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Department(s)	:	Institutional analysis
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Author(s)	:	Willemien Kets, Arjan Lejour[1]
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Sectoral TFP developments in the OECD

This note describes the sectoral total factor productivity (TFP) developments in the OECD between 1970-1990. Based on the ISDB data of the OECD, we confirm the stylised fact that TFP growth is relatively high in agriculture and relatively low in services. Within manufacturing, the TFP growth in chemicals and in capital goods is high whereas it is low in food processing, paper and publishing and metals. The TFP growth in services sectors like construction, financial services and other (government) services seems to be zero or even negative, while it is relatively high in transport and communication. These sectoral pictures are not universal. Differences between countries are rather large. Also, the TFP growth per year appears to be non constant over time. We use the results from this study in our dynamic CGE model WorldScan to model differences in productivity growth between the sectors. In particular, we employ this mechanism in the European long term scenarios.

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1 Introduction

In WorldScan, GDP growth is attributed to growth in high and low skilled labour, the growth of capital and technological progress (Total Factor Productivity, TFP). The growth of capital is endogenously determined in the model, while the growth of labour follows from projections of population growth and participation rates (see e.g. Lejour and Van Leeuwen , 2002). Given the projections for economic growth, the growth of the total factor productivity is determined. This mechanism operates at a macro level. In a dynamic sectoral CGE model such as WorldScan (CPB, 1999), one is interested in how this TFP growth is divided over the sectors. Is the TFP growth equal for all sectors (balanced growth mechanism/ unbiased technological progress), or are there reasons to believe that the TFP growth differs for the various sectors? Experience tells us that the assumption of unbiased technological progress is generally not satisfied. For example, a well known stylised fact tells us that TFP-growth in developed countries is highest in agriculture, followed by manufacturing and the service sector. So far, however, empirical research was lacking to devise an alternative division scheme for our application.

Other dynamic CGE models, such as the G-Cubed model (McKibbin and Wilcoxen, 1999), the Linkage model (Van der Mensbrugghe, 2001) and the dynamic GTAP model (Walmsley et al., 2000), do not give much guidance. In the G-Cubed model productivity growth is equal for all sectors within a country, except for the energy sector. In the Linkage model sectoral TFP is affected by the export ratio and a parameter to allow for exogenous differences between the sectors. The endogenous mechanism via the export ratios represents the fact that higher export ratios could lead to more (knowledge) spillovers which increase sectoral productivity. The parameter that allows for exogenous differences makes that productivity in agriculture exceeds that in manufacturing and services. However, a better empirical underpinning is not available. The documentation on the dynamic GTAP model ignores sectoral productivity. From private conversation with these researchers we understood that their handling of these productivity differences is not based on empirical research.

In order to design an empirically based division scheme for TFP growth, we have examined the historical developments in sectoral TFP using the International Sectoral Database 1998 (ISDB98) from the OECD (OECD, 1998). This database presents data for 14 OECD countries and 29 sectors.[2] We have looked at the TFP developments in the period 1970 - 1990. Our focus was on three dimensions: the variation across sectors and across countries, and changes in TFP growth over time. The latter dimension is investigated to see whether there are long run trends or temporal effects related to the stage of development of a country that should be accounted for

[2] A concordance table between the WorldScan and ISDB sectors can be found in Appendix A.

on our model. In section 2, we discuss the methodology. In section 3, the results are presented. Additional results can be found in Appendix D. We conclude in section 4.

2 Methodology

We have employed the variable TFP from the ISDB database. The definition of this variable reads:

$$TFP = \left(\frac{VA}{ET^{w} \cdot GCS^{1-w}} \right) \Big/ TFP_{t_b}$$

where VA is gross value added (GDP at market prices, in 1990 US$), ET is total employment, GCS the gross capital stock (at market prices, in 1990 US$), and w the standardised labour share weights. The latter variable is set to 70% for all sectors and countries, except for "electricity, gas and water", "mining", "finance, insurance, real estate and business services" and "real estate", where a labour share weight of 33% is used. The variable TFP_{tb} denotes the total factor productivity in the base year, 1990. This variable is thus indexed at 1 in 1990 for every country and every sector.[3]

We compare the relative growth rates of various sectors and different countries. The ISDB distinguishes 29 sectors in total, of which we consider 20. The relevant ISDB industry codes are collected in Table 2.1. The period 1970 to 1990 is chosen because of the ample availability of complete time series for this period. Only for the various service sectors few time series are present. This is in particular the case for the ISDB service sectors communication (COM), transport and storage (TAS), financial institutions and insurance (FNS) and real estate and business (RES). Furthermore, no time series are available for the PGS sector, nor for the ISDB sector mining and quarrying (MID), which makes up the WorldScan sectors other raw materials (RAW) and the composite sector coal, gas and gas distribution, petroleum products, and electricity (ENG).

[3] In fact, to incorporate the sectoral growth rates in WorldScan, we should use the WorldScan production function to calculate the TFP growth. Unfortunately, the data required are not available. By employing the ISDB definition of the TFP growth, we hope at least to be able to incorporate some stylized facts in WorldScan.

With the TFP time series, the average yearly growth rate in the period t_0 to t_n (where t_0 = 1970, and t_n = 1990) is calculated for the sector s and region r[4]:

$$g_{s,r} = \left[\frac{TFP_{s,r}(t_n)}{TFP_{s,r}(t_0)} \right]^{1/(t_n - t_0)} - 1$$

Another interesting variable is the TFP level, especially in the country comparisons. However, the data quality is such that the TFP levels seem to be unreliable. Moreover, for our purposes - introducing differential TFP growth rates in WorldScan - knowledge of the TFP levels is not necessary.

Table 2.1 ISDB Industry codes

AGR	Agriculture, hunting, forestry and fishing
MID	Mining and quarrying
FOD	Food, beverages and tobacco
TEX	Textiles, wearing apparel and leather industries
WOD	Wood and wood products, including furniture
PAP	Paper and paper products, printing and publishing
CHE	Chemicals and chemical petroleum, coal, rubber and plastic products
MNM	Non-metallic mineral products, except products of petroleum and coal
BMI	Basic metal industries
MEQ	Fabricated metal products, machinery and equipment
MOT	Other manufacturing industries
EGW	Electricity, gas and water
CST	Construction
RET	Wholesale and retail trade, restaurants and hotels
TAS	Transport and storage
COM	Communication
FNS	Financial institutions and insurance
RES	Real estate and business services
SOC	Community, social and personal services
PGS	Producers of government services

[4] Of course, the TFP-growth in the years t_0 and t_n can be higher or lower than the average growth rate. This is not very unlikely, as TFP growth varies over the business cycle. Furthermore, TFP growth is - by its nature - very hard to measure. Possible anomalies are averaged out over the 20 year period, however. To get some insight in the time fluctuations, we also performed a regression analysis on the time trend.

We have examined three dimensions: variation of TFP growth between sectors, between countries and developments over time. We will discuss the methods below. For the sectoral dimension, we have looked at the TFP-growth per sector and sector group averaged over all countries for which time series are available. We have considered four different sectoral classifications:

- an aggregated classification in manufacturing, agriculture, raw materials and services;
- the ISDB sectoral classification;
- the sectoral classification of the European version of WorldScan;
- the sectoral classification of the energy version of WorldScan.

Here we present the results of the most aggregated classification and the WorldScan classification in the European version, as these two yield most insight. The other classifications yield similar results, unless stated otherwise. The results for these alternative sectoral classifications can be found in Appendix D. A concordance table for the WorldScan and ISDB sectors can be found in Appendix A. In Appendix B, a concordance table can be found for the regional classifications.

For each of the classifications we have averaged the TFP growth rate (1970 - 1990) over all countries r[5] for which time series are available, weighted by their value added share:

$$g_s = \sum_r g_{s,r}^{TFP} \cdot \left(\frac{GDP_{s,r,\bar{t}}}{GDP_{s,\bar{t}}} \right)$$

where $GDP_{s,\bar{t}} = \sum GDP_{s,r,\bar{t}}$. The symbol $\bar{t}$ denotes the average over 1970 - 1990. Subsequently, the sectoral TFP growth rate (averaged over countries) is averaged over the sectors s that make up a WorldScan sector Z, again weighted with the value added shares:

$$g_Z^{TFP} = \sum_{s \in Z} g_s^{TFP} \cdot \left(\frac{GDP_{s,\bar{t}}}{GDP_{Z,\bar{t}}} \right)$$

with $GDP_{Z,\bar{t}} = \sum_{s \in Z} GDP_{s,\bar{t}}$. This can easily be rewritten to:

[5] We have left the Netherlands out of our calculations of international averages. The reason is that there are only data for very few sectors available.

$$g_Z = \sum_{r_s, s \in Z} g_{s,r_s} \cdot \left(\frac{GDP_{s,r_s}}{\sum_{s \in Z} GDP_{s,r_s}} \right) \cdot \left(\frac{\sum_{s \in Z} GDP_{s,r_s}}{\sum_{r_s, s \in Z} GDP_{s,r_s}} \right)$$

$$= \sum_{r_s, s \in Z} g_{s,r_s} \cdot \left(\frac{GDP_{s,r_s}}{\sum_{r_s} GDP_{s,r_s}} \right) \cdot \left(\frac{\sum_{r_s} GDP_{s,r_s}}{\sum_{r_s, s \in Z} GDP_{s,r_s}} \right)$$

The subscript $\bar{t}$ is dropped for clarity. Here, r_s denotes a region for which data for the sector s are present. This implies that the order of averaging is irrelevant. However, this is only true in case there exists a balanced sample of countries for which TFP data are present for all sectors. Unfortunately, only Denmark and Finland meet this requirement. Therefore, we chose to use the larger sample, with data missing for some sectors. In this case, the calculation order does matter, as the averaging procedure is much stricter for determining the average over several subsectors than for averaging over countries.[6] This implies that averaging first over countries, followed by averaging over subsectors yields more data points than the reverse procedure. That is why we chose the former approach.[7] Moreover, the procedure described above gives biased results. The value added share of a aggregated sector Z is determined by:

$$Q_Z^{GDP} = \frac{\sum_r GDP_{S,r}}{\sum_r \sum_{s \in Z} GDP_{S,r}}$$

Now, it is possible that a small sector gets a large weight, because for this sector, many observations are present, while a larger sector gets a smaller weight because only data are present for one country. We have solved this problem by employing value added weights

[6] The reason is that in the former case, the average cannot be determined if no data (value added or TFP) are present for a subsector. In the latter case, on the other hand, the average is simply calculated without the missing data points. In this case, the averaging groups for different sectors contain different (numbers of) countries. This is undesirable (the TFP of one sector is e.g. calculated wit the contribution of a country with overall high TFP growth, while the TFP of another sector is calculated without this contribution), but not prohibitive. In the case the averaging is first over the subsectors, however, the average cannot be determined, unless points are constructed.

[7] If data are missing for any one of the subsectors in a particular region, then data points can be constructed by either entering the TFP growth rate of this subsector averaged over certain countries, or by entering a (weighted) average over the other subsectors for that region. However, we did not construct any data points due to high costs, low benefits and missing value added data.

calculated for a representative sample of countries[8] for which GDP data were present for all sectors.

These formulae yield an average growth rate (averaged over all countries) for 1970 - 1990 for the different ISDB sectors, the core model sectors and the sectors in the European version. Weighing the observations of a country with its value added does justice to the different sizes of the countries. On the other hand, one could reason that each country represents one single observation, so that the results should not be weighted. We will therefore present both a weighted and a simple average.[9]

Looking at the global sectoral differences does not give insight in the variation between countries. Therefore, we have also looked at the four OECD regions in the core model, and at the OECD regions in the European version. The averaging method is analogous to the method employed for the sector dimension.

The third relevant dimension is the time axis. There exists a general development pattern, in which the sector share (both in terms of employment and in terms of value added) of agriculture declines, while the sector share of manufacturing rises and subsequently falls, in favour of an emerging service sector (see e.g. Dollar and Wolff, 1993; De Nooij, 1998). This is caused by several factors, including differential productivity growth. Most OECD countries can be expected to have completed this development pattern, but for the non-OECD it might be relevant.[10] For our purposes, we need to know the long run trends in productivity growth, abstracting from business cycle effects. If there would be large changes in the productivity in the period 1970 - 1990, then the average growth rate cannot simply be extrapolated.

3 Results

3.1 Variation between sectors

The average yearly TFP growth is very different for different sectors, as can be seen from Tables 3.1 (aggregate classification) and 3.2 (WorldScan "European" aggregation). The results for alternative aggregations can be found in Appendix D.

[8] That is, the USA, Canada, Western Germany, France, Great Britain, Finland, Denmark and Sweden.

[9] i.e. we did use weights in averaging over the subsectors; however, the country averages are unweighted.

[10] This also points at problems of applying the OECD results to developing countries.

Table 3.1 Sectoral TFP growth rates, 1970 - 1990, averaged over the OECD countries

	Weighted average growth rate[b] (%)	Simple average growth rate (%)
Agriculture	2.27	2.68
Manufacturing	1.95	1.95
Services	0.43	0.42
Raw materials	-1.33	0.68
Average[a]	0.66	0.87

a excluding raw materials, because of the poor data quality of this sector.
b TFP growth rates weighted by value added-share of the countries.

Table 3.2 Sectoral TFP growth rates, 1970 - 1990, averaged over the OECD countries, European version

	Weighted average growth rate[a] (%)	Simple average growth rate (%)		Weighted average growth rate (%)	Simple average growth rate (%)
AGR	2.27	2.68	TRA	1.55	1.38
RAW	-1.33	0.68	CNS	-0.42	0.03
COS	1.66	1.57	TRD	0.41	0.52
FOD	0.96	1.05	CMN	3.71	3.38
PPP	0.54	0.99	FSR	-0.84	-0.06
CRM	2.08	2.93	OSB	0.39	0.09
MET	0.77	2.04	OSG	-0.41	0.24
CPI	2.17	2.08			

a TFP growth rates weighted by value added-share of the countries.

Note that generally the simple average is considerably higher than the weighted average, especially at the higher aggregation levels. This implies that the growth rate in smaller OECD countries is higher than in the larger ones. The most notable example is the basic metal industry (MET) with an average TFP growth of 3.4% for the small countries[11] (Belgium, Denmark, Sweden, Norway, Finland, Australia), and an average growth rate of 0.9% for the large ones (France, Italy, Japan, USA, Western Germany, Canada). For the small countries, growth is high across the board, ranging from 2.7% in Sweden to 4.8% in Belgium. For the large countries, the variance is much larger: from -0.7% in the US to 2.0% in Western Germany. The result is a weighted average of 0.8% as compared to an unweighted figure of 2.0%. Something similar is the case for construction (CNS). The weighted average of -0.4% is pushed down by the decline in productivity in the US of -1.2%. The variation between countries is large, however: from -1.2% in Norway, Denmark and the US to 1.4% in Finland. Again the

[11] The distinction between small countries and large countries is based on a comparison of the value added shares per sector.

small country average is larger than that of the large countries: 0.1% and -0.03% respectively. The unweighted average is 0.0%. Also for the raw materials sector, the difference between the weighted and the simple average is significant: -1.3% as compared to 0.7%. For this sector, the data vary widely, from -4.6% in France to 14.0% in Denmark. The data quality in this sector is notorious, so that we will not use these results.

Also for the sector 'Water distribution and other services' (OSG), the weighted and the unweighted average differ widely, -0.4% versus 0.2%. The difference lies mostly in the ISDB subsector 'Electricity, gas and water' (EGW). For this sector, average yearly growth rates vary from -1.8% for Italy to 4.7% for Great Britain. On average, the TFP growth is considerably larger in the small countries: 2.0% versus 0.8%. The results for the personal service sector (SOC) are more moderate.

In some cases, the weighted average is larger than the simple average, though the differences are smaller. The most notable differences arise in the service sectors: TRA, CMN and OSB. One example is the business sector (OSB): 0.4 versus 0.1%. For this sector, few data are available: only for 6 of the 14 countries, data are present. The small country average is pushed down by the decline in Norway and Sweden, the large country average is only composed of France and the USA. Something similar is the case with TRA and CMN. Also for these sectors, few time series are available. With such a small sample, it is hard to draw any conclusions.

Which is more realistic, the weighted or the simple average? Weighted averaging takes into account the different economic weights of the countries. If the US would be split up in its fifty states or if the EU would be treated as one region instead of as the individual countries, then the simple average would give different results for the same 'physical' situation. However, with weighted averaging, an extreme value for a large country such as the US cannot be compensated for by several more moderate values of smaller countries. If there are many outliers or the data quality is low, as in our case, the simple average probably yields the most realistic results.

In any case, at both aggregation levels and for both types of averaging, the well-known stylised fact is reproduced that states that growth is highest in agriculture, followed by the growth in the manufacturing sectors (COS, FOD, PPP, CRM, MET, CPI), while the total factor productivity in the service sectors (CNS, TRD, FSR, OSB, OSG, TRA and CMN) show virtually no growth at the aggregate level. However, the growth rates within the service sectors are highly variable. The high growth (3.7%) for the communication sector (CMN) is remarkable. This can be the result of the recent spur in technological progress in the ICT sectors (although our measurement period ends in 1990, at the beginning of the rise). The TFP growth has been steadily rising since 1970. It is unclear whether this high growth will persist in the longer run.

Furthermore, the low or negative growth rates of construction (CNS), financial services (FNS), and community and other services (OSG) are remarkable. In the latter case, this negative

growth rate is mainly due to the fall in productivity in personal services (SOC). Generally, a persistent negative growth rate is rather unlikely. It could be the case that the TFP growth in these sectors is (more or less) 0%, which can become negative due to noise. Another remarkable feature is the strong growth for the transport sector (TRA), that is traditionally part of the service sector. These results comply with Baumol's law: almost no growth in stagnant services such as SOC, positive growth rates in technologically progressive service sectors such as communication and transport.

Also the dispersion within the manufacturing sector is quite large: from 0.5% or 1.0% (weighted and simple average, respectively) for paper and paper products (PPP) to more than 2% for chemical, rubber and plastic products (CRM) and for capital goods (CPI). The latter sectors are capital intensive by nature. This could give relatively high growth rates, if capital intensive also denotes technology-intensive and if there is room for innovation. Also the growth rate in the consumer goods sector is high. This high growth is mainly the results of the high growth rate of in textiles (TEX), with lower (but still sizeable) growth in wood and wood products (WOD) and other manufacturing industries (MOT). Perhaps this is the result of the fierce competition in the textiles sectors, which can only survive the competition with the Asian low wage countries by specialising in capital intensive segments with high technological growth. Whether this high growth rates can be sustained in the future is uncertain, in any case.

Apart from this sectoral classification, we also employ an alternative, more aggregated classification for the WorldScan energy model (see Appendix D). Looking at the growth rates in the constituting sectors reveals that the growth rates within these WorldScan sectors are not always homogenous. Examples are the growth rates of the sectors consumption goods (CON), energy intensive goods (ENI) and services (OSE). The growth rates for sectors that make up CON (FOD, TEX, MOT, WOD) vary from 1.1% for FOD to 1.9% (TEX); for ENI the growth rates are between 1.0% (PAP) to 3.2% (CHE), for OSE they lie between -0.1% (FNS and SOC) to 3.4% (COM) (all simple averages). This heterogeneity problem is more severe than in the classification presented above, due to the large heterogeneity in ENI and OSE, which are more disaggregated in the European version.

3.2 Variation between countries

Also the variation of TFP growth between countries has been considered. First, results are presented in Table 3.3 for the four aggregated OECD regions employed in the WorldScan core model). Results for a more disaggregated classification, used in the European version of WorldScan are shown in Table 3.4. In this section, we restrict attention to the TFP growth in the

Table 3.3 Average yearly growth rates in the aggregated OECD regions, 1970-1990 (%)[a,b]

	EU	rest OECD	Japan	USA
AGR	3.25	1.83	0.94	2.44
RAW	1.47	0.82	-0.24	-1.53
CON	1.58	0.43	-	1.80
ENI	2.59	1.68	1.92	0.96
CPI	1.99	1.30	5.11	1.34
TRA	1.38	-	-	-
OSE	0.69	-	-	-

a The regional classification can be found in appendix B.

b Simple average.

different WorldScan core sectors to keep the presentation surveyable. The TFP growth rates will generally depend on the local circumstances and the stage of development of a country (degree of competition, institutions etcetera). This is very clear from both tables. We have looked at the relationship between macro labour productivity growth and sectoral TFP-growth, by regressing the latter on the macro labour productivity growth and its square. The coefficients turned out to be insignificant, however.

Even so, there are meaningful differences between the countries. The TFP growth for agriculture, for instance, varies greatly between a meagre 1% for Japan to 3% in the EU. The low growth rate for Japan is possibly the result of the local circumstances. The farmland in Japan is highly scattered, and there are few major farming companies. This implies a low TFP level, but also a low TFP growth, as there is little room for innovation. It is hard to judge whether these differences are real, in the light of the considerable error margin.

For the sectors transport (TRA) and other services (OSE), too few data are present to draw any conclusions. For machinery and equipment (CPI), the growth rate for Japan is exceptionally high (more than 5% as compared to 2% world average). Perhaps this can be explained by the turbulent economic and technological growth in Japan in the seventies and eighties. Whether this high growth rate will continue, is uncertain.

There are a few pros and cons in making a regional or national distinction as compared to considering only the OECD average. A clear advantage is that countries can have a totally different TFP growth pattern, depending on their stage of development. Even within the OECD, there are differences in development between the various countries, although not as large as between OECD and non-OECD countries. This could also help in applying the OECD figures to non-OECD countries. A disadvantage of employing a regional distinction, however, is that there are fewer data available. An additional complication for the regional aggregation of the European model is that there are no data for Spain, which is a separate region in the European

Table 3.4 Average yearly growth rates in the OECD regions in the European version 1970-1990 (%)[a,b]

	Belgium, Luxemb[c]	Rest EU	France	Germany[d]	Italy	Great Britain	Rest OECD	USA
AGR	3.21	3.42	3.90	4.68	1.10	2.86	1.61	2.44
RAW	-	5.37	-4.63	-3.72	-	1.05	0.55	-1.53
CON	-	1.57	-	1.03		-	0.38	1.80
ENI	5.71	2.01	1.51	1.31	-	-	1.75	0.96
CPI	2.58	1.86	1.96	1.29	3.09	1.41	2.57	1.34
TRA	0.72	1.27	2.02	1.67	1.33	-	-	-
OSE	-	0.79	1.22	-	-	-	-	-

a The regional classification can be found in appendix B.
b Simple average
c In the European version, we employ the ISDB data for Belgium for the region 'Belgium and Luxembourg'.
d In the European version, we employ the ISDB data for Western Germany for the Germany after the reunification.

model. Furthermore, possible noise cannot be averaged out over several regions. If the data for one country are unreliable, this will hardly affect the overall average. A more fundamental difficulty is that one could question whether certain exceptional regional developments can be extrapolated into the future. An example is of course the extremely strong TFP growth of machinery and equipment (CPI) in Japan. In a global average, these effects are usually averaged out, as countries are in different stages of development.

3.3 Changes over time

Finally, we have looked at the developments in the growth rate over time, which is important in judging whether certain developments can be extrapolated into the future. To incorporate the TFP growth in WorldScan, we need to know what the long run trend in TFP growth is, abstracting from business cycle effects.

To that aim, we have regressed the logarithm of the TFP-growth per year for every ISDB sector on a time trend. We have employed the simple OECD average. The results are presented in Table 3.5 and 3.6 for agriculture and manufacturing and the service sectors, respectively. Ideally, the coefficient of the constant should be significant, while the time trend parameter is zero. In the tables, also the exponent of the constant is reported, to give some measure that can be compared to the average TFP growth reported earlier.

Table 3.5 **Sectoral TFP growth in agriculture and manufacturing regressed on a time trend[a]**

	AGR	BMI	CHE	FOD	MEQ	MNM	MOT	PAP	TEX	WOD
c	-3.67*	-2.45*	-2.36*	-3.86*	-4.19*	-2.94*	-4.04*	-3.68*	-3.83*	-4.10*
	(0.49)	(0.66)	(0.50)	(0.42)	(0.68)	(0.27)	(1.15)	(0.88)	(0.52)	(0.90)
year	0.01	-0.07	-0.10*	-0.08*	0.02	-0.03	0.01	-0.04	-0.02	-0.02*
	(0.04)	(0.05)	(0.04)	(0.04)	(0.06)	(0.02)	(0.10)	(0.08)	(0.05)	(0.08)
exp(c) (%)	2.56	8.64	9.41	2.11	1.51	5.28	1.75	2.52	2.17	1.66

a Standard errors are reported in parenthesis. For all sectors the number of observations is 20.

* significant at the 10% level.

Table 3.6 **Sectoral TFP growth in the service sectors regressed on a time trend[a]**

	COM	CST	EGW	FNS	RES	RET	TAS	SOC
c	-3.92*	-5.72*	-2.91*	-3.89*	-5.31*	-4.30*	-4.21*	-5.10*
	(0.26)	(0.51)	(0.61)	(0.91)	(0.58)	(0.40)	(0.51)	(0.76)
year	0.05*	0.07	-0.11*	-0.02	0.03	-0.02	0.04	0.01
	(0.02)	(0.04)	(0.05)	(0.07)	(0.05)	(0.04)	(0.04)	(0.07)
exp(c)(%)	1.99	0.33	5.45	2.05	0.49	1.36	1.49	0.61

a Standard errors are reported in parenthesis. For all sectors the number of observations is 20.

* significant at the 10% level.

In all cases, the constant is significant, while the time trend coefficient is only significant in a limited number of sectors. However, the exponents of the constants are not always similar to the simple averages reported earlier, as should be the case if the time trend coefficient is zero. For agriculture and manufacturing, the results of the regression match quite well with the average TFP growth over 1970 - 1990 if the time trend coefficient is insignificant. Only for BMI, MNM and PAP there is a considerable discrepancy. In the former two cases, the coefficients for the time trend parameter is significant at 20%, though not at 10%. The explanation for the discrepancy in PAP could be related to the wild fluctuations of the yearly TFP growth, with a growth of more than 6% in 1973 and 1976. In determining the average over the whole period, only the TFP growth in the first and final year is considered, while the regression is based on all observations. Something similar is perhaps the case for the service sectors. For FNS, RET and SOC, there is quite a difference between the regression results and the average yearly TFP growth. In the latter two cases, visual inspection suggests that there might also be a time trend present on average, though the regression results are not significant.

For some sectors, the time trend is significant (at 10%). For CHE, FOD, WOD and EGW, the fall in yearly TFP growth over time explains the positive difference between the exponent of the constant and the average yearly TFP growth. Especially for CHE and EGW, the fall is large, and thus also the discrepancy. For COM, the yearly TFP growth rises considerably, explaining

the negative difference between exp(c) and the average yearly TFP growth. For the sectors with a non zero time trend, the average yearly TFP growth is not the right measure of yearly TFP growth, as it increases over time. On the other hand, extrapolating the trend into the future yields unrealistic results when the underlying mechanisms are unknown. If the time trend is linearly extrapolated, TFP growth in CHE, FOD, WOD and EGW would be virtually zero in 2020, while the TFP growth for COM would be more than 23%! Of course, this objection could be at least partly overcome by introducing non linear time trend terms, but the number of observations does not allow for this.

Therefore, we take the average yearly TFP growth to be constant in our model. In fact, the parameter included in our model is actually the average yearly TFP growth relative to the macro average (see Appendix C), so that our interest lies primarily in the change over time of the yearly TFP growth relative to this average.

4 Conclusions

The well-known stylised fact on TFP growth (TFP growth in the agricultural sector is higher than that of the manufacturing sectors, which in its turn exceeds the growth in the services) is clearly reproduced in the figures. It therefore seems worthwhile to introduce sectoral TFP growth in WorldScan. The simple average gives more realistic (moderate) results than the weighted averaging, probably due to the data quality. Therefore, we have incorporated the simple average TFP growth in the model.

The next question is which aggregation level is most appropriate.[12] The different possibilities are:

- an aggregated classification: a division in agriculture, services, manufacturing;
- the sectoral classification of the European version;
- the sectoral classification of the energy version.

On the basis of our results, a more detailed classification than the traditional trinity seems justified. That leads to more noise, but it also yields a richer picture. Both the "European" classification and the "energy" classification give reasonable results. It would therefore be natural to employ them both. However, employing a regional disaggregation seems to be not possible due to the limited number of observations. This implies losing information on some meaningful differences between countries. We use the OECD average for both the OECD and non OECD regions in the model. This is not very realistic, as the non OECD countries are

[12] A more extensive treatment of the implementation in WorldScan can be found in Appendix C.

generally in a different stage of development than the OECD countries, but we cannot do better than this 'best guess', as there are no data on the non OECD countries.

Finally, we did not incorporate a time trend. For most sectors, the yearly TFP growth seemed to be fairly constant over time. In the cases where there seemed to be a time trend, extrapolating this linear trend into the future does not seem to give realistic results. The number of observations limits the possibilities for incorporating non linear time trends, however. In any case, extrapolating without any knowledge of the underlying mechanisms is not advisable.

A number of things can be said about the sectoral growth rates. Firstly, there is quite some variation in the growth rates of the service sectors. The TFP growth in the transport sector is rather high, being 1.38%. This coincides with the booming trade flows in the eighties and nineties. This growth rate is in particular interesting in the view of the CPB European scenarios, to be published in 2003. A high TFP growth in the transport sector lowers costs and stimulates trade. TFP growth is even higher in the communication sector, and has been rising in the period 1970 - 1990. Both for the transport sector and the communication sector, it is reasonable to expect that the TFP growth will continue to be higher in the coming decades than the average TFP growth in the other service sectors, although perhaps not as great as the last years. For that reason, it would be good to distinguish both sectors separately. The growth of two other service sectors (financial institutions and insurance and community, social and personal services) is slightly negative. In the long run, this is not plausible. We propose to set the TFP growth in these sector slightly positive.

Furthermore, there is also quite some variation within the manufacturing sector. The TFP growth in the capital intensive goods sector, the basic metals sector and most notably in the chemical products sector exceeds the average for manufacturing. The consumption goods sector (CON) is relatively homogeneous in its TFP growth. The low TFP growth in CON is due to the low growth rates for food, beverages and tobacco (FOD), wood and wood products (WOD) and other manufacturing industries (MOT). The textiles sector (TEX) has a higher TFP growth, which can perhaps explained by its specialisation in the OECD in capital intensive segments.

The growth rates of the underlying subsectors of the WorldScan core sector energy intensive goods (ENI) are more heterogeneous, though. The high TFP growth in chemicals (CHE) seems to follow from the high capital intensity of this sector. In the European version, the ENI sector is split up in the more homogeneous sectors paper products (PAP), chemicals and minerals (CHE and MNM) and ferrous and other basic metals (BMI).

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Appendix A Concordance WorldScan and ISDB sectors

Concordance ISDB and WorldScan sectors

Energy version		ISDB	European version		ISDB
AGR	Agriculture	AGR	AGR	Agriculture	AGR
ENG	Coal, gas and gas distribution, petroleum products, electricity	MID	ENG	Coal, gas and gas distribution, petroleum products, electricity	MID
RAW	Oil, minerals nec[a]	MID	RAW	Oil, minerals nec[a]	MID
CON	Consumer goods	TEX	COS	Consumer goods excluding food products	TEX
		MOT			MOT
		WOD			WOD
		FOD	FOD	Food, beverages and tobacco	FOD
ENI	Other energy intensive products	PAP	PPP	Paper products, publishing	PAP
		CHE	CRM	Chemical, rubber, plastic products and minerals nec[a]	CHE
		MNM			MNM
		BMI	MET	Ferrous and other basic metals	BMI
CPI	Capital goods and durables	MEQ	CPI	Capital goods and durables	MEQ
TRA	Trade, transport and communication	TAS	TRA	Trade, transport and communication	TAS
OSE	Water, construction, trade and other services	CST	CNS	Construction	CST
		RET	TRD	Trade	RET
		COM	CMN	Communication	COM
		FNS	FSR	Financial services and insurance	FNS
		RES	OSB	Business services nec[a]	RES
		SOC	OSG	Water distribution and other services	SOC
		PGS[b]			PGS[b]
		EGW[c]			EGW[c]
		DWE[b]			DWE[b]

a nec: not elsewhere classified

b No data available; not used in determination of TFP

c Incomplete concordance: EGW contains electricity sector, in the core model this sector is classified under ENG.

Appendix B Regional classification in WorldScan and ISDB98

Regional classifications WorldScan - ISDB

Energy version[a]	ISDB98	European version[a]
European Union	Belgium	Belgium and Luxembourg
	Great Britain	Great Britain
	France	France
	-	Spain
	Western Germany[b]	Germany
	Italy	Italy
	The Netherlands	The Netherlands
	Sweden	Rest EU
	Finland	Rest EU
	Denmark	Rest EU
USA	USA	USA
Japan	Japan	Rest OECD
Rest OECD	Australia	Rest OECD
	Canada	Rest OECD
	Norway	Rest OECD

a Only the OECD regions

b In the ISDB98, two 'Germanies' are distinguished: WGR (Western Germany before the reunification) and DEU (Germany after the reunification). For DEU, no data were available, however.

Hence, no data are available for Spain, which is a separate region in the European model. Furthermore, no data are present for the OECD countries New Zealand, Greece, Ireland, Poland, Turkey, Austria, the Czech Republic, Hungary, Portugal, Luxemburg, Iceland, Slovakia, Switzerland, Mexico and South Korea.

Appendix C Implementation of sectoral TFP growth in WorldScan

In WorldScan, the average TFP growth rate is imposed by assumption or derived from the imposed GDP growth rate, given that labour supply is exogenous. The sectoral TFP growth rates deviate from the average TFP growth rate. This deviation is based on the empirical findings in this paper. The table below presents these relative sectoral growth rates for the European version and the energy version of the model.

For the European version the numbers in the table below are the sectoral numbers divided by the average (macro) growth rate presented in Table 3.1. For the European version, we have divided the simple averages in table 3.2 by the simple average of 0.87%. Based on expert opinions, we have set the TFP growth rates in energy and raw materials at zero. Furthermore, we do not believe the negligible growth rates for business services and financial services. We assume that for these sectors the TFP growth rates are equal to the growth rate in trade services.

Sectoral TFP growth rates relative to the macro average

Energy version		European version			
agriculture	3.1	agriculture	3.1	capital goods	2.4
raw materials	0.0	energy	0.0	transport	1.6
consumption goods	1.3	other raw materials	0.0	communication	3.9
energy-intensive goods	2.6	food processing	1.2	construction	0.0
capital goods	2.4	other consumption goods	1.8	trade services	0.6
transport	1.6	paper and publishing	1.1	financial services	0.6
other services	0.4	chemicals and minerals	3.4	other business services	0.6
		metals	2.3	other services	0.3

Appendix D Results for alternative sectoral classifications

Here, some additional results are presented for two alternative sectoral classification: the full ISDB sectoral classification and the WorldScan core classification. In general, these figures yield a similar picture as discussed in the main text for the sectoral classification of the European version. Notable differences are discussed in the main text.

Sectoral TFP growth rates, 1970 - 1990, averaged over the OECD countries, ISDB sectoral classification (%)

	Weighted average	Simple average		Weighted average	Simple average
AGR	2.27%	2.68%	MNM	1.61%	1.61%
BMI	0.77%	2.04%	MOT	0.93%	1.28%
CHE	2.16%	3.16%	PAP	0.54%	0.99%
COM	3.71%	3.38%	RES	0.39%	0.09%
CST	-0.42%	0.03%	RET	0.41%	0.52%
EGW	0.23%	1.41%	SOC	-0.59%	-0.07%
FNS	-0.84%	-0.06%	TAS	1.55%	1.38%
FOD	0.96%	1.05%	TEX	2.22%	1.90%
MEQ	2.17%	2.08%	WOD	1.29%	1.29%
MID	-1.33%	0.86%			

Sectoral TFP growth rates, 1970 - 1990, averaged over the OECD countries, core sectoral classification (%)

	Weighed average	Simple average
Agriculture	2.27	2.68
Raw materials	-1.33	0.86
Consumption goods	1.30	1.30
Energy intensive goods	1.44	2.24
Capital goods	2.17	2.08
Services	0.17	0.36
Trade and transport	1.55	1.38