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The Growth Disease at 50 – Baumol after Oulton

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Abstract

The year 2017 marks the 50th anniversary of William J. Baumol's seminal model of 'unbalanced growth', which predicts the so-called 'Growth Disease', i.e., the tendency of aggregate productivity growth to slow down in the process of tertiarisation. In an important contribution published in 2001, however, Nicholas Oulton showed that the shift of resources to the service sector may *raise* rather than lower aggregate productivity growth if the service industries produce intermediate rather than final products. While Oulton's reasoning is logically consistent, the question arises whether it is also valid from an empirical point of view. We use the 2011 release of EU KLEMS data to determine whether the shift of resources to services has raised or lowered aggregate productivity growth in the G7 countries.

JEL classification: E24, O14, O41, O47, O57

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I. Introduction

Fifty years ago, William J. Baumol published a paper which today is widely regarded as a major contribution to the literature on structural change. Baumol (1967) presents a simple neo-classical two-sector growth model, characterized by 'unbalanced' productivity growth between the two sectors. Productivity growth is higher in the 'progressive' (secondary) sector than in the 'nonprogressive' – or 'stagnant' – (tertiary) sector of the economy, but wages grow more or less at the same rate in both sectors. Therefore, unit costs and also prices rise much faster in the tertiary sector than in the secondary sector. At the same time, demand for certain services, like health care and education for instance, is hardly price-elastic. Hence, even if real production in both sectors develops proportionately, an increasing share of total expenditures will be channelled into stagnant service industries which are mainly financed by taxes and social contributions. This phenomenon is known as the 'Cost Disease'. Moreover, since aggregate productivity growth is a weighted average of the sectoral productivity growth rates, with the weights being the nominal value added shares, the aggregate productivity growth rate will decline over time as the weight of the industries with low productivity growth steadily increases. Nordhaus (2008) calls this the 'Growth Disease.' Assuming full employment along neo-classical lines, Baumol (1967) shows that the progressive sector continuously lays off employees which in turn are absorbed by the stagnant sector. Eventually, at the margin all employees work in the tertiary sector.

Baumol's model focuses on services provided for the final consumer ('personal services'). Services such as business services, however, are increasingly produced for intermediate use (Wölfl, 2005; De Backer et al., 2015). Oulton (2001) has called attention to the seemingly paradoxical fact that a shift of economic activity from manufacturing to the production of intermediate services may raise rather than lower aggregate productivity growth even if productivity growth in the intermediate service industries is lower than in manufacturing. When all services are intermediate services, so the argument runs, manufacturing remains the only industry producing final goods even if workers move to the service sector. Productivity growth in manufacturing does not decline due to this shift. Rather, productivity growth in the intermediate service industries – however small it may be – adds to total factor productivity growth in manufacturing and hence to aggregate productivity growth.

Baumol endorsed Oulton's argument, mentioning in an interview with Alan B. Krueger:

> "There's a note I got from a young man who works at the Bank of England, Nick Oulton, which points out an important but paradoxical result I overlooked. […] Say that the final product is growing at 10 percent a year, and the productivity in the intermediate good grows at 2 percent a year. As more and more of the labor force goes out of the fast-growing sector into the slow-growing sector, the more the labor force is getting the benefit of both the 2 percent and the 10 percent, as opposed to getting only the 10 percent if it stayed only in the fast-growing sector. So, since Oulton argues that most of the growth of the service sector has been in intermediate goods, then what would appear from the cost disease to be a drag on the economic growth is, in fact, a contributor to economic growth. He's absolutely right." (Krueger, 2001, p. 223)

Oulton is clearly right as far as intermediate services are concerned. Of course, some services will always be provided for the final consumer, and for these Baumol's original argument is still valid.[1] Sasaki (2007) presents a theoretical model in which services are produced for both final consumption and intermediate demand. He shows that under these assumptions the rate of economic growth declines in the long run irrespective of the magnitude of the elasticity of substitution between labour and service input. Even if personal services are ignored, however, two conditions have to be met for Oulton's result to hold. First, the industry producing intermediate services must have a positive total factor productivity (TFP) growth rate and, secondly, its (Domar-) weight in the economy must rise over time. Our aim in this paper is to examine whether these two conditions are valid from an empirical point of view. We use the March 2011 release of the EU KLEMS database and focus on the G7 countries.

The paper is structured as follows: The next section outlines Oulton's theorem formally. Section 3 discusses the database and the methodology for testing Oulton's theorem. Section 4 presents our empirical results and discusses measurement issues. Section 5 concludes.

[1] In Krueger (2001, p. 223), Baumol maintains: "[…] if the slow-growing sectors are producing *final products*, the larger their labor force, the slower the economy's average productivity will grow. But if it's slow growth in *intermediate goods*, then its result is the opposite."

II. Oulton's theorem

Oulton (2001, pp. 613–18) defines industry *i*'s production function as

(1) $$y_i = f_i(x_i, m_i, t)$$

where *y* is real gross output, *x* is labour input, *m* is the intermediate input from other industries, and *t* stands for time. He assumes perfect competition so that, in long-run equilibrium, the value of output is equal to the cost of inputs:

(2) $$p_i y_i = w_i x_i + p_i^m m_i$$

where p_i is the output price , w_i is the wage rate, and p_i^m is the price for intermediate inputs in industry *i*. Total factor productivity growth in industry i ($\hat{q}_i$) is equal to real output growth ($\hat{y}_i$) less the growth of inputs ($\hat{x}_i; \hat{m}_i$), each weighted by the share of their cost in nominal output:

(3) $$\hat{q}_i = \hat{y}_i - \left(\frac{w_i x_i}{p_i y_i}\right)\hat{x}_i - \left(\frac{p_i^m m_i}{p_i y_i}\right)\hat{m}_i$$

It is important to note that TFP growth can be defined in terms of gross output (as in equation 3) but also based on value added:

(4) $$\hat{q}_i^v = \hat{v}_i - \hat{x}_i$$

where ($\hat{v}_i$) denotes growth in value added in industry i.

Assuming that the production function is separable, equation (1) can be re-written as:

(1') $$y_i = f_i(v_i, m_i)$$

where

(5) $$v_i = g_i(x_i, t)$$

where g(·) is the value added production function. Differentiating equation (1') with respect to time yields the growth rate of value added as:

(6) $$\hat{v}_i = \left(\frac{p_i y_i}{w_i x_i}\right)\hat{y}_i - \left(\frac{p_i^m m_i}{w_i x_i}\right)\hat{m}_i$$

Substituting the right-hand side of equation (6) into equation (4), then solving equation (3) for $\hat{x}_i$ and substituting this also into equation (4) yields

(7) $$\hat{q}_i^v = \left(\frac{p_i y_i}{w_i x_i}\right)\hat{q}_i$$

Equation (7) states that TFP growth in terms of value added equals TFP growth in terms of gross output divided by the share of value added in gross output.

Aggregate productivity growth is the difference between value added growth and the growth of labour input. Aggregate value added growth, in turn, is a weighted average of sectoral value added growth. Likewise, aggregate growth of labour input is a weighted average of the sectoral labour input growth rates. Assuming perfect competition, the weighting factors are identical and equal to the share of aggregate labour input in industry i

(8) $$r_i \equiv w_i x_i \Big/ \sum_{i=1}^{n} w_i x_i = w_i x_i / p^v v$$

The aggregate productivity growth rate can eventually be calculated as

(9) $$\hat{q} = \hat{v} - \hat{x} = \sum_{i=1}^{n} r_i(\hat{v}_i - \hat{x}_i) = \sum_{i=1}^{n} r_i \hat{q}_i^v$$

Substituting equations (7) and (8) into equation (9) yields

(10) $$\hat{q} = \sum_{i=1}^{n} \left(\frac{p_i y_i}{p^v v}\right)\hat{q}_i$$

Aggregate productivity growth is thus a weighted average of sectoral productivity growth. The weighting factors are given by the ratio of nominal gross output in each industry to

nominal aggregate value added (total final demand).[2] These are the so-called Domar weights (Domar, 1961; Hulten, 1978).

Equation (10) illustrates the following: No matter how high the productivity growth rate in an industry (say, an industry producing intermediate services), it will raise aggregate productivity growth as long as the Domar weight of that particular industry increases. As Oulton (2011, p. 617) put it:

> "If there is a rise in the Domar weight of an industry supplying an intermediate product, the aggregate productivity growth rate will rise, even if the industry in question has lower than average productivity growth. More precisely, aggregate productivity growth will rise provided only that TFP growth in the industry is positive."

III. Data and methodology

There are two conditions for Oulton's theorem to hold: Total factor productivity growth in industries producing intermediate services must be positive, and the Domar weights of these industries must increase over time. We will test empirically whether these conditions are met using EU KLEMS data.

The EU KLEMS Growth and Productivity Accounts were first released in 2007. They include measures of output, capital formation, employment, and TFP at the industry level according to the Statistical classification of economic activities in the European Community (NACE), Rev. 1 for European Union (EU) countries and some major non-EU economies from 1970 onwards.[3] The EU KLEMS Growth and Productivity Accounts are the result of a joint

[2] In an open economy, total final output exceeds nominal GDP by the amount of intermediate imports, see Oulton (2001, p. 616, fn. 8) and Gollop (1983).

[3] The latest (December 2016) release of the EU KLEMS database switched from the European System of National Accounts (ESA) 1995 to ESA 2010 and uses NACE, Rev. 2 instead of NACE, Rev. 1. The number of countries covered by this latest release is relatively small, however, and the time period covered is relatively short (1995-2014) for most countries and industries. We therefore use the March 2011 update of the December 2009 release of the EU KLEMS Growth and Productivity Accounts, which has the broadest coverage of countries and covers more years.

research project which was funded by the European Commission and involved 24 institutes from several European countries and Japan (see Timmer et al., 2007; O'Mahony and Timmer, 2009). The term 'KLEMS' refers to the input measures included in the database: various categories of capital (K), labour (L), energy (E), material (M) and service inputs (S). Since their release, EU KLEMS data have been widely used in the analysis of growth, productivity, and structural change.[4]

In terms of methodology, we follow Oulton's (2001, pp. 621–24) approach which involves several steps. The first step is to extract time series data for TFP on a value added basis (TFP_VA) from the EU KLEMS database and to calculate the average growth rate for each industry over a certain period of time.[5] Oulton (2001) uses TFP_VA data for the United Kingdom (UK) derived by O'Mahony (1999) and calculates the average growth rate over the period 1973–95. Our first aim is to investigate whether his results can be replicated with EU KLEMS data for this period. Additionally, we investigate the UK-case for the entire period for which data are available (1970–2007) as well as a number of additional countries. We initially intended to include all G7 countries. However, there are no data for Canada in the March 2011 release. As older data for Canada are not comparable to the March 2011 release owing to a different industry structure, Canada is not considered in what follows. Average TFP_VA growth rates are calculated for the longest period for which data are available. These periods typically differ from country to country, ensuring that our results are not dependent on a particular historical episode.

To analyse whether the first condition for Oulton's theorem to hold (i.e., positive TFP growth in intermediate service industries) is fulfilled, the second step involves the conversion of (average) TFP growth based on value added (TFP_VA) into TFP growth based on gross output (TFP_GO). According to equation (7) above, this requires multiplying the TFP_VA growth rate by the share of value added (VA) in gross output (GO). As recommended by Oulton (2001, p. 622, fn. 13), we use the average (VA÷GO) ratio over the first and the last

[4] The website of the EU KLEMS project (www.euklems.net) provides information on the methodology used for the various releases. It also lists 17 'core publications' in journals. A 'Google Scholar' search for 'EU KLEMS' yields almost 4'000 hits (April 2017).

[5] TFP data are available as indices (1995 = 100) in the EU KLEMS Growth and Productivity Accounts.

year of the period under investigation.[6] Completing the second step allows us to answer the question whether intermediate service industries show positive TFP growth. This is the first condition for Oulton's theorem to hold.

The second condition is that the Domar weights of intermediate service industries must increase over time. Following standard practice (e.g. Jorgensen and Stiroh, 2000; Oliner and Sichel, 2000; Timmer and van Ark, 2005), we calculate Domar weights as the industries' nominal gross output divided by aggregate nominal gross value added.[7]

The Domar weights, together with the TFP_GO growth rates, allow to calculate the contribution of each industry to aggregate TFP growth. This is not our primary concern, however. We rather focus on the *change* in the industries' Domar weights over the period under examination multiplied by the industries' (average) TFP_GO growth rates over the same period. If an industry shows both a rising Domar weight and a positive TFP growth, aggregate TFP growth rises over time. The same is true when TFP growth is negative and the Domar weight decreases. If the Domar weight decreases, however, and the industry has positive TFP growth, the aggregate TFP growth rate is reduced over time. The same is true for industries with rising Domar weights and negative TFP growth. We can thus determine for each industry whether its gain or loss in weight in the process of structural change raises or lowers aggregate productivity growth. Hence, we can also determine how the shift of resources from manufacturing to services, especially intermediate services, has contributed to aggregate productivity growth. Has the shift 'cured' Baumol's 'Growth Disease' – as

[6] Oulton uses 1995 weights, not the average of 1995 and 1973 weights, because the latter were unavailable to him.

[7] We are aware that this is not entirely correct because, as was mentioned in footnote 3, intermediate imports should be added to aggregate value added in the denominator to arrive at total final output for open economies. Unfortunately, data on intermediate imports are not readily available. Recently, the OECD and the WTO have jointly started the 'Trade in Value Added' (TiVA) initiative which aims at better tracking global value added chains. Through TiVA, data on intermediate imports have become available (see also Miroudot et al., 2009). The current (October 2015) version of TiVA provides intermediate imports data (in US Dollars) for 61 countries and the period 2008–11 plus three earlier benchmark years (1995, 2000, 2005). Even if TiVA data were available for more years, it would be unclear, however, if and how they could be linked to EU KLEMS data. For instance, the TFP_VA data from the EU KLEMS project we use in step 1 have been calculated ignoring the role of imports (see O'Mahony and Timmer, 2009, p. F395).

Oulton's theorem suggests? The next section shows the results of our empirical analysis of that question.

IV. Results

Table 1 shows the results of Oulton's empirical analysis of structural change in the UK. While Oulton does not present such a table himself, we calculate the numbers by multiplying the industries' average TFP_GO growth rates given in his Table 3 with the change in the industries' Domar weights given in his Table 4. Note that, due to data limitations, Oulton (2001) could not calculate the change in the Domar weights over the same period for which he calculated the average TFP_GO growth rates (1973–95). He compares the Domar weights of 1995 with those of 1979.

<Insert Table 1>

The first line of Table 1 restates the UK's average TFP_GO growth rate over the period 1973–95 from Oulton's Table 3. The remaining lines *do not* show the industries' contributions to this average growth. They rather show by how much aggregate TFP growth *would have been higher or lower* if the respective industry had not gained (or lost) in (Domar) weight. For instance, manufacturing had a positive TFP_GO growth according to Oulton's Table 3. Manufacturing lost almost 3 percentage points (PP) in Domar weight between 1979 and 1995, however (see Oulton's Table 4). This loss in weight of a high-performing industry reduced average aggregate TFP growth by 0.024 PP per year.

The biggest positive contributions come from mining and oil refining – an industry with negative TFP growth that lost weight – and financial and business services. TFP growth in financial and business services was moderate according to Oulton's calculations. This industry increased its Domar weight by spectacular 11.4 PP between 1979 and 1995, however. This shift raised aggregate TFP growth by 0.078 PP per year on average. Overall, Oulton's theorem is vindicated by his data. The shift of resources into services supported aggregate TFP growth, and this was mostly due to financial and business services, an industry that mainly sells intermediate services. The shift of resources out of goods-producing industries somewhat lowered aggregate TFP growth, but overall, structural change raised the aggregate TFP growth rate by 0.086 PP per year on average.

Table 2 shows the results of our new calculations for the UK based on EU KLEMS data. Although referring to the same period (1973–95 average TFP growth, 1979–95 change in Domar weights), the results differ considerably from Oulton's calculations. The intermediate

service industries which were responsible for Oulton's vindication of his theorem – financial and business services – now jointly drag aggregate TFP growth down by 0.123 PP per year on average (combined contribution of sectors J, 70, 71-74) instead of raising it by 0.078 PP. While some service industries raise aggregate TFP growth over time, in aggregate they are adversely linked to TFP growth. The shift of resources into services has reduced aggregate TFP growth by 0.097 PP over the period 1979–95 according to EU KLEMS data. The overall shift to services necessarily implies a shift out of goods-producing industries, which adds another 0.229 PP to the decline in aggregate TFP growth (much more than according to Oulton's calculations). The total effect thus amounts to -0.326 PP.

The column on the right-hand side of Table 2 reports the results for the longest time period for which UK data are available in the EU KLEMS accounts (1970–2007). As compared to the shorter period analysed above, the negative impact of a shift to service industries on TFP growth is further reinforced. One exception is the 'core' business service industry (renting of machinery and equipment and other business services), where the negative impact becomes smaller. In real estate activities, on the other hand, it becomes stronger.[8]

<Insert Table 2>

Why are the results so different from Table 1? To answer this question, consider Table 3, which compares O'Mahony's (1999) TFP_VA growth rates used by Oulton and Oulton's (2001) change in Domar weights with those calculated from EU KLEMS data for industries that are roughly comparable. Three major differences stand out. First, TFP_VA growth in mining is not nearly as negative according to EU KLEMS data as it is according to O'Mahony (1999), so this industry's decline in Domar weight does not support aggregate TFP growth as much in Table 2 as it does in Table 1. Secondly, manufacturing's decline in Domar weight is much stronger according to EU KLEMS data than it is according to Oulton (2001), so this industry with positive TFP_VA growth drags aggregate TFP growth down much more in Table 2 than in Table 1. Finally, financial and business services display negative TFP_VA growth according to EU KLEMS data. This means that one of the conditions for Oulton's theorem to hold – positive TFP growth in intermediate services – is violated and that the rise in the Domar weight of this industry – which is even stronger

[8] Output of the real estate sector (NACE 70) is mostly imputed rent on owner-occupied dwellings. O'Mahony and Timmer (2009, p. F391) recommend to interpret productivity measures for this industry with care.

according to EU KLEMS data than according to Oulton (2001) – lowers aggregate TFP growth.

<Insert Table 3>

It is quite common that different data sources yield conflicting results. Given the huge collaborative effort behind the EU KLEMS Growth and Productivity Accounts, to which Mary O'Mahony was a leading contributor, however, we conjecture that Table 2 is likely to give a more accurate account of the impact of structural change on aggregate TFP growth in the UK than Table 1.

The last step in our empirical analysis is to calculate the impact of structural change on aggregate TFP growth for the remaining G7 countries (without Canada) in the same way as was done for the UK. Tables 4–8 present the results. Aggregate TFP growth was highest in France and lowest in the US. In all countries, TFP_VA (and TFP_GO) growth was negative in 'renting of machinery and equipment and other business services', so that the rise in the Domar weight of this industry lowered aggregate TFP growth. The Domar weights of 'financial intermediation' and 'real estate activities' also increased in all countries. TFP_VA growth rates were different, however. For instance, they were positive in France and Germany and negative in the US. France stands out in that the shift of resources to service industries has raised aggregate TFP growth, mainly thanks to 'real estate activities' and 'post and telecommunications'. The overall effect of structural change on TFP growth was negative in France as well, however, because two goods-producing industries with high productivity growth – agriculture and manufacturing – lost Domar weight. Germany is the only country where the Domar weight of manufacturing has not declined. This is partly due to the fact that the observation period is the shortest for Germany.

<Insert Tables 4-8>

The overall impact of structural change on TFP growth was negative in all countries. Also, the negative impact accumulates over time. The two countries with the shortest observation periods (Germany and France) display the smallest total impact. Time is not the only factor, however. For instance, Italy, for which the observation period is longer than for Japan and the US, experienced a smaller drop in average TFP growth than these two countries, while the UK witnessed a drop that was more than twice as large as that of Italy over the same period of time.

One important driver of our results is negative TFP growth in business services. In a recent paper, Nicholas Oulton has also examined EU KLEMS data and – in line with our results – found TFP growth in the aggregate of market sector industries to be negative in most countries.[9] Oulton, however, does not believe these results to present an accurate picture. In particular, he doubts that TFP growth in business services is actually negative. "Negative TFP growth", he writes, "suggests that firms in these industries are becoming less efficient over time or that technical knowledge is being forgotten, which seems highly implausible in peaceful conditions" (Oulton, 2016, p. 72).

Oulton's interpretation of the reasons for negative TPF growth – namely technological regress – is too narrow, however. Timmer et al. (2010), in what remains the most comprehensive account of the EU KLEMS database and the insights it offers, list several reasons apart from technological regress that might cause TFP growth to become negative. These include organisational changes, effects from changes in unmeasured inputs (e.g. R&D), deviations from the neo-classical assumption of marginal costs reflecting marginal revenues, changes in returns to scale, reallocations of market shares across firms in each industry, and measurement errors in inputs and outputs (see Timmer et al., 2010, pp. 87–9). Oulton focusses on the last-mentioned reason, implicitly dismissing more substantial explanations for negative TFP growth in business services. These include, first, the fact that business services firms – especially in Europe – are often small and probably below the size required for maximum efficiency and, secondly, that competition between them is relatively weak because of "market segmentation and lack of market transparency" (Rubalcaba and Kox, 2007, p. 8). Fernandez and Palazuelos (2012, p. 245) add that business services "include, among others, a wide range of operations related to maintenance, repair, cleaning, accounting, legal and technical services, as well as personnel training, security, advertising , marketing, and so on. […] (A)lmost all of them operate without foreign competition, are organized in relatively small establishments, and are driven toward high labour intensity due to the necessarily direct and personal contact between producers and consumers. […] Consequently, the labour productivity of these activities […] increases only slightly or even decreases."

[9] See Oulton (2016), Table 2, column 6. Oulton (2016) builds on an extended version that subsequently became available as Oulton (2017).

Nevertheless, Oulton is right to stress measurement issues. As a matter of fact, output measurement in financial and business services is still poor. Timmer et al. (2010, pp. 92-3) report that 48 percent of European national statistical institutes (NSIs) used inappropriate deflators to derive real output in business services around the year 2000. In financial intermediation the share was 43 percent. Both these shares even exceeded the percentage of NSIs using inappropriate deflators for social and personal services (42 percent), a sector in which adequate deflation is notoriously tricky. Hence, despite the overall conclusion of Timmer et al. (2010, p. 100) that output measurement in market services is "fairly accurate",[10] we should test the robustness of our conclusion to possible mismeasurement of TFP growth in financial and business services.

One possibility for such a robustness test is the so-called Corrado-Slifman correction. Like Oulton (2016), Corrado and Slifman (1999) doubt negative long-run productivity growth.[11]Their proposition is to assume a flat productivity growth instead of a declining one for the industries concerned (see also Hartwig, 2008b).

Tables 2 and 4–8 reveal that setting TFP growth in 'financial intermediation' and 'renting of machinery and equipment and other business activities' to zero in those cases where the rates are negative – which results in a zero contribution of the respective industries to the change in aggregate TFP growth – does not change our main conclusions, except for Germany. If the strongly negative contribution of 'renting of machinery and equipment and other business activities' is disregarded in Germany, both the aggregate of service industries (NACE codes G-P) and overall structural change (all industries) contribute positively to aggregate TFP growth. In France, the positive contribution of service industries becomes stronger. This positive effect is still not large enough, however, to overcompensate the negative impact of the shift of resources out of goods-producing industries. A similar picture emerges for Italy. In the US, the UK, and Japan both the aggregate of service industries and overall structural change still contribute negatively to aggregate TFP growth.

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[10] They quote Hartwig (2008a) in support of this conclusion, who shows that mismeasurement is not responsible for US labour productivity growth outperforming its European counterpart in certain market service industries after 1995.

[11] "It seem unlikely that firms with declining long-term productivity would be able to avoid bankruptcy, let alone maintain the rate of return to the owners" (Corrado and Slifman, 1999, p. 330).

Oulton (2016) suggests a more far-reaching correction. He sets TFP growth in business services equal to the average market sector TFP growth rate in each country and year. He then uses half of that growth rate as a sensitivity test.[12] In the latter case, the overall effect of structural change on aggregate TFP growth in the market sector remains negative in Italy, Japan, the UK and the US It becomes positive in France and Germany, however. When TFP growth in business services is assumed to be equal to the full market sector growth rate, Japan joins France and Germany in recording a (small) positive effect. What these correction exercises show is that, even if the arguments in favour of small or even negative TFP growth rates in business services discussed above are disregarded,[13] the effect of structural change on aggregate TFP growth remains negative in many countries. The countries in which the effects become positive (Germany and France) are those with the shortest observation periods. Given that the negative impact of structural change seems to accumulate over time, we conclude that poor measurement of TFP growth in business services is unlikely to be the cause behind the apparent persistence of the 'Growth Disease'.

V. Conclusion

Baumol's 'Growth Disease', i.e., the proposition that aggregate productivity growth will decline over time as service industries with low productivity growth receive an ever-increasing weight in the economy, turns 50 this year. It has sparked off a large body of theoretical and empirical literature. One of the most important contributions came from Oulton (2001) who made an important qualification. If resources shift to intermediate (business) services instead of personal services, aggregate productivity growth might increase, instead of declining. Baumol endorsed Oulton's argument wholeheartedly.

There are two conditions for Oulton's theorem to hold, however: Total factor productivity growth in industries producing intermediate services must be positive, and the Domar

[12] Oulton (2017) adjusts the TFP growth rate of finance as well, which does not change his conclusions.

[13] Byrne et al. (2017) argue that prices for high tech products are mismeasured and that correcting this mismeasurement implies faster TFP growth in high-tech industries and slower TFP growth outside the high-tech sector. If this was the case, then TFP growth in business services might even be upward-biased in EU KLEMS data.

weights of these industries must increase over time. We tested whether these conditions apply to EU KLEMS data for the G7 countries (without Canada).

Our findings suggest that the second condition is fulfilled. The Domar weights of intermediate services are rising. Oulton's claim that intermediate services expand faster than personal services is also reflected in our calculations of Domar weights. The first condition, however, is not fulfilled. Business services typically show negative TFP growth. Therefore, their rising weight slows aggregate productivity growth down.

Oulton (2016, 2017) thinks that negative TFP growth in business services is implausible. We disagree, as there are plausible reasons why TFP growth in this industry might be small or negative. Even if the negative rates are 'corrected' – various ways how this could be done have been suggested in the literature – the effect of structural change on aggregate TFP growth remains negative in most countries. The reason is that agriculture and manufacturing – two industries with positive TFP growth – lose (Domar) weight in all countries except Germany. This implies that aggregate productivity growth slows down in the process of tertiarisation. At the age of 50, the 'Growth Disease' is in good health.

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Table 1: Industries' contributions to average annual change in TFP growth in the UK according to Oulton (2001)

	Contribution to change in TFP growth 1979-1995 (PP)
AGGREGATE TFP GROWTH	0.94
AGRICULTURE, FORESTRY AND FISHING	-0.020
MINING AND OIL REFINING	0.081
MANUFACTURING	-0.024
UTILITIES	-0.024
CONSTRUCTION	-0.016
DISTRIBUTIVE TRADES	0.002
TRANSPORT AND COMMUNICATIONS	-0.005
FINANCIAL & BUSINESS SERVICES	0.078
MISCELLANEOUS PERSONAL SERVICES	0.007
NON-MARKET SERVICES	0.007
Sum services	0.089
Sum all industries	0.086

Source: Own calculations based on Oulton (2001), Tables 3 and 4.

Table 2: Industries' contributions to change in TFP growth in the UK

	NACE code	Contribution to change in TFP growth 1979-1995 (PP)	Contribution to change in TFP growth 1970-2007 (PP)
AGGREGATE TFP GROWTH	TOT	0.338	0.378
AGRICULTURE, HUNTING, FORESTRY AND FISHING	AtB	-0.025	-0.047
MINING AND QUARRYING	C	0.002	-0.008
TOTAL MANUFACTURING	D	-0.203	-0.406
ELECTRICITY, GAS AND WATER SUPPLY	E	-0.005	-0.003
CONSTRUCTION	F	0.001	0.008
WHOLESALE AND RETAIL TRADE	G	0.007	0.007
HOTELS AND RESTAURANTS	H	0.001	-0.008
TRANSPORT AND STORAGE	60t63	0.007	0.009
POST AND TELECOMMUNICATIONS	64	0.006	0.018
FINANCIAL INTERMEDIATION	J	-0.015	-0.020
Real estate activities	70	-0.036	-0.091
Renting of m&eq and other business activities	71t74	-0.072	-0.017
PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECURITY	L	0.004	0.004
EDUCATION	M	0.003	-0.017
HEALTH AND SOCIAL WORK	N	0.000	0.006
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	O	-0.001	-0.019
Sum services (NACE code G-O)		-0.097	-0.127
Sum all industries		-0.326	-0.583

Source: Own calculations based on the EU KLEMS Growth and Productivity Accounts, March 2011 update of the December 2009 release.

Table 3: Industries' contributions to change in TFP growth in the UK

	TFP_VA growth (1973-95)		Change in Domar weights (1979-95)	
	O'Mahony (1999)	EU KLEMS	Oulton (2001)	EU KLEMS
AGRICULTURE, FORESTRY AND FISHING	2.92	2.32	-0.013	-0.024
MINING	-2.15	-0.09	-0.051	-0.033
MANUFACTURING	1.85	1.65	-0.027	-0.365
UTILITIES	2.87	2.09	-0.017	-0.006
CONSTRUCTION	2.15	1.16	-0.015	0.002
DISTRIBUTIVE TRADES	0.43	0.31	0.010	0.038
TRANSPORT AND COMMUNICATIONS	3.06	1.82	-0.003	0.013
FINANCIAL & BUSINESS SERVICES	0.98	-1.33	0.114	0.162

Source: Oulton (2001), Tables 3 and 4 and own calculations based on the EU KLEMS Growth and Productivity Accounts, March 2011 update of the December 2009 release.

Table 4: Industries' contributions to change in TFP growth in France

	NACE code	Contribution to change in TFP growth 1980-2007 (PP)
AGGREGATE TFP GROWTH	TOT	0.911
AGRICULTURE, HUNTING, FORESTRY AND FISHING	AtB	-0.082
MINING AND QUARRYING	C	0.008
TOTAL MANUFACTURING	D	-0.102
ELECTRICITY, GAS AND WATER SUPPLY	E	0.004
CONSTRUCTION	F	-0.005
WHOLESALE AND RETAIL TRADE	G	-0.002
HOTELS AND RESTAURANTS	H	-0.008
TRANSPORT AND STORAGE	60t63	0.004
POST AND TELECOMMUNICATIONS	64	0.055
FINANCIAL INTERMEDIATION	J	0.006
Real estate activities	70	0.058
Renting of m&eq and other business activities	71t74	-0.056
PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECU	L	-0.004
EDUCATION	M	-0.002
HEALTH AND SOCIAL WORK	N	0.004
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	O	0.003
PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS	P	0.003
Sum services (NACE code G-P)		0.060
Sum all industries		-0.116

Source: Own calculations based on the EU KLEMS Growth and Productivity Accounts, March 2011 update of the December 2009 release.

Table 5: Industries' contributions to change in TFP growth in Germany

	NACE code	Contribution to change in TFP growth 1991-2007 (PP)
AGGREGATE TFP GROWTH	TOT	0.651
AGRICULTURE, HUNTING, FORESTRY AND FISHING	AtB	-0.015
MINING AND QUARRYING	C	-0.011
TOTAL MANUFACTURING	D	0.027
ELECTRICITY, GAS AND WATER SUPPLY	E	0.007
CONSTRUCTION	F	0.010
WHOLESALE AND RETAIL TRADE	G	-0.008
HOTELS AND RESTAURANTS	H	0.001
TRANSPORT AND STORAGE	60t63	0.021
POST AND TELECOMMUNICATIONS	64	0.022
FINANCIAL INTERMEDIATION	J	0.002
Real estate activities	70	0.014
Renting of m&eq and other business activities	71t74	-0.115
PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECUL		-0.010
EDUCATION	M	-0.004
HEALTH AND SOCIAL WORK	N	0.025
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	O	-0.003
PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS	P	0.000
Sum services (NACE code G-P)		-0.054
Sum all industries		-0.036

Source: Own calculations based on the EU KLEMS Growth and Productivity Accounts, March 2011 update of the December 2009 release.

Table 6: Industries' contributions to change in TFP growth in Italy

	NACE code	Contribution to change in TFP growth 1970-2007 (PP)
AGGREGATE TFP GROWTH	TOT	0.447
AGRICULTURE, HUNTING, FORESTRY AND FISHING	AtB	-0.240
MINING AND QUARRYING	C	0.000
TOTAL MANUFACTURING	D	-0.013
ELECTRICITY, GAS AND WATER SUPPLY	E	-0.006
CONSTRUCTION	F	0.021
WHOLESALE AND RETAIL TRADE	G	0.009
HOTELS AND RESTAURANTS	H	-0.028
TRANSPORT AND STORAGE	60t63	0.026
POST AND TELECOMMUNICATIONS	64	0.032
FINANCIAL INTERMEDIATION	J	-0.021
Real estate activities	70	0.036
Renting of m&eq and other business activities	71t74	-0.072
PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECU	L	0.002
EDUCATION	M	-0.001
HEALTH AND SOCIAL WORK	N	0.005
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	O	-0.005
PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS	P	-0.006
Sum services (NACE code G-P)		-0.023
Sum all industries		-0.262

Source: Own calculations based on the EU KLEMS Growth and Productivity Accounts, March 2011 update of the December 2009 release.

Table 7: Industries' contributions to change in TFP growth in Japan

	NACE code	Contribution to change in TFP growth 1973-2006 (PP)
AGGREGATE TFP GROWTH	TOT	0.776
AGRICULTURE, HUNTING, FORESTRY AND FISHING	AtB	-0.015
MINING AND QUARRYING	C	-0.003
TOTAL MANUFACTURING	D	-0.231
ELECTRICITY, GAS AND WATER SUPPLY	E	0.011
CONSTRUCTION	F	0.027
WHOLESALE AND RETAIL TRADE	G	-0.001
HOTELS AND RESTAURANTS	H	-0.016
TRANSPORT AND STORAGE	60t63	0.002
POST AND TELECOMMUNICATIONS	64	0.027
FINANCIAL INTERMEDIATION	J	0.050
Real estate activities	70	-0.108
Renting of m&eq and other business activities	71t74	-0.038
PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECU	L	0.009
EDUCATION	M	0.003
HEALTH AND SOCIAL WORK	N	-0.022
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	O	-0.027
Sum services (NACE code G-O)		-0.122
Sum all industries		-0.332

Source: Own calculations based on the EU KLEMS Growth and Productivity Accounts, March 2011 update of the December 2009 release.

Table 8: Industries' contributions to change in TFP growth in the US

	NACE code	Contribution to change in TFP growth 1977-2007 (PP)
AGGREGATE TFP GROWTH	TOT	0.231
AGRICULTURE, HUNTING, FORESTRY AND FISHING	AtB	-0.047
MINING AND QUARRYING	C	0.002
TOTAL MANUFACTURING	D	-0.223
ELECTRICITY, GAS AND WATER SUPPLY	E	-0.001
CONSTRUCTION	F	0.010
WHOLESALE AND RETAIL TRADE	G	-0.030
HOTELS AND RESTAURANTS	H	0.000
TRANSPORT AND STORAGE	60t63	-0.009
POST AND TELECOMMUNICATIONS	64	0.000
FINANCIAL INTERMEDIATION	J	-0.062
Real estate activities	70	-0.005
Renting of m&eq and other business activities	71t74	-0.050
PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECU	L	0.004
EDUCATION	M	-0.010
HEALTH AND SOCIAL WORK	N	-0.058
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	O	0.022
Sum services (NACE code G-O)		-0.198
Sum all industries		-0.456

Source: Own calculations based on the EU KLEMS Growth and Productivity Accounts, March 2011 update of the December 2009 release.