5	-0.4	0.1	1.4	0.1	1.5
Computer and related activities	-17.7	35.6	17.9	3.0	1.2	4.1	-0.9	0.3	-0.6	-0.3	0.6	0.2
Research and development	36.1	-51.6	-15.5	0.3	-0.2	0.1	-0.3	-3.9	-4.1	0.1	0.0	0.1
Other business activities	-100.5	18.1	-82.3	-38.2	-10.1	-48.3	-21.1	10.2	-10.9	6.2	1.2	7.4
Public administration and defence; Compulsory social security	53.8	-0.9	52.9	-26.3	-5.4	-31.7	-14.5	6.8	-7.7	17.2	-2.8	14.4
Education	386.0	-63.2	322.8	13.8	-6.9	6.9	-6.5	-0.7	-7.2	22.8	-1.6	21.2
Health and social work	47.8	-167.3	-119.4	41.2	-19.1	22.1	6.2	-7.0	-0.9	12.1	-0.2	11.9
Sewage and refuse disposal, sanitation and similar activities	67.8	134.2	202.0	1.0	0.3	1.4	2.3	-4.1	-1.9	4.7	1.3	6.0
Activities of membership organizations n.e.c.	41.7	-14.4	27.4	16.8	-12.0	4.8	-4.7	3.2	-1.5	0.3	0.1	0.4
Recreational, cultural and sporting activities	32.2	32.8	65.0	5.8	-0.2	5.6	-2.5	-1.1	-3.6	3.0	-0.1	2.9
Other service activities	-9.5	-96.1	-105.6	1.2	0.3	1.5	-3.1	1.3	-1.8	1.0	0.3	1.3
SERVICES	-368.3	468.3	100.0	-31.9	-68.1	-100.0	-112.3	12.3	-100.0	100.9	-0.9	100.0

Table A.3e Percentage contribution of the efficiency effect (EFF) and the structural effect (STR) by sector to the average annual growth rate of service sector energy intensity per country, for the period 1995–2005.

	Sweden			United Kingdom			USA		
	EFF	STR	TOT	EFF	STR	TOT	EFF	STR	TOT
Sale, maintenance, repair motor vehicles and –cycles; retail sale of fuel	-3.7	1.3	-2.4	131.0	-32.1	99.0	-32.3	23.2	-9.0
Other wholesale trade and commission trade	-29.0	10.3	-18.7	253.7	-125.8	127.9	-15.9	-4.5	-20.4
Other retail trade; repair of household goods	-10.5	3.7	-6.8	126.7	-14.5	112.2	-51.4	25.5	-25.9
Hotels and restaurants	-0.7	-0.3	-1.1	74.3	-31.3	42.9	-7.1	-8.1	-15.2
Post and Telecommunications	-7.2	4.2	-3.0	-117.4	157.8	40.4	-4.6	3.8	-0.8
Financial intermediation, except insurance and pension funding	-0.3	0.5	0.2	-157.4	64.7	-92.7	-7.5	7.0	-0.5
Insurance and pension funding, except compulsory social security	-1.1	-1.2	-2.3	73.7	-107.0	-33.2	0.5	-1.4	-0.9
Activities related to financial intermediation	0.0	0.1	0.1	6.2	14.8	20.9	—	—	—
Renting of machinery and equipment	-4.6	1.7	-2.9	-14.2	11.8	-2.4	6.9	-4.4	2.5
Computer and related activities	-0.3	0.9	0.6	-12.9	90.5	77.6	-1.0	2.7	1.7
Research and development	-1.6	1.5	-0.2	17.6	-9.5	8.0	1.1	0.2	1.3
Other business activities	-4.1	-0.9	-5.0	-93.6	106.0	12.5	1.0	1.4	2.5
Public administration and defence; Compulsory social security	-10.4	-20.8	-31.1	192.7	-253.6	-60.9	9.3	-26.7	-17.5
Education	-2.0	-3.2	-5.1	19.3	-118.2	-98.9	1.0	-1.1	-0.1
Health and social work	-2.8	-8.5	-11.3	3.8	-56.3	-52.5	-5.4	-0.7	-6.1
Sewage and refuse disposal, sanitation and similar activities	-1.5	2.1	0.6	3.2	-25.6	-22.4	1.4	-4.7	-3.3
Activities of membership organizations n.e.c.	-1.3	-4.7	-5.9	0.6	-10.8	-10.2	-1.0	-2.6	-3.5
Recreational, cultural and sporting activities	-5.1	0.0	-5.0	-51.1	-5.2	-56.3	-2.4	1.4	-1.0
Other service activities	-0.6	-0.1	-0.7	4.1	-16.1	-11.9	-2.7	-1.0	-3.7
SERVICES	-86.7	-13.3	-100.0	460.4	-360.4	100.0	-110.1	10.1	-100.0

Table A.4. Country fixed effects (extending Table 12 in the main text)

Sector	TRA	HOT	TEL	FIN	OBU	ADM	EDU	HEA	SOC	SRV	MAN	TOT
AUT	0.154	0.084	-0.042	0.347	0.473	-0.353	0.072	-0.080	-0.016	0.072	0.174	0.138
BEL	-0.278	0.014	-0.219	0.118	-0.182	0.196	0.383	0.185	-0.182	0.000	-0.300	-0.227
CZE	-0.556	-0.245	0.123	-0.081	0.083	-0.241	-0.421	0.077	0.107	0.019	0.006	0.069
DNK	-0.166	-0.079	0.187	0.176	0.132	0.426	0.873	0.307	0.058	0.232	0.508	0.377
FIN	-0.819	-0.239	0.952	0.270	1.007	0.309	2.136	0.716	0.077	0.569	0.061	0.281
FRA	-0.069	0.137	-0.045	-0.154	-0.343	0.436	-0.220	0.328	0.009	-0.037	-0.094	
GER	0.373	-0.060	-0.166	-0.306	0.056	0.418	-0.416	0.089	0.347	0.121	0.056	0.024
HUN	-0.218	0.291	0.071	0.248	-0.075	-0.794	-0.195	0.241	-0.199	0.144	0.384	0.355
JPN	0.593	-0.321	-0.625	0.100	-0.545	-0.094	-0.447	-0.321	-0.152	-0.158	0.006	-0.235
KOR	0.358	-0.198	-0.566	-0.026	-0.564	-0.749	-0.546	-1.051	-0.208	-0.300	-0.467	-0.222
NLD	0.370	-0.480	0.426	0.014	-0.015	0.250	0.173	0.231	-0.361	0.063	-0.112	-0.135
PRT	0.245	0.321	0.214	0.426	-0.127	-0.888	-1.015	-0.763	-0.036	-0.214	-0.184	-0.112
SPA	-0.210	0.905	-0.044	-0.129	0.050	-0.267	-1.167	0.001	0.408	-0.082	-0.055	0.058
SWE	-0.050	-0.579	0.375	0.193	0.199	0.120	0.810	0.220	-0.259	0.270	0.286	0.136
UK	-0.031	0.264	0.130	-0.689	0.114	0.429	-0.132	0.288	0.466	-0.018	0.001	0.080
USA	-0.041	-0.223	-0.212	-0.294	-0.110	0.362	0.447	0.000	-0.308	-0.148	-0.158	-0.279

Notes: The country fixed effects are centered around zero. The sectors are labeled as follows: TRA: Wholesale and retail trade; HOT: Hotels and restaurants; TEL: Post and telecommunications; FIN: Financial intermediation; OBU: Renting, computer, R&D and other business; ADM: Public admin and defence; compulsory social security; EDU: Education; HEA: Health and social work; SOC: Other community, social and personal services; SRV: Services; MAN: Manufacturing; TOT: Aggregate economy.