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INNOVATION-FUELLED, SUSTAINABLE, INCLUSIVE GROWTH

Working Paper

An Empirical Analysis of Sectoral Employment Shifts and the Role of R&D

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1. INTRODUCTION

This document contributes to Task 1.4 of the ISIGrowth project by collecting empirical evidence with respect to shifts in employment between manufacturing and service sectors and the role of R&D investments as well as productivity dynamics in this process. In particular, relying on World Bank as well as on OECD STAN sectoral-level data for European countries the following questions are addressed:

i) How has the overall employment share of the manufacturing respectively the service sectors evolved over time in different European countries? Are there qualitative differences in the evolution between 'old' and 'new' EU member countries?

ii) How is the shift in employment shares related to (country-specific) changes in labor productivity? Does it contribute to a faster increase in total labor productivity?

iii) What is the impact of (country- and sector-specific) R&D expenditure on employment in a sector? Is there a systematic difference with respect to this impact between manufacturing and service sectors?

The motivation to explore these questions is twofold. First, it should help to identify the driving forces of the observed sectoral employment shifts. Second, and more importantly, gaining a better understanding of the role of R&D for employment and for sectoral shifts clearly has important implications for innovation policy. If certain sectors can be identified

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where increases in R&D investments tend to have particularly strong positive effects on employment, then fostering investments in those sectors would not only have direct effects on productivity and international competitiveness in such sectors but would also contribute to positive second order effects through demand stimulation and human capital improvements, e.g. through learning by doing effects. Also, the analysis sheds light on the question in how far the observed shifts in employment might be desirable or at least necessary from the perspective of overall labor productivity increases.

From a methodological perspective, we combine a pure descriptive treatment of the time series data for different countries and sectors with a shift-share analysis (see e.g. Fagerberg (2000), Maudos et al. (2008) and OECD (2014)) which disentangles productivity dynamics into within-sector effects and changes that are driven by labor movements betweeen sectors and pooled as well as sector-specific regressions analyzing the relationship between R&D and employment. The extensive theoretical and empirical literature dealing with the effects of R&D on employment is discussed in detail in the companion paper Mitkova (2016) and therefore we abstain from reviewing these streams of literature here.

2. Country level evidence on shift between manufacturing and services: an aggregate perspective

We start our analysis with a purely descriptive treatment of the sectoral shifts of employment between industrial production and service during the last 20-25 years. Figure 2.1 depicts the development of the three main economic sectors (agriculture[1], industry[2] and services[3]) and the evolution of their employment shares for the U.S., the EU15 and the 13 newer EU members (Data source: The World Bank). The figures for the two groups of EU countries are done by taking yearly averages. There is an evident cross-sectoral shift of labor between manufacturing and services. We can see that the share of workers employed in services has been steadily increasing everywhere over the considered periods[4]. Moreover, the importance of the services is still on the rise, while employment in manufacturing and agriculture is decreasing. Also, it should be noted that, although the employment share of services in the U.S. is considerably above that in the EU, the speed of growth of the service sector in Europe seems larger than that in the U.S. In Figures A.1, A.2 and A.3 in the Appendix we show the breakdown of employment shares for each EU member country. It can be clearly seen that the employment share in the service sector in the new member countries is below that in most countries of the EU15. Qualitatively, all considered countries in the EU share the same upwards trend in the service sector share, however for some the new EU member countries, in particular those where in 1990 a substantial fraction of the work force was still employed in agriculture, the increase in the service sector share has been much more rapid than the average across the EU. Focusing however on the shift from manufacturing to service the patterns

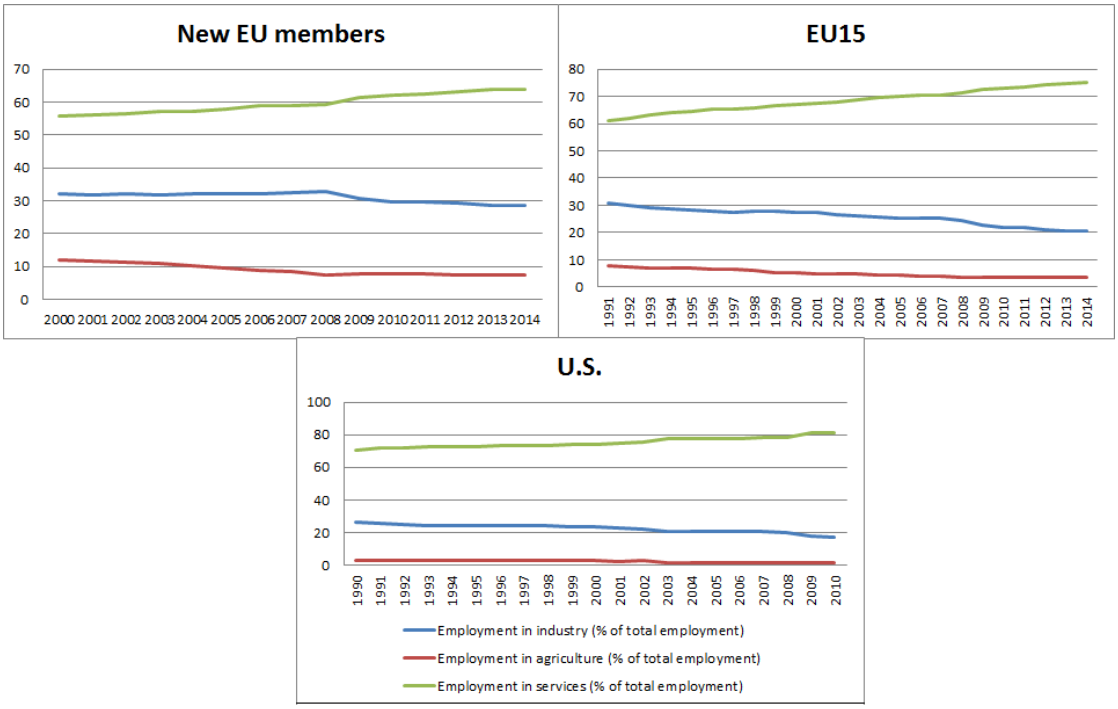
[1] Agricultural activities, forestry, hunting and fishing

[2] Manufacturing, mining, construction, quarrying, public utilities (electricity, gas, and water)

[3] Communications, insurance, financing, real estate, business services, social, community and personal services, trade, hotels and restaurants

[4] Note that based on the availability of data, the three figures consider different time spans.

Figure 2.1: Sectoral Employment Share Comparison



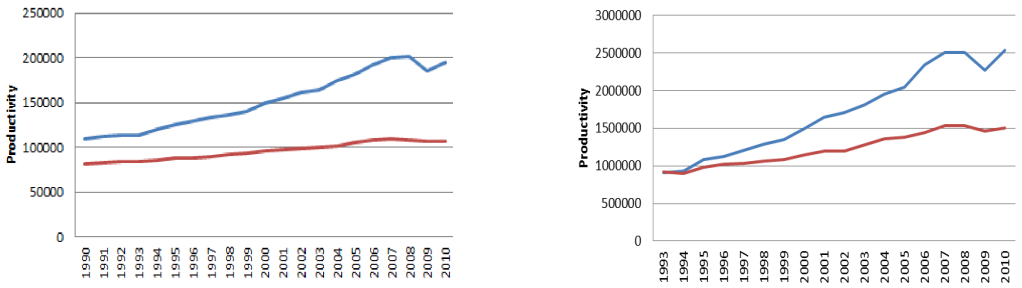
seem rather uniform across all considered countries.

3. Role of Productivity Differences: A Shift-Share Analysis

Having observed a clear pattern of an increasing employment share in service across all European countries and the U.S., we will now try to gain a better understanding of what is driving this phenomenon and how it differs between various sectors within service and manufacturing. As a first step we explore the question whether the shift in employment is an expression of changes of relative labor productivity across sectors, in a sense that workers move from sectors where their labor becomes (relatively) less productive to those with high labor productivity or faster labor productivity growth. Figure 3.1 shows the evolution of average labor productivity (measured in local currency in 2005 prices) in 14 manufacturing and 14 service sectors[5] covering overall about 75% of employment, for Austria and the Czech Republic, as representatives of old and new EU member countries. In both countries productivity is higher and also faster growing in the manufacturing sector. Putting this together with the insights from the previous Section means that overall, workers tend to move towards less productive employment.

To further explore the relationship between employment shifts and productivity changes

[5] A list of the 28 sectors is provided in Appendix B. The data is taken from the OECD Structural Analysis (STAN) database.



(a) (b)

Figure 3.1: Average labor productivity in Austria (a) and the Czech Republic (b) in manufacturing (blue line) and service (red line) sectors.

we carry out a shift-share decomposition of the change in labor productivity in 11 European countries[6]. In particular, we use a shift-share decomposition equation of the following form:

$$\begin{aligned}\frac{P_{c,t+k}-P_{c,t}}{P_{c,t}} = &\underbrace{\frac{\sum_i (p_{c,i,t+n}-p_{c,i,t})\,l_{c,i,t}}{P_{c,t}}}_{\text{Within Effect}} \\ &+\underbrace{\frac{\sum_i (l_{c,i,t+n}-l_{c,i,t})\,p_{c,i,t}}{P_{c,t}}}_{\text{Static Shift Effect}} \\ &+\underbrace{\frac{\sum_i (p_{c,i,t+n}-p_{c,i,t})(l_{c,i,t+n}-l_{c,i,t})}{P_{c,t}}}_{\text{Dynamic Shift Effect}},\end{aligned} \tag{3.1}$$

where $p_{c,i,t}$ is the labor productivity in sector i in country c at time t and $l_{c,i,t} = \frac{L_{c,i,t}}{\sum_i L_{c,i,t}}$ is the employment share of sector i in country c with $L_{c,i,t}$ denoting total employment in sector i in country c at time t. Labor productivity in country c is calculated as a weighted sum of the productivity in the different sectors: $P_{c,t} = \sum_i p_{c,i,t} l_{c,i,t}$.

The **Within Effect** measures the contribution of the sectoral productivity growth on total productivity growth, assuming that labor input remains constant, the **Static Shift Effect** measures the effect of labor mobility between different sectors on total productivity growth, assuming that productivity within each sector remains constant, and the **Dynamic Shift Effect** measures the change in the share of labor in each sector, as well as the impact of labor reallocation between sectors with differential productivity growth rates on total productivity growth. Considering the time average of these effects for a given country and a given time window allows to examine whether the increase in labor productivity in a country is primarily driven by productivity increases within the different sector or by employment shifts to

[6]The selection of the considered countries was mainly driven by the availability of the necessary data for a sufficiently long time interval.

sectors that are already more productive or exhibit faster productivity growth. We calculate the shift-share decomposition relying on the data for 14 service and 14 manufacturing sectors from the OECD Structural Analysis (STAN) database[7]. In particular, we take employment data on the sectoral level and calculate sector-specific labor productivity using production (gross product) volumes and again employment at the sectoral level using this database. The considered time window spans from 1990-2010 and is cut in four 5-year periods for which the three different effects are calculated. For some countries, due to data restrictions only a subset of these periods could be covered .

Table 3.1 shows the results of the shift-share analysis for the considered 11 EU countries. Apart from a few exception in Belgium, Finland and Italy labor productivity has been growing in all countries in all the covered time intervals. Particularly, for the new EU member countries growth rates of labor productivity have been substantial in the 1990s and early 2000s. However, the shift-share analysis indicates that consistently throughout the considered time period and across countries the contribution of the sectoral employment shifts to that productivity increase are rather limited. For all considered old EU member countries, both the static shift effect and the dynamic shift effects are negative in almost all periods, indicating that in these countries the employment shift has reduced the increase in labor productivity emerging from the evolution of productivity within the sectors. This negative static shift effect indicates that labor is shifting to industries with lower productivity or, put differently, that high productivity industries are contracting. This is further supported by the often negative dynamic shift effect. For the new EU member countries in the sample the static shift effect tends to be positive, although much smaller than the within effect. This suggests that in the new EU member countries some productivity gains were made by workers moving to more productive sectors. However, also for these countries the dynamic shift effect is consistently negative, indicating that there is no systematic movement of workers to sectors in which the growth of labor productivity is above average.

Overall, these results imply that an increase in labor productivity in general does not correspond to an expansion of this sector in terms of employment, but they also suggest that in some countries, in particular new EU member countries, there seems to be a weak positive relationship between productivity growth and employment expansion. Generally speaking, these observations of course give little indication of the causal chains which are responsible for these relationships. For example, the underlying mechanism for a negative relationship between productivity and employment might be that due to productivity increases induced by technological change firms in a sector can reduce the workforce needed to satisfy demand. A similar negative relationship could however also emerge due to a reduction of the firm's output (e.g. because of demand contraction), which leads to an elimination of old and less productive machines or less skilled labor from the production process. An encompassing analysis of the different potential causal relationships between productivity increase and employment on a sectoral or even firm level are beyond the scope of this manuscript. However, in the next section we dig deeper into one particular channel influencing the relationship between productivity and employment, by exploring how sectoral employment depends on

[7] For Germany the analysis is done on a more aggregate level due to lack of output data for some manufacturing sectors

Table 3.1: Decomposition of Labor Productivity Growth

	Period	LPG[a]	WE[b]	SSE[c]	DSE[d]	AALPGR[e]
		percent	points	points	points	percent
Austria	1990–1995	9.93	11.19	−0.73	−0.53	1.92
	1995–2000	12.53	14.90	−1.29	−1.08	2.39
	2000–2005	12.78	14.90	−1.38	−0.74	2.44
	2005–2010	2.96	5.10	−1.87	−0.26	0.63
Belgium	1995–2000	12.90	15.80	−1.94	−0.96	2.47
	2000–2005	5.20	6.93	−1.73	0.00	1.03
	2005–2010	−0.39	1.68	−1.76	−0.31	0.02
Czech Republic	1993–1995	12.56	12.35	0.42	−0.21	6.25
	1995–2000	27.02	24.47	2.17	0.39	4.91
	2000–2005	29.39	30.33	0.26	−1.20	5.31
	2005–2010	14.95	16.59	−0.80	−0.83	3.03
Denmark	1990–1995	12.30	13.04	−0.19	−0.55	2.36
	1995–2000	13.17	80.38	1.54	−68.75	2.51
	2000–2005	12.17	13.21	−0.27	−0.77	2.33
	2005–2010	1.41	3.37	−1.49	−0.47	0.33
Finland	1990–1995	26.17	23.51	1.97	0.69	4.82
	1995–2000	14.29	15.80	−1.61	0.10	2.71
	2000–2005	9.45	13.57	−2.92	−1.20	1.84
	2005–2010	−1.08	2.47	−2.81	−0.74	−0.10
France	1990–1995	7.79	11.34	−2.31	−1.23	1.52
	1995–2000	9.95	14.95	−3.42	−1.58	1.92
	2000–2005	5.43	7.06	−1.23	−0.40	1.07
	2005–2010	0.35	3.26	−2.40	−0.50	0.10
Germany	1991–1995	9.54	11.68	−0.14	−2.00	2.31
	1995–2000	10.86	11.68	0.73	−1.54	2.08
	2000–2005	6.55	7.96	−0.93	−0.49	1.29
	2005–2010	4.30	6.62	−1.87	−0.45	0.95
Hungary	1995–2000	13.48	10.10	1.82	1.56	2.58
	2000–2005	33.20	33.35	1.03	−1.18	5.91
	2005–2010	2.22	2.46	1.45	−1.69	0.57
Italy	1990–1995	12.13	15.48	−2.33	−1.01	2.36
	1995–2000	8.52	9.85	−0.42	−0.91	1.66
	2000–2005	−2.96	0.79	−3.12	−0.63	−0.59
	2005–2010	−7.00	−4.77	−2.05	−0.19	−1.35
Netherlands	1990–1995	5.28	9.02	−2.15	−1.59	1.04
	1995–2000	12.21	15.09	−2.46	−0.42	2.33
	2000–2005	4.76	6.60	−0.99	−0.86	0.94
	2005–2010	2.43	5.87	−2.85	−0.59	0.51
Slovenia	2000–2005	18.27	16.86	5.33	−3.91	3.42
	2005–2010	5.74	7.31	0.52	−2.09	1.33

[a] Labor Productivity Growth
[b] Within Effect
[c] Static Shift Effect
[d] Dynamic Shift Effect
[e] Average Annual Labor Productivity Growth Rate

Table 4.1: Independent Variables

Variable	Description
GERDL2	gross domestic expenditure on R&D, as a percentage of GDP, second lag*
GDPgrowthL1	lagged (first lag) value of GDPgrowth rate
lngdppercap	GDP per capita, constant prices (US dollar 2010), constant exchange rates (natural logarithm)
lntotalempl	total employment (measured in number of workers, natural logarithm)
IndProdGrowth	growth rate of industrial production
strictness	strictness of employment protection - individual and collective dismissals (regular contracts) Version 1**

* We use the second lag since it is well known that R&D activities typically need some time to produce relevant results. Different lags have been tried as well without qualitatively affecting results

** Version 1 is used because later versions cover only short time spans

the level of R&D activities and whether this relationship differs between manufacturing and service sectors.

4. Role of R&D: comparison of manufacturing and services

Our analysis of the relationship between R&D activity and employment relies on country and sector specific regressions and, in order to have a sufficient number of observations to obtain meaningful results we restrict attention to countries for which data is available for the time span 1995-2010. Because of this we have to drop some of the countries considered in the previous sections. In the sample remain 8 EU member countries: Austria, Belgium, Denmark, Finland, France, Germany, Italy and the Netherlands.

First, we consider the growth (decline) of the service (manufacturing) sector's employment share as a whole in the period 1995-2010. The Hausman test indicates that the use of a fixed-effects model is appropriate. However, diagnostic tests suggest that the errors are heteroskedastic and autocorrelated. Therefore, we estimate a robust fixed-effects (within) regression with Driscoll and Kraay standard errors (see e.g. Hoechle et al. (2007)), which assumes a heteroskedastic, autocorrelated up to some lag and cross-sectionally dependent error structure. The regression equation has the following form:

$$sharemanu_{it} = \beta X'_{it} + \alpha_i + u_{it} \tag{4.1}$$

where β is the coefficient vector, X'_{it} is the vector of independent variables, α_i captures country fixed effects and u_{it} is the error term. Here i stands for the cross-sectional unit (i.e., the 8 countries) and t denotes time (1995-2010). The dependent variable **sharemanu** is defined as the total employment in the manufacturing sectors as a share of total employment in country i. The share of the service sector, **shareser**, is defined analogously. Since these two shares add to one it is sufficient to consider only the manufacturing employment share. All the independent variables are listed in Table 4.1. As above, we use OECD and OECD STAN data.

(a) (b)

Figure 4.1: Distribution of manufacturing share across years for different countries (a) and across countries for different years

Table 4.2 provides descriptive statistics for the used variables and shows the amount variation between countries and across time within countries. This heterogeneity is also in illustrated in Figure 4.1, which shows that consistent with the evidence from Section 2 the share of labor employed in the considered manufacturing sectors differs substantially between countries but exhibits a consistent downward trend over time.

The choice of explanatory variables is partially based on previous empirical studies which have focused on possible determinants of sectoral employment. In particular, higher GDP per capita is associated with higher employment in the service sector (Messina (2005), based on 27 OECD countries for the period (1970-1998), d'Agostino et al. (2006) for EU-15 (1970-2003)). Hence, we expect a negative correlation between GDP per capita and the employment share in manufacturing. On the other hand, different studies find different effects of higher employment regulations (strictness) on the expansion of the service sector. OECD (2000) and d'Agostino et al. (2006) find that on an aggregate level, higher employment protection hinders the expansion of the service sector. On the other hand, Messina (2005) does not find a significant relationship between the two.

In addition, we control for demographic changes coming from, for example, migration (controlled for by total employment) and productivity growth (industrial productivity growth) which might also impact service and manufacturing employment. Our main focus is, however, on the role of R&D on sector specific employment growth.

The results for the regressions with different set of explanatory variables are shown in Table 4.3. Quite strikingly, we consistently obtain a statistically significant coefficient for R&D expenditures, which means that, considering all manufacturing sectors, there is a negative correlation between the R&D investment in a country and the share of employment in manufacturing. Apart from this, we obtain a positive correlation of the employment share in manufacturing with the growth rates of GDP and industrial production, as well as negative correlation with total employment and with GDP per capita. This latter result is consistent with the observation that in particular the new EU member countries are characterized by higher manufacturing shares but lower per capita GDP and employment compared to the old EU member states. Concerning the negative correlation between the manufacturing share and R&D, in principle this phenomenon is in accordance with our evidence from the pre-

Table 4.2: Descriptive Statistics

Variable		Mean	Std. Dev.	Min	Max	Observations
shareser	overall	0.689	0.047	0.605	0.794	N = 128
	between		0.044	0.629	0.773	n = 8
	within		0.022	0.634	0.737	T = 16
sharemanuu	overall	0.311	0.047	0.206	0.395	N = 128
	between		0.044	0.227	0.371	n = 8
	within		0.022	0.263	0.366	T = 16
GERDL2	overall	2.060	0.585	0.940	3.550	N = 111
	between		0.576	1.039	3.072	n = 8
	within		0.218	1.188	2.619	T-bar = 13.875
GDPgrowthL1	overall	1.870	2.274	-8.300	6.300	N = 120
	between		0.660	0.967	2.953	n = 8
	within		2.188	-9.383	5.217	T = 15
lngdppercap	overall	6.044	0.152	5.768	6.416	N = 128
	between		0.136	5.880	6.326	n = 8
	within		0.081	5.786	6.219	T = 16
lntotalempl	overall	15.918	1.045	14.535	17.519	N = 128
	between		1.112	14.658	17.481	n = 8
	within		0.048	15.790	16.011	T = 16
IndProdGrowth	overall	1.854	5.154	-18.600	11.600	N = 128
	between		1.517	-0.050	3.938	n = 8
	within		4.953	-19.427	11.673	T = 16
strictness	overall	2.441	0.327	1.845	2.885	N = 128
	between		0.337	1.887	2.865	n = 8
	within		0.082	2.251	2.646	T = 16

vious sections that employment tends to move to sectors with lower growth rates of labor productivity. However, it should be noted that here we do not distinguish between R&D expenditures in manufacturing and service, such that it is not clear that in the countries in the sample with particularly high R&D the majority of this investment was done in the manufacturing sectors. Furthermore, we should expect a large heterogeneity across manufacturing sectors with respect to the elasticity of employment with respect to R&D, which clealry limits the informativeness of such considerations on the aggregate level.

Table 4.3: Manufacturing share

	(1) sharemanu	(2) sharemanu	(3) sharemanu	(4) sharemanu	(5) sharemanu
GERDL2	-0.0573***	-0.0475***	-0.0100*	-0.0147**	-0.0133*
	(0.00363)	(0.00560)	(0.00548)	(0.00494)	(0.00641)
GDPgrowthL1		0.00233***	0.00256***	0.00202***	0.00227***
		(0.000724)	(0.000210)	(0.000279)	(0.000289)
lngdppercap			-0.191***	-0.0814	-0.119***
			(0.0140)	(0.0517)	(0.0391)
lntotalempl				-0.189**	-0.124**
				(0.0736)	(0.0472)
IndProdGrowth					0.000432***
					(0.000116)
strictness					-0.0145
					(0.0116)
cons	0.424***	0.400***	1.480***	3.844***	3.064***
	(0.00628)	(0.0111)	(0.0752)	(0.871)	(0.552)
N	111	111	111	111	111
Within R-sq	0.4642	0.5336	0.7818	0.8097	0.8231

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

To address this shortcoming we now perform sector specific regressions using again OECD STAN data from the 28 sectors listed in Appendix B. The dependent variable in each case in the natural logarithm of total employment in a specific sector. As explanatory variables we include now in addition to country-wide R&D also country-wide R&D in the considered sector. Unfortunately, the data on sector specific R&D expenditures is scarce for some countries and especially for the service industries. Hence, we can include the explanatory variable **R&D expenditure by industry** only for some of the sectors, depending on the availability of observations. Again, fixed effects (within) regressions with with Driscoll and Kraay standard errors are estimated. We add a set of additional explanatory variables which could have effect on the employment levels in individual sectors such as changes in gross value added or changes in unit labor cost. On the one hand, an increase in gross value added per hour worked could have an ambiguous effect on the dependent variable. It might lead to higher employment due to higher productivity but could also reduce employment because less labor input is needed for the same output. On the other hand, we could expect that an increase in the labor cost might increase unemployment in the given sector. The additional

Table 4.4: Additional Independent Variables

Variable	Description
GVAC	Annual change of gross value added per hour worked: C: Manufacturing (%)
GVAF	Annual change of gross value added per hour worked: F: Construction (%)
GVAG_I	Annual change of gross value added per hour worked: G_I: Wholesale retail trade accommodation food services, transportation and storage (%)
GVAJ	Annual change of gross value added per hour worked: J: Information and communication (%)
GVAK	Annual change of gross value added per hour worked: K: Financial and insurance activities (%)
GVAMN	Annual change of gross value added per hour worked: MN: Professional, scientific and technical activities, Administrative and support service activities (%)
ULCC	Annual change of unit labor costs: C: Manufacturing (%)
ULCF	Annual change of unit labor costs: F: Construction (%)
ULCG_I :	Annual change of unit labor costs: G_I: Wholesale retail trade accommodation food services, transportation and storage (%)
ULCJ	Annual change of unit labor costs: J: Information and communication (%)
ULCK	Annual change of unit labor costs: K: Financial and insurance activities (%)
ULMN	Annual change of unit labor costs: MN: Professional, scientific and technical activities, Administrative and support service activities (%)
lnrd_XL1	R&D expenditures in industry **X**, first lag, natural logarithm, measure: 2010 dollars - constant prices and PPP's.

independent variables used in the sector-specific regressions are given in Table 4.4.

Tables 5.1 to 5.4 show the regression results for all manufacturing sectors in our sample. The sectors are ordered in these Tables based on their employment share starting with the largest sectors. For each sector where data about sector-specific R&D expenditures are available we present results for two different regressions, one where sector specific R&D is included and one where it is excluded. The second model is presented in order to facilitate the comparison of findings with such sectors where we do not have data on sector-specific R&D. As expected, quite substantial differences between sector can be observed. We have run additional regressions including different subsets of the considered independent variables, however these variations did not change the qualitative picture which emerges.

Focusing on the largest manufacturing sectors treated in Tables 5.1 and 5.2 we observe that sector-specific R&D has a positive relationship with employment whenever this coefficient is significant. The negative relationship of the manufacturing share with total R&D in the country, which we found in the previous Section, might be strongly driven by the construction sector ('f'), which is by far the largest among the manufacturing sectors in terms of

employment and exhibits a negative relationship of employment with R&D. Another negative relationship arises for food products ('ca'), also a sector for which one would typically not expect a strong impact of technological change. For sector more closely related to high technology, like machinery ('ck'), transport equipment ('cl') and computer and electronic products ('ci') the corresponding coefficients for R&D investments are all positive and highly significant. Overall, the sector-specific perspective suggests that in manufacturing R&D has positive effects on employment, in particular in those industries which we expect to be strongly influenced by technological change.

Moving to the service sectors, for which the results are collected in Tables 5.5 to 5.7, we observe consistently a positive relationship between country-wide R&D and employment in all considered sector in which the corresponding coefficient is significant. Unfortunately, data about sector-specific R&D expenditures is available only for two of the fourteen service sectors, one of them being scientific research and development ('mb'), for which as expected the correlation between R&D expenditures and employment is positive and highly significant. Overall, the results for the service sectors do not seem to be substantially different from those for the considered manufacturing sectors, if we exclude construction and food products.

5. CONCLUSIONS

The purpose of this study is to provide some empirical diagnostics of the relationship between R&D, productivity growth and employment on a sectoral level and to explore in how far these relationships differ qualitatively between manufacturing and service sectors. As a first step we have documented a clear and persistent movement of employment from manufacturing to service sectors in all European countries in our sample. Second, we have shown that this shift of employment corresponds to a movement from sectors with higher and faster growing productivity to such with smaller and slower growing productivity. This holds particularly true for old EU member countries, whereas for new member countries some movement towards more productive sectors could be observed. Finally, we have shown that there is a negative correlation between the manufacturing share in employment and the total R&D expenditures in that country. In terms of absolute employment (rather than employment share) we find that for most manufacturing sectors and for all service sectors an increase in R&D corresponds to a positive employment effect, where the relationship is however inversed for some important manufacturing sectors. Sector specific R&D seems to have consistently positive effects on sectoral employment. Overall, this evidence gives little indication that there is a substantial difference in the impact of R&D on employment between manufacturing and service sectors.

	(1) ln_f	(1a) ln_f	(2) ln_ch	(2a) ln_ch	(3) ln_ca	(3a) ln_ca
GERDL2	-0.00758	-0.112**	0.1141***	0.101***	-0.0383*	-0.0525*
	(0.0337)	(0.0474)	(0.0181)	(0.0289)	(0.0183)	(0.0276)
GDPgrowthL1	0.00377***	0.00622**	0.0172***	0.0123***	0.00656***	0.00314***
	(0.000883)	(0.00248)	(0.00157)	(0.00139)	(0.00161)	(0.000575)
lngdppercap	-1.037***	-0.726***	-0.824***	-0.299	-0.616***	-0.294
	(0.234)	(0.196)	(0.119)	(0.189)	(0.172)	(0.246)
lntotalempl	3.015***	2.867***	1.385***	0.984***	0.518**	0.157
	(0.207)	(0.308)	(0.208)	(0.326)	(0.195)	(0.317)
IndProdGrowth	0.00136***	0.000453	0.00340***	0.00254	0.00173	-0.0000719
	(0.000418)	(0.000800)	(0.00109)	(0.000902)	(0.00115)	(0.000835)
GVAF	0.00222	-0.00126				
	(0.00251)	(0.00411)				
ULCF	0.000399	-0.00566				
	(0.00272)	(0.00398)				
GVAC			-0.00609*	-0.00341**	-0.00131	-0.000620
			(0.00290)	(0.00137)	(0.00140)	(0.00210)
ULCC			-0.00418	-0.00367**	-0.00153	-0.00178
			(0.00249)	(0.00122)	(0.00149)	(0.00176)
lnrd_cfL1		0.0894*				
		(0.0457)				
lnrd_chL1				0.00942		
				(0.0198)		
lnrd_caL1						0.0629*
						(0.0327)
cons	-28.59***	-29.54***	-5.213*	-1.972	7.633***	10.30***
	(2.086)	(3.812)	(2.611)	(3.987)	(2.329)	(3.292)
N	108	71	108	71	108	71
Within R-sq	0.4926	0.6339	0.4199	0.6674	0.5148	0.5849
Frac. of total empl. in 2010 (%)	6.59	6.59	2.39	2.39	2.05	2.05

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5.1: Sector-specific regressions for manufacturing sectors

	(4) ln_ck	(4a) ln_ck	(5) ln_cl	(5a) ln_cl	(6) ln_cg	(7) ln_cc	(7a) ln_cc
GERDL2	0.161***	0.0647*	0.305	0.324***	0.0493**	0.113***	0.261***
	(0.0217)	(0.0327)	(0.0578)	(0.0588)	(0.0180)	(0.0116)	(0.0719)
GDPgrowthL1	0.0131***	0.00816***	0.0238***	0.0258**	0.0174***	0.0276***	0.0292***
	(0.00146)	(0.00130)	(0.00424)	(0.00330)	(0.00256)	(0.00322)	(0.00469)
lngdppercap	-0.813*	-0.339*	-0.659	-1.106***	-0.412**	-1.488***	-1.881***
	(0.127)	(0.164)	(0.430)	(0.329)	(0181)	(0.0636)	(0.400)
lntotalempl	1.488***	1.318***	0.439	-0.248	0.335	0.852***	1.050*
	(0.180)	(0.329)	(0.435)	(0.423)	(0.302)	(0.250)	(0.576)
IndProdGrowth	0.00354***	0.000574	0.00505	0.00253	0.00368*	0.00491***	0.00239**
	(0.00111)	(0.00126)	(0.00329)	(0.00233)	(0.00184)	(0.00153)	(0.00108)
GVAC	-0.00403*	-0.00218	-0.00766	0.000133	-0.00547	-0.00547	-0.0000658
	(0.00217)	(0.00252)	(0.00697)	(0.00382)	(0.00347)	(0.00434)	(0.00231)
ULCC	-0.000884	-0.000997	-0.00544	-0.00150	-0.00331	-0-00630*	-0.00466**
	(0.00243)	(0.00166)	(0.00702)	(0.00189)	(0.00255)	(0.00305)	(0.00191)
lnrd_ckL1		0.0138					
		(0.0321)					
lnrd_clL1				0.108***			
				(0.0283)			
lnrd_ccL1							-0.0533
							(0.0419)
cons	-7.387***	-7.554*	8.247	19.28***	8.709*	6.928***	6.814
	(2.178)	(4.071)	(5.583)	(5.462)	(4.158)	(3.754)	(6.410)
N	108	71	108	71	108	108	71
Within R-sq	0.4757	0.7246	0.3244	0.6073	0.422	0.7769	0.8193
Frac. of total empl. in 2010 (%)	1.72	1.72	1.42	1.42	1.33	1.16	1.16

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5.2: Sector-specific regressions for manufacturing sectors (continued)

	(8)	(9)	(9a)	(10)	(10a)	(11)	(11a)
	ln_d31t32	ln_cb	ln_cb	ln_cj	ln_cj	ln_ci	ln_ci
GERDL2	-0.0908**	0.104*	0.100	0.355***	0.297***	0.141*	-0.0774
	(0.0397)	(0.0354)	(0.101)	(0.0553)	(0.0769)	(0.0678)	(0.0588)
GDPgrowthL1	0.0191***	0.0368**	0.0307***	0.0253***	0.0179***	0.0220***	0.0198***
	(0.00358)	(0.00628)	(0.00550)	(0.00345)	(0.00387)	(0.00557)	(0.00424)
lngdppercap	-0.620**	-2.491	-1.358**	-2.216***	-1.407***	-0.768	-1.148**
	(0.276)	(0.435)	(0.623)	(0.269)	(0.400)	(0.514)	(0.464)
lntotalempl	0.383	-0.544	-2.000*	2.189***	1.300*	-0.262	1.118*
	(0.408)	(0.789)	(1.122)	(0.489)	(0.631)	(0.763)	(0.607)
IndProdGrowth	0.00395*	0.00963**	0.00196	0.00911***	0.00364*	0.00320	-0.00183
	(0.00210)	(0.00366)	(0.00277)	(0.00229)	(0.00180)	(0.00248)	(0.00219)
GVAC	-0.00341	-0.00984	-0.00503	-0.0129*	-0.00390	-0.00341	0.00204
	(0.00564)	(0.00755)	((0.00471))	(0.00520)	(0.00436)	(0.00383)	(0.00565)
ULCC	-0.00349	-0.00700	-0.00778	-0.00524	-0.00166	-0.00279	-0.00453*
	(0.00478)	(0.00690)	(0.00235)	(0.00557)	(0.00444)	(0.00334)	(0.00235)
lnrd_cbL1			0.0525				
			(0.0335)				
lnrd_cjL1					0.0848***		
					(0.0189)		
lnrd_ciL1							0.380***
							(0.0744)
cons	9.234	34.59***	50.34***	-11.40*	-3.558	19.62*	-7.771
	(5.630)	(10.41)	(13.88)	(6.166)	(8.255)	(9.518)	(8.730)
N	108	108	71	108	71	108	71
Within R-sq	0.6036	0.7877	0.8081	0.4078	0.4953	0.3953	0.6556
Frac. of total empl. in 2010 (%)	0.95	0.88	0.88	0.75	0.75	0.68	0.68

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5.3: Sector-specific regressions for manufacturing sectors (continued)

	(12)	(13)	(14)
	ln_ce	ln_cf	ln_cd
GERDL2	0.204***	-0.0167	-0.139***
	(0.0322)	(0.0231)	(0.0347)
GDPgrowthL1	0.0164***	0.204***	0.00355
	(0.00137)	(0.00363)	(0.00355)
lngdppercap	-1.246***	0.317**	-0.984***
	(0.132)	(0.141)	(0.232)
lntotalempl	0.770**	0.195	0.722
	(0.260)	(0.243)	(0.419)
IndProdGrowth	0.00286**	-0.00398**	0.000643
	(0.00107)	(0.00180)	(0.00301)
GVAC	-0.00627**	0.00613	0.00265
	(0.00222)	(0.00629)	(0.00358)
ULCC	-0.00613***	0.00294	0.00145
	(0.00174)	(0.00575)	(0.00293)
cons	5.725	5.120	3.335
	(3.375)	(3.123)	(5.519)
N	108	108	108
Within R-sq	0.6540	0.2035	0.4702
Frac. of total empl. in 2010 (%)	0.63	0.29	0.07

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5.4: Sector-specific regressions for manufacturing sectors (continued)

	(1)	(1a)	(2)	(3)	(4)	(5)	(6)
	ln_g	ln_g	ln_ru	ln_n	ln_h	ln_d69t71	ln_i
GERDL2	0.00323	0.0465**	0.104***	0.264***	-0.0331	0.0331	0.0618***
	(0.00865)	(0.0174)	(0.0205)	(0.0488)	(0.0214)	(0.0187)	(0.0141)
GDPgrowthL1	0.00112	0.00346**	-0.00367*	0.000639	-0.000331	-0.00762***	-0.000776
	(0.00101)	(0.00120)	(0.00207)	(0.00339)	(0.000753)	(0.00111)	(0.00138)
lngdppercap	0.0113	-0.0843	-0.238	0.150	0.259***	0.568***	-0.341***
	(0.0516)	(0.101)	(0.157)	(0.348)	(0.0847)	(0.149)	(0.0937)
lntotalempl	0.927***	0.826***	1.496***	3.204***	0.282***	2.157***	2.125***
	(0.0509)	(0.205)	(0.195)	(0.339)	(0.0918)	(0.200)	(0.250)
IndProdGrowth	0.0000549	0.000284	-0.000677	0.000837	-0.000146	-0.00217***	0.000381
	(0.000377)	(0.000306)	(0.000519)	(0.000841)	(0.000300)	(0.000693)	(0.000430)
GVAG_I	0.000336	0.000727			0.000696		-0.000119
	(0.000969)	(0.00137)			(0.00149)		(0.003237)
ULCG_I	0.000336	-0.000405			0.00226		0.000536
	(0.00111)	(0.000790)			(0.00150)		(0.00349)
GVAMN				0.0107			
				(0.00744)			
ULCMN				0.00783*			
				(0.00419)			
lnrd_gL1	-0.00151						
		(0.00673)					
cons	-0.837	1.263	-9.535***	-39.65***	7.016***	25.19***	-19.27***
	(0.645)	(2.624)	(2.255)	(3.549)	(1.328)	(2.336)	(3.617)
N	108	70	111	108	108	111	108
Within R-sq	0.8279	0.8501	0.7755	0.8941	0.6574	0.9289	0.7464
Frac. of total empl. in 2010 (%)	14.29	14.29	7.30	6.48	4.85	4.38	4.32

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5.5: Sector-specific regressions for service sectors

	(7)	(8)	(9)	(10)	(11)	(12)
	ln_k	ln_t	ln_jc	ln_mc	ln_l	ln_ja
GERDL2	0.0417	0.220***	0.238***	0.139***	0.0784***	0.0859***
	(0.0336)	(0.0630)	(0.0401)	(0.0332)	(0.00900)	(0.0179)
GDPgrowthL1	-0.000170	-0.00889	-0.00474	-0.000493	-0.00231	0.00905***
	(0.00160)	(0.00606)	(0.00492)	(0.00222)	(0.00159)	0.00253
lngdppercap	-0.616***	0.330	1.163***	0.953***	-0.0525	-0.758***
	(0.123)	(0.578)	(0.248)	(0.198)	(0.165)	(0.120)
lntotalempl	1.405***	0.486	2.071***	-0.000875	1.626***	1.537***
	0.222	(0.856)	(0.324)	(0.233)	(0.270)	(0.300)
IndProdGrowth	-0.000243	-0.00368**	-0.00363***	-0.00198**	-0.000066	0.00139**
	(0.000545)	(0.00165)	(0.000905)	(0.000905)	(0.000348)	(0.000523)
GVAK	0.000164					
	(0.00107)					
ULCK	0.000698					
	(0.00130)					
GVAJ			0.00201			0.00125
			(0.00342)			(0.00263)
ULCJ			0.00236			0.000121
			(0.00419)			0.00262
GVAMN				-0.00114		
				(0.00473)		
ULCMN				0.00128		
				(0.00422)		
cons	-6.364*	1.215	-28.90	5.430*	-14.57***	-8.956*
	(3.014)	(10.60)	(4.857)	(2.593)	(3.317)	(4.189)
N	108	111	108	108	111	108
Within R-sq	0.4386	0.4160	0.8725	0.6780	0.8542	0.2587
Frac. of total empl. in 2010 (%)	2.92	2.65	1.61	1.21	0.90	0.81

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5.6: Sector-specific regressions for service sectors (continued)

	(13)	(13a)	(14)
	ln_mb	ln_mb	ln_jb
GERDL2	0.184***	0.0853	0.00512
	(0.0489)	(0.0901)	(0.00387)
GDPgrowthL1	0.00136	-0.00235	0.0176
	(0.00407)	0.00569	(0.00775)
lngdppercap	0.148	-0.590	-0.301
	(0.415)	(0.461)	(0.521)
lntotalempl	1.673**	2.724***	-0.200
	(0.674)	(0.399)	(0.573)
IndProdGrowth	-0.000148	-0.00131	0.00277*
	(0.00103)	(0.00140)	(0.00153)
GVAMN	0.00814*	0.00260	
	(0.00411)	(0.00209)	
ULCMN	0.00616	-0.000861	
	(0.00429)	(0.00201)	
GVAJ			0.00695*
			(0.00363)
ULCJ			0.00512
			(0.00387)
lnrd_mbL1		0.143***	
		(0.0220)	
cons	-17.52*	-32.64***	15.83*
	(8.506)	(4.417)	(7.934)
N	108	71	108
Within R-sq	0.6756	0.8669	0.3264
Frac. of total empl. in 2010 (%)	0.54	0.54	0.43

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5.7: Sector-specific regressions for service sectors (continued)

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Appendix

A. Country-level evidence on the dynamics of employment shares

Figures A.1, A.2 show the evolution of employment shares in service, manufacturing and agriculture for the EU15 countries, whereas Figure A.3 covers the new EU member countries.

Figure A.1: Old EU Members: Part 1

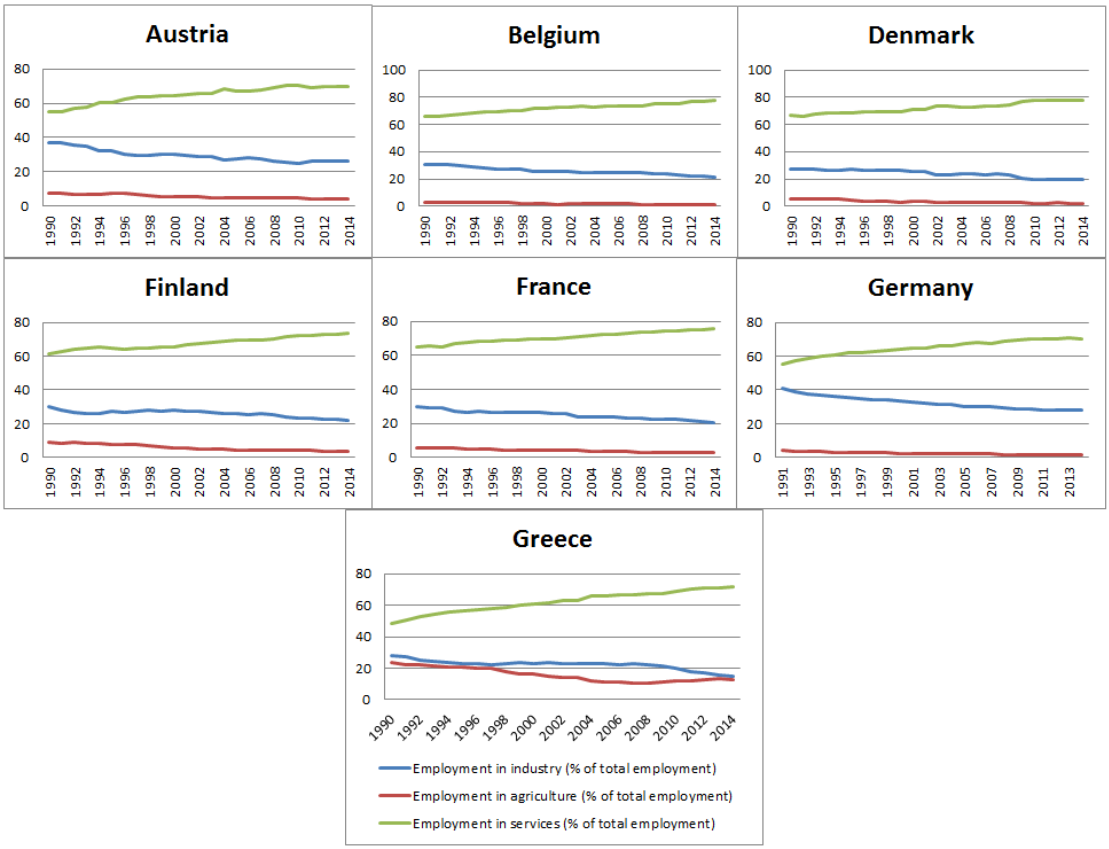


Figure A.2: Old EU Members: Part 2

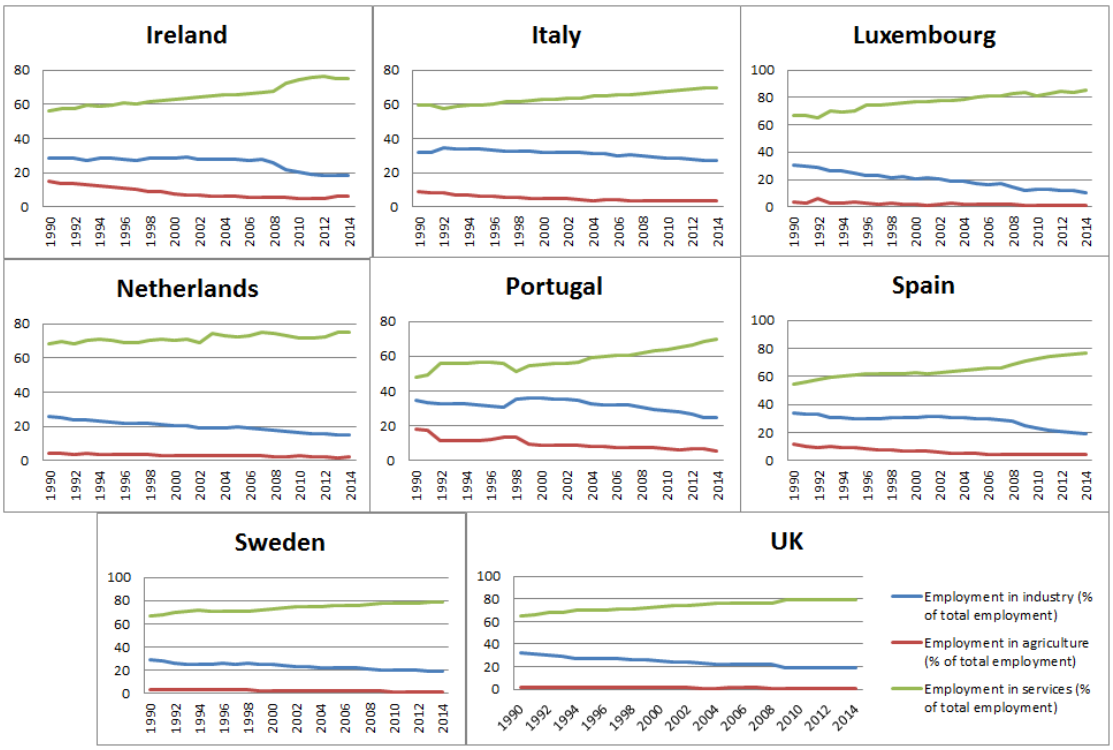
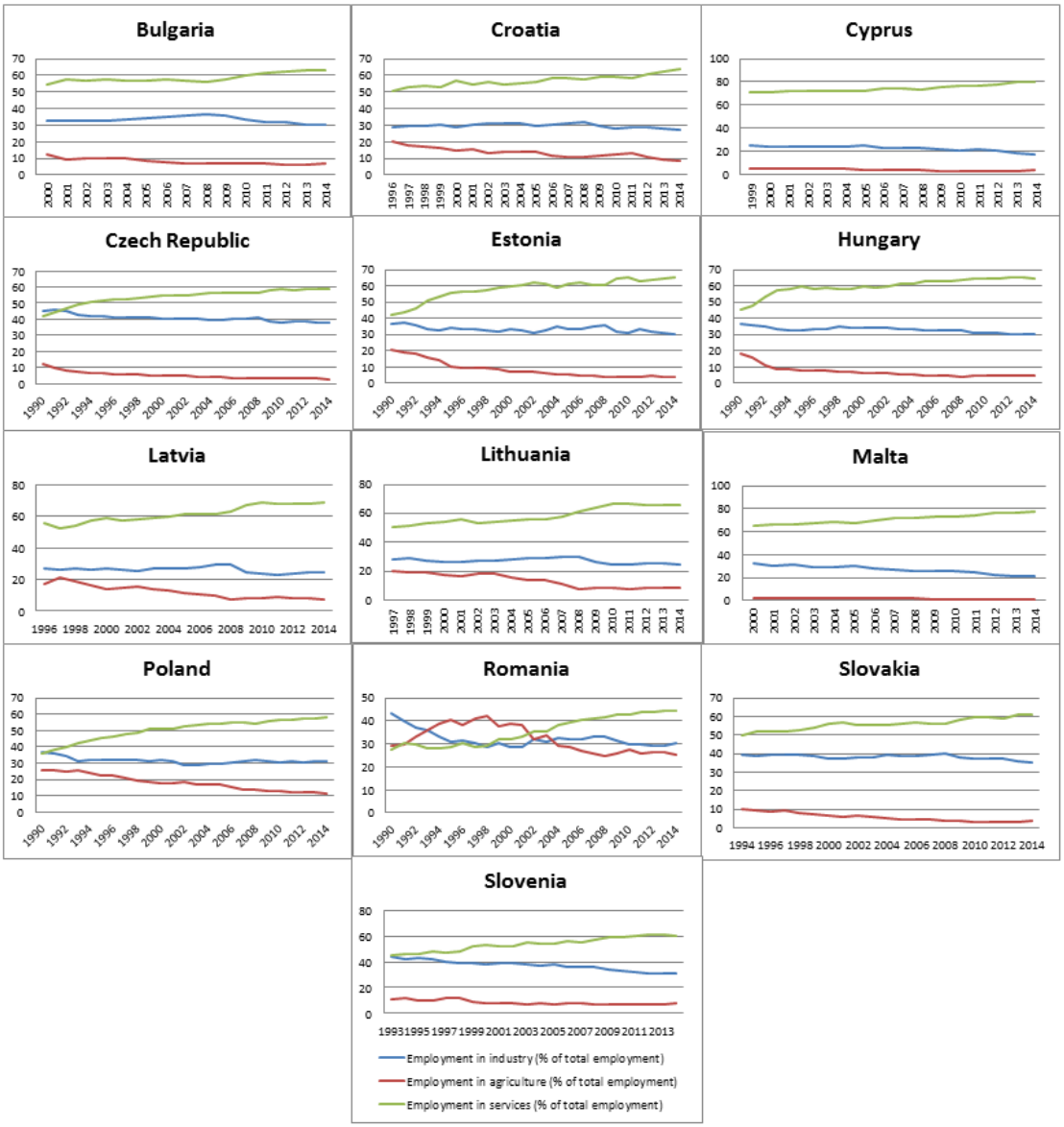


Figure A.3: New EU Members



B. List of sectors considered in the analysis

Below we list the overall 28 sectors in manufacturing and services considered in the analyses in Sections 3 and 4. We also give the labels for the sectors used in the regression tables.
Manufacturing

1. **ca:** Food products, beverages and tobacco
2. **cb:** Textiles, wearing apparel, leather and related products
3. **cc:** Wood and paper products, and printing
4. **cd:** Coke and refined petroleum products
5. **ce:** Chemicals and chemical products
6. **cf:** Basic pharmaceutical products and pharmaceutical preparations
7. **cg:** Rubber and plastics products, and other non-metallic mineral products
8. **ch:** Basic metals and fabricated metal products, except machinery and equipment
9. **ci:** Computer, electronic and optical products
10. **cj:** Electrical equipment
11. **ck:** Machinery and equipment n.e.c.
12. **cl:** Transport equipment
13. **d31t32:** Furniture, other manufacturing
14. **f:** Construction

Services

1. **g:** Wholesale and retail trade, repair of motor vehicles and motorcycles
2. **h:** Transportation and storage
3. **i:** Accommodation and food service activities
4. **ja:** Publishing, audiovisual and broadcasting activities
5. **jb:** Telecommunications
6. **jc:** IT and other information services
7. **k:** Financial and insurance activities
8. **l:** Real estate activities

9. **d69t71:** Legal and accounting activities; activities of head offices; management consultancy activities; architecture and engineering activities;
10. **mb:** Scientific research and development
11. **mc:** Advertising and market research; other professional, scientific and technical activities; veterinary activities
12. **n:** Administrative and support service activities
13. **ru:** Arts, entertainment, repair of household goods and other services
14. **t:** Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use