DIVERGENCES IN PRODUCTIVITY BETWEEN EUROPE AND THE UNITED STATES

Measuring and Explaining Productivity Gaps Between Developed Countries

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9. Outsourcing and Productivity Growth: Sectoral Evidence from Germany

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9.1 ABSTRACT

We examine the determinants of German sectoral productivity growth in the 1990s. To establish the importance of outsourcing across industries and time, we compare and contrast alternative productivity measures. The new *Ifo Productivity Database* now allows interindustry and intertemporal comparisons between gross value and value added measures of productivity growth, to highlight the effects of changing intermediate input shares in German production.

By constructing the gross output productivity measure for Germany we find that output (productivity) growth is significantly understated (overstated) by the value added measure over time and across industries. We also provide preliminary evidence that many sectors do not satisfy the assumptions to allow value added to proxy for gross output measures.

In terms of the sources of economic growth, we find that, true to the theory, outsourcing is the key variant between the two productivity measures, and that apparently most of this outsourcing has its origin in increased German imports. Most strikingly, the factor that drives productivity growth in Germany between 1993 and 2001 is intermediates and here high intermediate growth also translated not only into high output growth but also high sectoral TFP growth.

analyzing German sectoral productivity growth. The purpose is not only to contrast the two measures, but to highlight the effect of outsourcing on German productivity growth.

Our two measures of productivity growth are based on value added and on gross output. The former excludes the contribution of intermediate inputs (materials, energy and services in sectoral production) while the latter includes all inputs into production. The two measures thus differ roughly by the degree to which changes in intermediates are underreported and counted as productivity changes in the value added measure.

Higher levels of sectoral aggregation diminish the differences between the two output measures; however, even at the national level the measures differ to the extent that intermediate inputs are sourced from imports (Schreyer 2001, p. 42). We can thus utilize the differential between value-added productivity and gross output productivity to provide inferences about the changing outsourcing shares across German sectors.

Gross output or the value-added measures have been used extensively to characterize total factor productivity (TFP) growth. Value-added productivity reports capital-labour TFP while gross-output productivity reports capital-labour-intermediate TFP is reflected by the gross output measure (see OECD 2001, p. 10). The new Ifo Productivity database allows us to break aggregate sectoral performance into its components of capital, labour and intermediate goods and hence establish the first gross output productivity measures for Germany during the information technology boom. In addition, the Ifo Productivity Database contains assembled capital stocks and capital services flows data that more accurately reflect the contributions of factor inputs in sectoral and aggregate growth accounting exercises than most other studies. Our resulting productivity measures are important benchmarks for comparisons with long established value-added productivity measures in the literature.

The significance of intermediates in production varies across countries and industries. For the case of Germany, the median ratio of intermediates over gross output across sectors is 60.5 per cent in 2001. This statistic emphasizes how dramatically changes in the intermediate intensity in production will affect output and productivity; an effect that is documented extensively below. The large share of intermediates in output at the German sectoral level also highlights the importance of considering intermediate inputs in productivity growth accounting.

All productivity measures are inherently sensitive to substitution between factor inputs (including intermediate inputs) and outsourcing (of intermediate services); the question is how this sensitivity is reflected in the productivity statistic. The value-added productivity measure will be shown to exaggerate productivity since it implicitly includes changes in the structure of intermediates inputs. There are several theoretical reasons to prefer the gross output productivity measure, particularly at the sectoral level. First, the measure does not ignore improvements in the price-efficiency ratio of intermediate inputs, second, it allows for an adequate account of intersectoral production spillover effects, and finally the gross output productivity measure does not neglect intermediates-input-embodied technological change. The disadvantage of the gross output based measure is, however, that it is not a reliable representation of a sector's contribution towards aggregate TFP trends. To calculate this contribution correctly, the sectoral productivities must be combined with Domar weights.

While the German Statistical Office does not provide gross output productivity measures, these figures are reported by the US Bureau of Labor Statistics for manufacturing industries. Previous authors that have examined gross output TFP at the sectoral level are Jorgensen et al. (1987), Gullickson and Harper (1999b) and (2002), Baldwin et al. (2001) for the US, Oulton and O'Mahony (1994) for the UK, Gu and Ho (2001) and Gu, Lee and Tang (2001) for Canada. Aside from Crafts and Mills (2001), who compare the UK and West Germany until 1996, to our knowledge there exists no gross output productivity measure for Unified Germany.

Value-added productivity measures are popular in comparative analyses: they lower the data requirements and thus facilitate cross country comparisons. For example Van Ark and Pilat (1993) and Bernard and Jones (1996a,b) use the measure in an OECD intercountry approach, Harris and Trainor (1997) for the regional UK. In Spain, Hernando and Nuñez (2002) use a value-added approach for regional comparisons of productivity.

There are also a number of studies that compare sectoral productivity growth rates according to value-added and gross output-based estimates. Oulton and O'Mahony (1994) provided estimates of aggregate manufacturing TFP for the period 1953–1986 based on both methods. Van der Wiel (1999) has estimated labour productivity and TFP according to both approaches for Dutch manufacturing and service industries, and Sichel (2001) provided a comparison for the US communication sector. Harchaoui et al. (2001) provide estimates of industry TFP in Canada according to several different output measures. Oulton (2000) obtained gross output-based estimates of TFP growth for UK industry sectors by using the ratio of value added to gross output to convert value-added based TFP estimates. Goerlich and Orts (1994, 1996) underline differences in sectoral TFP estimates at the aggregate level for the Spanish economy. In all cases the empirics confirm the analytical results we review below in that the value-added productivity measure consistently exceeds the gross output estimates TFP growth by a factor equal to the ratio of gross output to value-added.

By constructing the gross output productivity measure we find that, for the case of Germany, output productivity growth is significantly understated by the value-added measure, while TFP growth is significantly overstated if gross output is not taken into account. These results are similar to those obtained by Oulton and O'Mahony (1994) for the UK. We also provide preliminary evidence that many sectors do not satisfy the assumptions to allow value added to proxy for gross output measures.

In terms of the sources of economic growth, we find that, true to the theory, outsourcing is a key variant between the two measures, and that apparently most of this outsourcing has its origin in increased German imports. Most striking is that the factor which drove productivity growth in Germany between 1993 and 2001 is intermediates and here high intermediate growth also translated not only into high output growth but also high sectoral TFP growth. These results are reminiscent of Jorgenson et al. (1987) and Jorgenson and Stiroh (2001) for the case of the US.

The structure of the chapter is as follows. First we outline the differences, advantages and disadvantages of the gross and value-added productivity measures. Then we describe the novel dataset that has been assembled at the IFO Institute. Finally we compare the performance of the value-added and gross output measures with special emphasis on the contributions of intermediates and outsourcing to sectoral productivity. Section 9.6 concludes.

9.3 METHODOLOGY: VALUE-ADDED VS. GROSS OUTPUT MEASURES

There exist two standard concepts in the economics literature to establish 'output'. Gross output is the total value of sales and operating receipts, while value added subtracts from gross output the value of goods and services purchased from other sectors as intermediate inputs. The differences between the measures are both practical and conceptual.

Value added is attractive because of its relative simplicity; dollar income, or payments to capital and labour are readily available from tax data. Time series data also requires, however, the use of separate deflators for sales and inputs. Gross output is closer to the ordinary notion of productivity as it represents sales per employee. As gross output deals explicitly with intermediate goods it is not subject to distortions when the primary and intermediate input mix changes.

The value-added productivity concept is widely used for international comparisons because the data are more readily available from countries' national accounts whereas sectoral gross output requires more detailed and disaggregated data and is therefore less easily available. Hence, while the US

Bureau of Labor statistics has determined that gross output is the correct basis for US measures of productivity, it acknowledges that there are other considerations that may make value added a better concept for international comparisons such as differences among countries in the extent of vertical integration of industries. We commence with a brief review of the issues related to gross and value-added output productivity measures and then examine their performance in Germany.

Gross Output

The most natural measure of productivity is directly related to the volume changes in output. The gross output productivity measure is a natural analog to the model of Hicks neutral technical change. Here technological change could be R&D or learning-by-doing. The productivity increase is disembodied technical change because it is the residual output change that is not physically tied to any factor of production.

The basic growth accounting equation using the gross output concept is:

$$\Delta \ln Y_{it} = \bar{v}^{L}_{it} \Delta \ln L_{it} + \bar{v}^{K}_{it} \Delta \ln K_{it} + \bar{v}^{M}_{it} \Delta \ln M_{it} + \Delta \ln TFP_{Y_i}, \quad (9.1)$$

with Y_{it} as gross output in industry i during period t, L is the flow of labour inputs, K are capital service flows, M are intermediate inputs, and TFP_Y is gross output total factor productivity. v_{it} represents the input shares in gross output, under constant returns they fulfill the condition: $\bar{v}^{L}_{it} + \bar{v}^{K}_{it} + \bar{v}^{M}_{it} = 1$.

In a perfect world, the gross output concept is, as highlighted by Jorgenson and Stiroh (2001), the appropriate concept for industry-level growth accounting studies. However, the measure has several shortcomings. Sichel (2001, p.7) reviews the literature and highlights that in practice, gross output TFP measures also reflect a number of additional influences including changes in efficiency, economies of scale, capacity utilization, market structure and measurement error. Under the assumption of competitive markets and constant returns to scale, these factors are assumed to be constant and to have no effect on TFP.

The value-added productivity measure is, however, subject to the same criticism. The advantage of the gross output-based productivity measure is that it accounts for intermediate inputs as a source of industry growth and hence appropriately considers differences in the input mix as explanations for output and TFP growth. Some argue that this renders a more complete representation of the production process (Sichel 2001, p. 7). Jorgenson and Stiroh (2001) have provided an example of the importance of intermediate input growth in the analysis of TFP, when they showed that productivity improvements reduced semi-conductor prices and increased their flow as intermediate nputs to other industries. A full account of the contribution of these inputs ippropriately reduces biases of the attributed productivity contribution to primary inputs (capital/labour) and TFP across sectors.

By correctly accounting for the quantity and quality of intermediate inputs, he gross output concept allows aggregate TFP gains to be better allocated among industries (Jorgenson and Stiroh 2001, p. 53). The method of aggregation is crucial (Gullickson 1995, p. 15). Aggregate outputs and inputs are not simple sums of their sectoral counterparts and inconsistencies can arise between the productivity estimates. Aggregate output and input measures exclude all intermediate transactions between domestic industries to avoid double counting and to capture movements in inputs and outputs resulting from technological change and other efficiency changes. However, industry inputs include purchases from other industries and industry outputs include sales to other industries as well as sales to final demand. As a result, aggregate productivity growth cannot be obtained as an average using a set of weights that sum to one (Gullickson and Harper 1999a, p. 51).

Consistency between aggregate and sectoral estimates of TFP based on gross output is enhanced by the exclusion of intra-industry inputs and by the adoption of a sectoral productivity weighting system to derive aggregate estimates. As the sector size increases, the proportion of all transactions that are intra-sector tends to rise and the ratio of intermediate inputs to value added tends to fall. Equivalently, as the level of sectoral aggregation increases, the difference between gross output-based estimates of TFP growth and value-added based estimates tends to decrease. In the case of a closed economy, sectoral output at the most aggregate level is identical to total value added (OECD 2001, p. 91).

Domar (1961) proposed that TFP growth at the aggregate level should be measured as a weighted sum of industry-level TFP growth rates (see Oulton and O'Mahony 1994, pp. 13–14 and pp. 118–21). The industry productivity growth rates are estimated using gross output and incorporate intermediate inputs from other sectors. The 'Domar' weight is the ratio of the value of gross output of an industry/sector to the sum of value added in all industries/sectors. This weighting scheme can be adapted to different aggregates, whether a sectoral aggregate or the market economy.

The effect of weighting industry growth rates is to scale the industry TFP estimates by their relative importance to permit reconciliation with aggregate estimates. These weights reflect the direct contribution of sectoral productivity change to economic growth through deliveries to final demand and the indirect contribution through deliveries to intermediate demand (Jorgenson et al. 1987, p. 7). This weighting methodology implies that economy-wide TFP growth can grow faster than productivity in any single industry, since productivity gains are magnified as they work their way through the production process (Jorgenson and Stiroh 2001, p. 53).

Table 9.1 Industry output growth and average contributions 1993–2001

	ΔY	ΔK^{n}	ΔK^{ICT}	ΔLH	ΔLQ	ΔM	TFP_Y
Communications	13.31	0.25	0.06	-0.88	-0.03	7.49	6.41
Transport Equipment	3.99	0.26	-0.02	0.26	0.15	4.13	-0.79
Financial Intermediation	3.71	0.19	0.15	0.22	1.04	2.16	-0.04
Real Estate Activ. & Bus. Services	3.49	2.42	0.10	0.80	0.46	0.71	-1.01
Chemicals	3.48	0.43	0.03	-0.55	0.07	2.86	0.65
Transport	3.39	0.84	0.10	-0.11	0.09	1.91	0.57
Elec. and Electron. Equip. Instr.	3.29	0.09	-0.07	-0.44	0.08	3.77	-0.13
Rubber & Plastics	2.42	0.33	0.04	-0.01	0.11	1.85	0.10
Electricity, Gas and Water Supply	2.41	1.30	0.07	-0.69	0.29	1.36	0.08
Wood & Pro. of Wood and Cork	1.77	0.32	0.03	-0.75	0.33	1.84	0.01
Basic Metals & Fab.Metal Products	1.77	0.22	0.00	-0.27	-0.04	1.59	0.27
Agriculture, Forestry and Fishing	1.45	0.80	0.00	-0.61	0.41	0.69	0.16
Non-Market Services	1.44	0.73	0.05	0.09	0.60	0.49	-0.51
Other Services	0.77	0.61	0.13	0.98	0.38	0.01	-1.33
Food, Drink & Tobacco	0.77	0.14	-0.04	-0.06	0.08	0.52	0.13
Non-Metallic Mineral Products	0.74	0.44	-0.01	-0.61	0.31	0.84	-0.22
Repairs and wholesale trade	0.41	0.35	-0.02	-0.08	0.50	0.28	-0.62
Retail trade	0.38	0.36	0.04	0.02	0.50	-0.24	-0.29
Mechanical Engineering	0.24	0.15	-0.04	-0.36	0.05	0.57	-0.13
Construction	-0.37	-0.03	-0.01	-0.93	0.19	0.37	0.04
Pulp, & Paper Prod.; Print. & Publ.	-0.40	0.34	0.02	-0.63	0.03	0.21	-0.37
Furniture, Misc. Manuf.; recycling	-2.52	0.24	0.01	-0.66	0.19	-0.80	-1.50
Hotels & Catering	-2.68	0.30	0.00	0.68	0.31	-2.02	-1.95
Text., Leather, Footwear & Clothing	-3.47	0.04	-0.03	-1.22	-0.11	-1.72	-0.42
Mineral Oil Ref., Coke & Nuclear	-4.03	0.21	0.01	-0.08	0.00	-4.75	0.59
Mining and Quarrying	-9.62	0.00	0.00	-1.56	-0.38	-5.13	-2.56

Note: Percentage Points, ΔY: Output Growth; ΔK^{n}: non-ICT capital contribution, ΔK^{ICT}: ICT capital contribution, ΔLH: contribution of total hours worked, ΔLQ: contribution of labour quality changes, ΔM: contribution of intermediate input consumption, TFP: total factor productivity.

Source: Ifo Productivity Database.

The Domar aggregation of gross output-based TFP measures across industries provides an accurate picture of the contributions of industries to aggregate TFP change. However, there are significant data problems associated with input-output tables and their consistency with national accounts. This issue is discussed below. One cost of this approach is that sectoral productivity growth rates cannot be compared with the aggregate because the aggregate is built up as weighted sums, but not averages, from its components. In contrast, as noted earlier, value-added based productivity measures of aggregates are weighted averages of their components and can be compared across levels of aggregation because the weights add to unity.

Table 9.1 represents the average gross output growth between 1993 and 2001 and the contributions of various inputs to the average output growth. Table 9.1 indicates that, for example in the case of the communications sector 7.49 per cent of the 13.31 per cent productivity growth is derived from intermediates. TFP growth contributed 6.41 per cent to the average growth rate in between 1993 and 2001.

The top 5 sectors in terms of average growth rates are Communications, Transportation Equipment, Financial Intermediation, Real Estate and Chemicals. Most of the growth in these sectors is derived via growth in intermediates (except in the case of real estate where capital accumulation dominated). The same is true for the 5 biggest losing sectors, Mining, Minerals, Textiles, Hotel, and Furniture, where most of the contraction is derived from reductions in intermediates. Hence their gross output measure highlights the importance of German growth in the 1990s being driven by changes in outsourcing or intermediates.

Note that TFP contributes positively in only 11 of the 26 sectors. Most interesting is that the correlation between the TFP contribution to output growth and the intermediates contribution to output growth is 0.66, suggesting that those sectors that had large expansions (contractions) in intermediate growth also experienced large TFP contributions to output growth. Only the correlation between TFP and output growth is higher with 0.77, clearly indicating the important relationship between total factor productivity and output performance.

Value Added

The value-added productivity measure possesses two strong advantages. First, it can be derived with relatively low data requirements, as it abstracts from inter-sectoral good and service flows. Secondly, the approach provides a simple link between sectoral and aggregate TFP growth (see OECD 2001, p. 30). Sectoral value added can also be simply aggregated using weights that represent each sector's current price share in total value added. This implies that value-added productivity can be easily compared across sectors or industries, and that sectoral productivity growth can be compared to the national average.

The basic value-added growth accounting equation is:

$$\Delta \ln VA_{it} = \tilde{v}_{it}^{L} \Delta \ln L_{it} + \tilde{v}_{it}^{K} \Delta \ln K_{it} + \Delta \ln TFP_{VA\,i}, \qquad (9.2)$$

where VA is value added, and TFP_{VA} is value-added total factor productivity. $\widetilde{v}_{it}$ represent the input shares of labour and capital for value added; they fulfill the condition: $\widetilde{v}_{it}^{L} + \widetilde{v}_{it}^{K} = 1$.

This conveniently implementable and comparable methodology comes at a price. Value-added productivity is at times criticized as providing at best an ambiguous picture of the actual productivity, due to its abstraction from intermediates, and due to the fact no real world analog to value added is actually produced by plants (Sudit and Finger 1981, p. 14; Oulton and O'Mahony 1994, p. 33; Hulten 2000, p. 58).

Since value added is the difference between separately deflated gross output, Y, and intermediate inputs, M, the concept requires an additively separable production function of the type $Y = VA + M$. Such a function imposes strong restrictions on generality and the role of technological change (see Gollop 1979, p. 320; Bruno 1980; Diewert 1980). Empirical testing suggests, for example, that there exists no separability between the value-added function and intermediate inputs. Jorgenson et al. (1987) find that the conditions necessary and sufficient for the existence of a sectoral value-added function did not exist in forty out of forty-five US industries analyzed.

An additional simplification of the value-added measure is that it abstracts from substitution between capital/labour and intermediate inputs. This assumption is especially problematic in countries with rigid labour markets where downsizing limits introduce friction and slack into sectoral employment. One might argue that in this respect, Germany is a good candidate for establishing gross output productivities.

Price changes in intermediate inputs, potentially significant drivers of sectoral productivity growth, are assumed not to affect the relative usage of other inputs (Jorgenson et al. 1987, p. 9; Dean and Harper 2000, p. 48). The value-added concept thus assumes that prices of intermediates always rise at the same rate as those of all other factors. Finally, technological change is assumed to affect only capital and labour, since intermediate usage is, by assumption, not affected by the improvements in productivity (Gollop 1979, p. 322 and Gullickson 1995, p. 17). Hence a country that experiences rapid productivity growth through outsourcing and a shift of sectoral production towards higher productivity intermediate goods will find such changes attributed to capital and labour in the value-added measure.

Value-added productivity estimates can thus be expected to be higher than gross output-based estimates, since value-added productivity reflects implicit changes in intermediate inputs. Following Diewert (2001, p. 18), gross output productivity can be written as $Y/(M + L + K)$ and value-added productivity is then defined as $VA/(L + K) = (Y - M)/(L + K)$. In real terms, a productivity improvement of $\Delta\widetilde{Y}$ that cannot be attributed to changes in M, L, K, yields a gross output productivity growth rate of

$$\hat{TFP}_Y = \frac{Y + \Delta\tilde{Y}}{M + L + K} \bigg/ \frac{Y}{M + L + K} = 1 + \frac{\Delta\tilde{Y}}{Y} \tag{9.3}$$

which is less than the real value-added productivity growth rate given by

$$\hat{TFP}_{VA} = \frac{Y + \Delta\tilde{Y} - M}{L + K} \bigg/ \frac{Y - M}{L + K} = 1 + \frac{\Delta\tilde{Y}}{Y - M} \tag{9.4}$$

The smaller denominator in the value-added TFP measure translates into larger TFP growth measure for value added. Comparing the two growth rates, it follows that

$$\hat{TFP}_{VA} = (Y / VA)\hat{TFP}_Y \tag{9.5}$$

Which clearly highlights that value-added productivity is expected to exceed TFP productivity.

Comparisons of gross output and value-added measures of sectoral TFP growth in Germany, confirm this observation:

Table 9.2 highlights several important factors. Interestingly in 18 out of 26 sectors the value-added concept over represents actual output growth. In addition, value-added TFP growth indeed significantly exceeds the gross output productivity measure (in 22 of 26 cases), however, not uniformly so. The last two columns of Table 9.2 indicate the existence of significant differences between the expected ratios of TFP_{VA}/TFP_Y and the estimated ones using the gross output and value-added concept. There exist large differences between the two ratios in just about all sectors. In 17 out of 26 industries the ratio is smaller than one and in nine out of these thirteen industries the ratio becomes even negative, which clearly contradicts the result proposed by the theory in equation (9.5). The two columns provide the first evidence that the assumptions necessary to derive qualitatively (and sometimes even quantitatively) valid statements of industry-level TFP using the value-added concept are too restrictive for the case of Germany. Below we present some analyses for a sample sector to indicate how the omission of intermediate inputs can cause the above described distortions in the value-added concept.

A caveat that must be added to Table 9.2 is, however, that intersectoral comparisons of productivity growth may be distorted because two sectors may share the same productivity growth on a gross output basis, but different rates of productivity growth on a value-added basis. As discussed above, this may occur because the proportion of intermediate inputs in total costs differs in these two sectors. This possibility is demonstrated for several Dutch industries by van der Wiel 1999 and in our data this is highlighted by, for example the German Electrical and Electronic sector and Mechanical Engineering. Both sectors share identical gross output productivities, but differ in their value-added productivity.

Table 9.2 Comparison of gross output and value-added measures, Germany 1993–2001

	Average 1993–2000						
	ΔY	ΔVA	TFP_Y	TFP_{VA}	Y/VA	TFP_{VA}/TFP_Y	$(TFP_{VA}/TFP_Y)/(Y/VA)$
Communications	13.31	9.75	6.41	10.91	3.00	1.70	0.57
Transport Equipment	3.99	0.53	-0.79	-0.02	1.32	0.03	0.02
Financial Intermediation	3.71	2.89	-0.04	3.98	2.69	-99.50	-36.99
Real Estate Activ. and Business Services	3.49	3.81	-1.01	-0.86	1.62	0.85	0.53
Chemicals	3.48	1.84	0.65	3.32	3.53	5.11	1.45
Transport	3.39	3.52	0.57	2.23	1.36	3.91	2.88
Electrical and Electronic Equipment; Instr.	3.29	-0.67	-0.13	1.66	2.44	-12.77	-5.23
Rubber & Plastics	2.42	1.61	0.10	1.67	1.37	16.70	12.19
Electricity, Gas and Water Supply	2.41	1.78	0.08	0.89	7.28	11.13	1.53
Wood & Products of Wood and Cork	1.77	-0.10	0.01	1.47	1.41	147.00	104.26
Basic Metals & Fabricated Metal Products	1.77	0.65	0.27	2.00	2.55	7.41	2.90
Agriculture, Forestry and Fishing	1.45	1.63	0.16	1.89	2.05	11.81	5.76
Non-Market Services	1.44	1.35	-0.51	0.10	2.55	-0.20	-0.08
Other Services	0.77	1.01	-1.33	-1.26	2.20	0.95	0.43
Food, Drink & Tobacco	0.77	1.01	0.13	1.10	2.42	8.46	3.50
Non-Metallic Mineral Products	0.74	-0.18	-0.22	0.76	1.84	-3.45	-1.88
Repairs and wholesale trade	0.41	0.30	-0.62	0.08	2.41	-0.13	-0.05
Retail trade	0.38	1.01	-0.29	0.21	2.35	-0.72	-0.31
Mechanical Engineering	0.24	-0.58	-0.13	1.80	2.41	-13.85	-5.75
Construction	-0.37	-1.61	0.04	0.02	2.67	0.50	0.19
Pulp, Paper & Paper Prod.; Print. & Publ..	-0.40	-1.37	-0.37	0.13	1.62	-0.35	-0.22
Furniture, Miscellaneous Manuf.; recycling	-2.52	-4.16	-1.50	-2.24	2.36	1.49	0.63
Hotels & Catering	-2.68	-1.65	-1.95	-4.31	2.63	2.21	0.84
Textiles, Leather, Footwear & Clothing	-3.47	-4.98	-0.42	0.74	1.82	-1.76	-0.97
Mineral Oil Refin., Coke & Nuclear Fuel	-4.03	4.58	0.59	5.11	2.50	8.66	3.46
Mining and Quarrying	-9.62	-11.16	-2.56	-4.82	3.27	1.88	0.58

Source: Authors' calculations using the Ifo Productivity Database.

Differences in Intertemporal Productivity Trends

The ratio of gross output to value added may vary dramatically according to the characteristics of a sector. This implies that not only average TFP growth rates may differ, but also that intertemporal comparisons of productivity are distorted (Gullickson and Harper 1999b, p. 19). The measures differ intertemporally because the value-added share in gross output changes as the composition between intermediates and capital/labour is altered. This composition is largely affected by outsourcing, as demonstrated by Gullickson and Harper (1999b, p. 18) who emphasized the role of outsourced production abroad by rewriting the relation between TFP_{VA} growth and TFP_G growth in equation (9.5) above as

$$\hat{TFP}_{VA} = (1 + M/VA)\hat{TFP}_Y \tag{9.5'}$$

If sectors increasingly outsource parts of the production process, and intermediate inputs account for an ever increasing share of value added in that sector, value-added productivity will grow ever faster than gross output productivity as a consequence of the outsourcing. Hence on an aggregate level, the differential between value-added productivity and gross output productivity can be seen as a rough measure of outsourcing activity. This outsourcing might be international or domestic. However, in Germany it is tempting to search for effects of outsourcing that are driven largely by international factors.

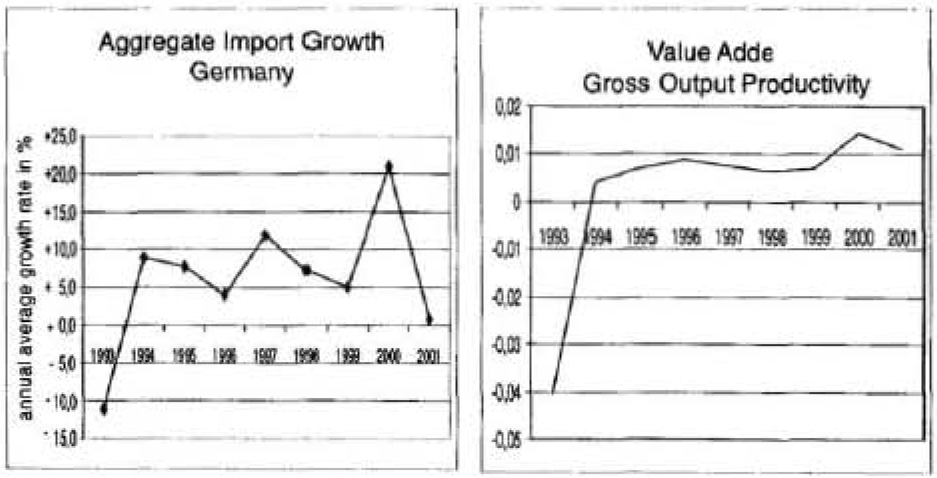

Figure 9.1 Comparison imports and TFP_{VA}/TFP_Y, 1993–2001

The graphs in Figure 9.1 nicely highlight the differences between the value-added and gross output productivity measures. First, the ratio of the two measures reflects the upward trends in imports between 1993 and 2000 in Germany. As outsourcing falls after 2000 (value-added TFP actually drops below aggregate TFP in 2001) possibly due to the large contraction of the construction industry, which constitutes a large share in German output, imports followed suit.

Figure 9.1 also shows that the intertemporal rate at which value-added productivity overestimates gross output productivity is largely stable; around one per cent on the aggregate level. This stability coincides with a tie of relatively stable import growth between 1994 and 2000. However, variations in imports are immediately reflected also in the amount by which value-added TFP overstates gross output productivity, as seen in 1994 and 2001.

Finally it is the contribution of any given factor to growth that is most severely distorted by the value-added measures. If we abstract from intermediates in the study of productivity growth, all improvements in productivity growth that actually arise through outsourcing or intermediate productivity growth are instead attributed to capital and labour. Several sectors, such as finance and computer services, rely heavily on the growth of intermediate inputs' efficiency. Indeed the entire R&D based literature has generated a cottage industry of models that rely on productivity increases generated by the intermediate inputs. In addition, any improvements in productivity in intermediate supplying industries may contribute to improvements in productivity in the downstream sector in several ways. Suppliers might increase output quality without changing inputs used and downstream firms might benefit from such quality improvement in the form of increased productivity (presuming the changed quality is not fully compensated for by price changes).

For the US, Jorgenson et al. (1987) and Jorgenson and Stiroh (2001) show that intermediate inputs are the predominant source of output growth at the sectoral level, exceeding both productivity growth and the contributions of capital and labour in the large majority of industries. The estimates prepared by Oulton and O'Mahony (1994) for the UK show that input growth explains a much higher proportion of productivity growth according to the gross output estimates than in the case of the value-added estimates. The same is true in the German data here.

9.4 THE IFO PRODUCTIVITY DATABASE

Our data is derived from the German Productivity Database that is currently being assembled at the Ifo Institute. At this point the database covers 52 sectors between 1991 and 2001, the associated capital stocks, asset types, prices, depreciation rates and labour, in 1995 and current prices. Currently this database is being expanded to cover 1960–2001. The Ifo Productivity Database allows for sector- and asset-specific price deflators in a growth accounting study for Germany.

Primary data on real and nominal output, value added and intermediates input data is obtained from the National Accounts statistics of the German Statistical office. The German Statistical Office classifies this data according to a 'Systematik der Wirtschaftszweige' (WZ 93) system, which is based on the NACE Industry Classification.[1] The source of the capital stock data is the *Ifo Investorenrechnung Database*, which augments German Statistical Office investment-series with Ifo survey data for 52 sectors and eleven investment assets/services.[2] The great advantage of the capital stock data in the Ifo Productivity Database is thus its reliance on sectoral capital stock and sectoral investment distributions data. Depreciation rates are survey based Germany-specific, industry-specific and asset-specific and are, according to our knowledge, unique and for the first time employed in a growth accounting study for Germany.

The capital stock is then calculated using the perpetual inventory method:

$$S_{i,j,t} = S_{i,j,t-1} + \left(1-\delta_{i,j}\right)I_{i,j,t} \tag{9.6}$$

where S is the capital stock, I is investment, δ is a constant depreciation rate, and the subscript j, refers to the asset type.[3] The Ifo Investorenrechnung Database permits the calculation of capital stock data for each investment type in each sector without restricting assumptions regarding investment distributions (e.g. a uniform distribution across industries and investment types) that are usually necessary in the literature.

Investment data is also taken from the Ifo Investorenrechnung Database, which recalculates data from the German Statistical Office using Ifo survey data, and the Ifo Investitionstest. The Ifo Investorenrechnung Database thus provides industry-specific investment distributions that establish a unique link between the economic use of an investment asset and its statistical classification.[4]

The Ifo Productivity Database employs the Jorgenson and Stiroh (2001) method of calculating the capital services flow over a given period, rather than the capital stock in this period. Capital services flows are assumed to be proportional to the average capital stock available at the beginning and end of a given period:

$$K_{i,j,t} = q_{i,j}\frac{\left(S_{i,j,t} + S_{i,j,t-1}\right)}{2}, \tag{9.7}$$

where q denotes a constant of proportionality. The aggregate capital flow data is based on disaggregated sectoral data for each asset.

Currently the investment price deflators used to value the capital stock are obtained from the German Statistical Office. However, the Ifo Productivity Database is currently expanded to include quality changes based on the US Bureau of Labor Statistic hedonic price indices. Preliminary calculations using the US hedonic price deflators for ICT-investment indicate that the differences resulting from the use of hedonic price deflators are small.

The quantity of the capital services flow over a given period is given by a rental price formula

$$\left(1+r_t\right)P_{i,j,t-1} = c_{i,j,t} + \left(1-\delta_{i,j}\right)P_{i,j,t} \tag{9.8}$$

which assumes investors are indifferent between a rental fee c, and a return on the capital market with nominal interest rate r_t.[5] In order to decrease the impact of cyclical fluctuations in the calculations of the capital services flow, we employ a 5-year moving-average smoothing method.

The rental arbitrage equation yields the familiar cost of capital equation:

$$c_{i,j,t} = \left(r_t - \pi_{i,j,t}\right)P_{i,j,t} + \delta_{i,j}P_{i,j,t} \tag{9.9}$$

where the industry and asset-specific capital gains are given by

$$\pi_{i,j,t} = \left(P_{i,j,t} - P_{i,j,t-1}\right) / P_{i,j,t-1} \tag{9.10}$$

The cost of capital equation includes expected capital gains of assets, which may differ across industries. The specification allows for both industry and asset specific price differences. The advantage of industry and asset specific investment pricing is that this method restricts investment-price-deflators to a lesser degree and hence delivers more realistic and appropriate results compared to other methods.

The Ifo Productivity data also contains data on labour inputs derived using the Jorgenson and Stiroh (2001) methodology (which is similar to the capital stock methodology). Labour input data are obtained from the German Statistical Office data, which contains information on wages and total hours worked.[6] For now the dataset includes labour quality data from the Groningen Growth and Development Data.[7]

Labour services flows are assumed to be proportional to total hours worked:

$$L_{i,t} = q_{i,t}H_{i,t} \tag{9.11}$$

where $H_{i,t}$ are total hours worked in industry i in period t and $q_{i,t}$ is a constant of proportionality. This methodology is similar to the one implied by Steindel and Stiroh (2001) and assures comparability with other growth accounting studies for Germany.

9.5 EXPLANATION OF KEY INDUSTRIES

A prime example of the differences between the value-added and gross productivity measures is the manufacture of vehicles (the transport equipment sector), which has always been uniquely dependent on complex subcontracting networks. Since the introduction of lean-management and just-in-time production the mid-1980s, the industry has created structures of legally independent companies that are closely related along the value-added chain. First-tier system-suppliers are know-how driven companies with a direct access to the major auto manufacturers. Then follow several layers of part and component suppliers that may or may not reside in the sector's classification.

During the second half of the 1990s, the dissemination of ICT technologies provided an additional stimulus to specialize production among subcontracting companies. E-business has become particularly important in this sector, although mostly for commodities and not for key car parts and components. The impact of the automotive production networks on growth and on productivity can be discussed on two levels. We can examine first the rise of efficiency as a result of specialization and subsequent reduction of transaction costs in addition to the reduction of labour costs due to outsourcing; and secondly, the scope of R&D in the growth and productivity of the automotive industry. The latter point is key to the understanding of the differences in the TFP concepts.

Value added in the automotive industry as defined by the European nomenclature group 34 (NACE Rev. 1) comprises the manufacture of engines, car bodies, drive trains etc. However, a number of parts that are destined to be assembled (such as wind-screens, plugs etc.) have never been part of the automotive industry production. These products are intermediates that are taken into account only in TFP_Y but not in the TFP_{VA} concept. As long as there are no changes in the automotive industry structure, technology and its upstream linkages within the production network, both concepts should provide intertemporally comparable results that differ only in levels.

Two major developments have, however, affected upstream linkages: innovation and outsourcing. Both activities induced a reduction of the manufacturing penetration. As measured by the share of value added on total gross-output, manufacturing penetration contracted dramatically between 1993 and 2001.

Technological progress led to the development of a broad range of new components that are indispensable in the modern car. Most of these elements are not manufactured by the automotive industry, e.g. anti-blocking systems and traction control (ABS, ASR), air bags, air-conditioning. These intermediate inputs receive an ever higher share in the total value of a car and have become important to the continued growth in the demand for vehicles. Gross-output has been stimulated by this development, whereas the value added cannot account for this increase over the period under investigation.

Outsourcing to subcontractors has long been a priority in the automotive industry. This trend has been driven by economies-of-scope and price differentials in factor inputs. Beyond the opportunities provided by the advanced ICT, the creation of the Single Market and the accession of CEE countries have also contributed to cross-border outsourcing. Generally speaking, these activities induce cost reductions based on automotive companies' decisions to make-or-buy. In real terms, the relocation has, *ceteris paribus*, the same impact on the TFP_Y and TFP_{VA} whenever companies shift abroad their capacities without friction. If factor markets are not perfectly flexible, however, TFP will be a negative during the adjustment period. This negative dip will be more pronounced for the TFP_{VA} concept.

9.6 CONCLUSIONS

The OECD Productivity Manual (2001, p. 10) states that the choice between productivity measures depends in part on the purpose of the productivity measure. In principle, the value-added and gross output-based measures are measures of two different concepts. We construct and employ a novel Ifo Productivity Database construct to allow the analysis of gross output productivity in Germany. We then compare sectoral productivities with exiting value-added measures in the literature.

The OECD (2001, p. 27) concludes that each measure has its place, depending on the standpoint adopted. Our results suggest that gross output and value-added based TFP measures are useful complements. Both follow roughly the same trend on the aggregate, although they do diverge significantly on the sectoral level. When technical progress affects all factors of production proportionally, the value-added measure is the simpler measure of technical change. Generally, the gross output-based TFP measure is less sensitive to situations of outsourcing, i.e., to changes in the degree of vertical integration between sectors. Value-added based TFP measures are contaminated by changes in outsourcing and provide an indication of the importance of the productivity improvement for the economy as a whole.

NOTES

1. For a small part of the output and intermediates real sample data is not available. In these cases the Ifo Productivity Database estimates real values using value-added data and the available data on the next higher aggregated level. This is the case for some manufacturing and service sectors. The estimation method guarantees consistent estimates of the sectoral and aggregate TFP. The estimates are also checked against current price data to avoid estimation biases.
2. The Ifo Productivity Database follows the procedures of the German Statistical Office to account for German reunification.
3. The depreciation rates refer to their economic use and not to tax-based depreciation rates.
4. The Investorenrechnung is less prone to misclassifications on the industry level due its use of an ownership-based statistical classification concept rather than an economic usage-based concept. The main difference between these concepts is that assets and investments of leas-

ing or other financial companies, not involved in the production process, are classified to the industry which has the economic use of the asset.

5. The use of the nominal interest rate rather than the ex-post rate of return is based on Steindel and Stiroh (2001).
6. Total hours worked over time are disaggregated data whenever possible. For 29 industries, only an aggregate data on the next higher industry level was available, so that the industry-specific total hours were estimated. Here it was assumed that sub-industries had the same change in hours as the lowest available industry level classification.
7. The Ifo Productivity Database is currently being expanded to include Jorgenson and Stiroh (2001) labour quality data. Please refer to www.ggdc.net for more information on the calculation of labour quality.

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