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The Impact of Introducing New Products on Firm Productivity: Evidence from German Manufacturing

Working paper nr. 32

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The impact of introducing new products on firm productivity.
Evidence from German manufacturing firms

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Abstract

Globalization offers new challenges for manufacturers to flexibly adjust their product range to the ever changing patterns of demand and technology. Introducing new products is a primary measure to capitalize on new market opportunities and to temporarily earn quasi-monopolistic rents (Penrose 1959; Chandler 1978).

Empirical research on the impact of new products on firm performance suffers from the lack of a generally accepted definition of what constitutes a “new” product. Some researchers rely on the (self-) assessment of firms whether they have introduced a new product (Peters 2008). An alternative way to observe and study the introduction of new products at the firm level is offered by the firm census system of official statistics. Statistics Germany asks manufacturers in its “Production census“ to classify their output according to the European PRODCOM-list, which includes about 6000 products. We have matched this output information firm-by-firm to information on manufacturers‘ performance from the „Cost census“, yielding a data set of roughly 7700 manufacturing firms observed between 1995 and 2001. We use the combined information on their product range, gross value added and employment to study the impact of changing the product range on productivity and performance (Görzig/Gornig 2007).

To separate the impact of product policy from those of other determinants of productivity we employ a decomposition approach suggested by Nopo (2004) as a nonparametric extension of the widely-used Oaxaca-Blinder decomposition (Blinder 1973; Oaxaca 1973). We decompose the observed “raw” productivity differences between modifiers and non-modifiers of the product range into a “structural“ and a “behavioural“ component. The former contains the part of the raw difference attributable to the different composition of modifiers and non-modifiers with regard to employment size and sector. The latter is the “pure” productivity difference between modifiers and non-modifiers of comparable size and sector.

We find that almost 30% of all firms introduced at least one new product into their product range between 1995 and 2001. These modifiers enjoyed an average productivity advantage in 2001 of 13% over non-modifiers. The data also shows a much higher variance of observed productivity among modifiers, pointing to the risk involved in this strategy. While some firms do reap the intended above-average rent, numerous other firms don’t – either because of a (temporary) loss in efficiency from readjusting production (Montgomery 1985) or because the new products failed to find a market.

Contents

List of Tables

List of Figures

1 Research objectives

Although the issue of diversification and specialisation is an elementary part of economic theory, there is a relatively limited amount of empirical knowledge about the role that product diversification plays in Germany. In particular, the objective of this paper is to find out what effect product diversification has on the success of firms. This paper is using a representative set of data made up of official governmental micro data on firms to investigate the degree of product diversification in Germany and to draw initial conclusions on the relationship with firm-specific profits.

2 Theoretical background

2.1 The importance of product innovation

Economic theory supposes that one of the central ways a firm can increase its profits is to gain advantages over its competitors. The literature on industrial organisation suggests that, along with cost-focused strategies, one vital factor is the strategies that firms adopt in their product markets. By offering new products and, as a result, opening up new markets, a firm can achieve quasi-monopolistic profits, for as long as its competitors do not have access to these markets.

Several factors make it difficult to carry out empirical studies on the relationships between this type of market development and firm success, including the fact that there is no generally accepted statistical definition of new products. As such products are unknown per se before they are created, it is not normally possible to differentiate them ex ante so as to allow them to be classified in a meaningful way. Questioning firms on the importance of new products is problematic because the term 'new' can be interpreted in a variety of different ways. The so-called 'growth impulses' supposedly provided by spurious innovations in centrally planned economies are well known (Lippe 1996).

On the other hand, the academic community is probably in agreement that the statistical recording and analysis of products that are already known tends to underestimate the actual dynamics of economic activities. This is shown by the discussion, after the release of the report by the Boskin Commission, on how to properly take the new economy into account (Boskin et al. 1996). If new products are not recorded, it is often impossible to explain the success of firms; in addition, the growth dynamics of the economy as a whole is underestimated.

Firms do not open up new markets solely by creating products with completely new characteristics. In general, the focus of the theoretical literature is on analysing single-product firms, as this is a way of creating a simplified model. However, existing firms generally have product ranges that differ in their extent (wide or narrow ranges of products). Innovative behaviour by firms can be described in terms of the extent and, in particular, the dynamics of their product diversification. In this sense, we do not ask for technological new products, which are new for the market, but for products, are new for the firm. Therefore, in multi-product firms, product innovations are always linked to changes in the product diversification.

Representative empirical research is needed to identify the strategies that, for the majority of firms in Germany, actually have a positive influence on their success and to identify the conditions that have to be taken into account. In reviewing the available findings based on German data, it must be remembered that the term 'product diversification' can be defined in different ways. The broadest definition refers to a strategy, pursued by large corporate groups, of changing the group's overall structure by purchasing or merging individual firms, without reference to the existing product range (lateral diversification). One reason for doing so is often to minimise risk.

When speaking about diversification in relation to product innovations, it would make sense to define the term more narrowly. This paper focuses on the smallest legal unit, i.e. the firm (the enterprise unit) as a decision-maker. Thus, we examine more closely technical production-related strategies of product diversification. The goal is to analyse the importance of new products the firm adds to its range that are linked to the existing product range (horizontal and vertical diversification).

2.2 Determinants of diversification

Ever since Adam Smith used the example of a pin factory to demonstrate the advantages of specialisation, it has been part of standard economic thought that labour specialisation increases efficiency and productivity, and thus increases overall wealth. However, empirical reality is often shaped by business behaviour that seems to strive for the opposite of specialisation, i.e. increased diversification. As the advantages of specialisation in an economy characterised by the division of labour are seen as an important foundation of economic thought, theoretical explanation of the phenomenon of diversification requires additional assumptions.

Research into industrial economy has developed a large number of explanations why, despite the fundamental disadvantages, diversification can be advantageous for firms. For example, theorists emphasise economies of scale (Kim 1985) in multi-product firms. Other studies make reference to ‘economies of scope’ in the sense that synergy effects are created when producing goods, either during the process through the use of common resources, or in marketing them (Markides/Williamson 1996). Matsusaka (2001) presents a similar argument, pointing to firm-specific skills that can make it profitable to take up additional activities if the existing ones are not creating sufficient levels of profit. This, he suggests, is more profitable than abandoning unprofitable activities altogether.

Hall (1995) reports on a range of empirical studies that identify a positive relationship between the extent of diversification and the success of a firm. However, the author notes, the number of studies concluding that there is a negative relationship tends to be higher.

In this context, it is suggested that diversification is not the reason for but the result of business success or lack of success. This can explain both how high levels of profit lead to increased diversification and the reverse. Hall (1995) shows that diversification has increased in particular in firms that are less successful than the average.

It can be demonstrated that in the event of monopolistic markets, vertical integration increases efficiency (Williamson 1979). There are various explanations for the trends towards horizontal diversification that may be observed. The explanations can be classified both as output-related and cost-related. The reasons given by Jovanovic/Gilbert (1993) why, despite the undisputed advantages of specialisation, diversification is a better strategy from the firm’s point of view, can mainly be assigned to the output side:

- gaining additional power in the market,
- risk avoidance and
- increasing product compatibility,

while explanations on the cost side include

- improved opportunities for financing and
- efficiency gains created through economies of scope.

Stigler (1951) suggested that the advantages of diversification for firms resulted mainly from the limited nature of markets. Increased growth in markets – whether through higher productivity or through easier trade – would thus be linked to increased specialisation by firms. This may also explain why assessments of the effect of diversification by firms on their profits are subject to change. For many years, diversification was regarded as the key to success. It is only in recent years that concepts such as ‘outsourcing’ and ‘focusing on core competencies’ have become established.

2.3 Existing empirical findings

The variety of different reasons for diversification makes it clear that the term can be interpreted in a narrow or broad sense. Correspondingly, attempts to provide empirical evidence for specialisation or diversification strategies vary greatly. The most general theories focus on attempts by corporate groups to change the overall structure of the group through buyouts and mergers. The main concern here is risk minimisation.

However, even when limited to analyses that examine changes in product diversification within firms as the smallest decision-making unit, the empirical findings are ambiguous. The main reason for this is that many of the existing studies are based on a fairly small number of firms, normally large corporations. As such, the results achieved depend to a large extent on the specific conditions of the sample chosen.

There is a fairly limited number of representative empirical studies on firms’ product diversification. Gollop/Mohanan (1991) used a large dataset to investigate diversification processes in the US between 1963 and 1982. There is a more recent study for Canada, based on the census of manufacturing for that country (Baldwin et al. 2002).

Jovanovic/Gilbert (1993) note with reference to a number of different authors that, at least for the US, most of the twentieth century was characterised by increasing diversification by firms. However, towards the end of the century, from about 1980 onwards, a decrease in diversification could be observed (Gollop/Monahan 1991).

The degree of specialisation, and whether there were changes towards increased or decreased product diversification, depends to a large extent on the sector under examination. In addition, empirical studies on diversification have identified a positive relationship between the size of the firm and the extent of diversification (Jovanovic/Gilbert 1993; Berry 1975; Gort 1962). The trends towards specialisation or diversification identified for individual economies or regions are thus also determined by the composition of the economy in terms of sectors and firm sizes.

3 Measuring diversification

In the literature, a variety of concepts for measuring specialisation and/or diversification at product level are discussed (Fan/Lang 2000). The most straightforward category-based measurement normally used involves measuring the number of products produced by a firm. However, this is a very approximate measure as each product is weighted equally for the analysis. It is very unlikely that all multi-product firms distribute their activities equally across all products. It is probably much more often the case that the firm's area of activity includes one major product and a large number of less important products.

Thus, a measurement whereby products are weighted is more useful. One way of creating this weighting is to use the amount of overall firm turnover contributed by each individual product. Established methods of measuring concentration, such as the Herfindahl index, are thus often used in studies on product diversification.

Along with these traditional methods, studies on product diversification increasingly make use of entropy measures as indicators of the degree of specialisation or differentiation of a product range. Entropy measures meet almost all the requirements listed by Gollop/Monahan (1991) for an ideal measure to determine the degree of specialisation or diversification by a firm. In particular, they have specific formal characteristics with regard to additivity, as they can be broken down into various components (Jacquemin/Berry 1979). This allows the values of the entropy parameter to be added together for different levels of aggregation.

Entropy measures are used in a variety of different scientific contexts. In the present study, one specialised variant, the 'numbers equivalent' entropy measure, is particularly helpful. If the products in a multi-product firm all have the same weighting, the numbers for equivalent entropy measure returns exactly the value of the number of goods produced by the firm. Where diversification is greatest, this measure will correspond exactly to the number of products manufactured. However, if the weighting differs, the numbers equivalent entropy measure will normally be lower than the number of products, but always higher than one. In other words, the more a firm's activities are concentrated on a single product, the more the diversification indicator moves towards a single-product firm. In addition, representing product variety for firms with a very large product range is facilitated by using a numbers equivalent entropy measure. For this reason, in the analysis below we use the numbers equivalent entropy measure (E) alone to measure the level of product diversification in a firm.

$$E(s) = exp\left(\sum_{i=1}^{N} s_i \, ln(1/s_i) \right)$$

$s_i =$ Sales of product *i* as a share of the sales of all products recorded for the firm

4 Data

4.1 Sources

The establishment of the Research Data Centres (FDZ) in Germany has made it possible to evaluate official statistics microdata (Zühlke et al, 2003; Wagner 2005). For this study, data from the statistics of the producing sector was evaluated for the first time, with two different statistics being linked together at firm level. A longitudinal dataset for firms in the manufacturing sector in the period 1995 to 2001 is used. As the industrial classification scheme was comprehensively revised in 1995, the official statistics available for this period include microdata for firms in the manufacturing sector collected according to a standardised scheme.

The statistical census system on the manufacturing sector in Germany are relatively well developed. In general, the firms[1] in question are fully covered. Units required by law to provide reports for these statistics include all firms with, generally, 20 employees or more. The data collection system consists of several consistently linked separate data sets on different

[1] We use the expression "firm" and the statistical definition "enterprise" synonymously.

topics. Two of these data sets, the production census and the cost structure census are used here in order to determine product diversification.

The *production census*[2] includes questions about the quantity and value of the products manufactured. This study focuses on production for sale. Intermediate products and allocated labour are not included. The census is directed at the respective production plants (establishments) of the firm, meaning the local units of the firms (enterprises). These plants can completely be assigned to the relevant firms. Details on the quantity and value of all 6,400 products[3] listed are taken from the quarterly census, which has for the purpose of this paper been aggregated to annual figures. The present study is based on GP 95, i.e. the 1995 edition. For each firm, the details from the production census have been combined with the information from the cost structure census. This makes it possible to include the number of employees for each firm as well as their production range (Görzig et al. 2007).

The *cost structure census* is conducted annually. It records data on approximately 18,000 reporting firms. It is a full census of all firms with over 499 employees. For all other reporting units, it consists of a representative rotating sample with panel properties. The random sample quota for firms with 20 to 249 employees is 38 percent, and 73 percent for firms with 250 to 499 employees. The present study is based solely on the census values. No projection has been made.

The use of the production census involves a narrower definition of the concept of diversification. The analysis is based on the smallest legal unit, the firm, as the decision-maker. It is therefore orientated more towards the diversification strategies relevant to the product market. Consequently, activities towards specialisation and/or diversification by large corporate groups, through purchases and sales of individual firms, are not observed here. The restriction of the study to production by firms means that the diversification applies to products connected to the existing product range (*related products*).

In order to understand what kind of diversification is measured here, the way in which products are classified is important. When statistical product classifications are used, as is the case here, physical classification criteria are normally employed to differentiate the products.

[2] Here production plants, the local sites of firms in the manufacturing sector with at least 20 employees are obliged to report. If the main focus of the owning firm's activity is not in the manufacturing sector, the corresponding plant in manufacturing must have at least 20 employees. There are different cut-off points for small-scale sectors (German Federal Statistical Office 2005).

These do not reflect demand-oriented adaptation of the products through slight changes of details of fittings or cognitive product properties, for example, those conveyed through advertising. Thus, not all economically relevant product diversification can be recorded by means of statistical product classifications. Nevertheless, the degree of detail of the physical product differences observed tends to be very high in official statistics. The production census conducted in Germany in accordance with the PRODCOM Regulation differentiates between more than 6,400 products.

4.2 Firm types and diversification

The strong positive correlation between product diversification and firm size reported for the US and Canada in various studies (Jovanovic/Gilbert, 1993; Baldwin et al., 2001) also applies to Germany (Görzig/Gornig 2007). The correlation coefficient between the firm size, measured according to the number of employees and the number of products, is 0.507 for all firms. For multi-product firms, it is not much higher at 0.515.

Table 1: Diversification according to size classes (all firms), 1995 – 2001

Employed persons from....to....	Firms 1000	Plants	Products	Entropy units[1]
		per firm		
20 - 49	32.94	2.7	2.7	1.8
50 - 99	25.72	3.0	2.9	1.9
100 - 199	19.95	3.6	3.4	2.1
200 - 499	15.68	4.7	4.3	2.4
500 - 999	6.74	6.6	5.6	2.9
1000 - 4999	4.09	11.1	8.7	3.8
5000 and more	0.42	58.8	40.2	11.4
Total	105.53	4.0	3.7	2.2

[1] Numbers equivalent entropy: Is usually smaller than the number of products of a firm, except in the case that all product specific sales have the same value.

Sources: Forschungsdatenzentrum der Länder; Calculations of DIW Berlin.

It would, however, be jumping to conclusions to surmise from this that the degree of specialisation in firms generally decreases with size (Table 1). A severe disadvantage of product diversification can be the possibility that firms with several products at the same time also have to use several production processes and thus only achieve below average economies of scale effects. In a borderline case, a firm might use a separate production process for each

[3] Corresponding to the Product Classification for Production Statistics (GP).

product. Essentially, it is then no longer a question of a single production unit but a plurality of production units combined under the formal umbrella of a firm. In such a case, even larger firms might not profit from size-specific scale effects linked to the division of labour. Efficiency gains are then only possible through inter-process cost-related synergy effects, *economies of scope,* if the same expenditure is of benefit to several production processes.

The answer to the question of whether product diversification also means process diversification may be gauged by the extent to which a firm's products are manufactured by different production plants, i.e. the local units of a firm. The empirical review shows a strong link between the number of local units and the number of products per firm. The correlation coefficient is 0.92 for both all firms and multi-product firms.

If the average number of products produced by an enterprise is not related to the firm but to its local units, then it can be clearly seen that larger firms tend to produce fewer products per local unit than small and medium-sized enterprises (Table 2). For a firm size of 100 or more employees, the number of firms increases where a product is manufactured by more than one production plant.

Table 2: Product and process diversification (all firms), 1995 – 2001

Employed persons from....to....	Products per	
	Firm	Plant
20 - 49	2.7	1.0
50 - 99	2.9	1.0
100 - 199	3.4	0.9
200 - 499	4.3	0.9
500 - 999	5.6	0.8
1000 - 4999	8.7	0.8
5000 and more	40.2	0.7
Total	3.7	0.9

[1] Numbers equivalent entropy: Is usually smaller than the number of products of a firm, except in the case that all product specific sales have the same value.

Sources: Forschungsdatenzentrum der Länder; Calculations of DIW Berlin.

Thus, a cross-sectional comparison for the German manufacturing industry confirms findings for the US by Gollop/Mohanan (1991) that increasing diversification by firms normally goes hand in hand with specialisation by the production plants. Also, for the average firm, the number of products manufactured per local unit is less than one. Multi-product production plants are, unlike multi-product firms, relatively rare in the German manufacturing sector[4]. In this respect, the corporate landscape, and/or that of the local units, differs considerably from the Canadian one. Baldwin et al. (2001) ascertained three products per local unit on average in Canada in the mid-nineties.

In addition to the size of the firm, the type of product manufactured also influences product diversification. Table 3 demonstrates that the number of products per firm can vary greatly depending on the sector of the firm. This ranges from 3.3 for leather products to 10.8 for chemical products (including coke). There exist product range sizes typical of each sector[5]. However, if the entropy units are calculated according to sector, the differences in diversification between the sectors measured with variation coefficients become significantly smaller. Even sectors with a typically high number of products have only a small number of key revenue-generating products for the most part.

Table 3: Diversification according to sector (multi-product firm), 1995 – 2001

Main production	NACE Code	Number of firms in 1000	Employed persons	Plants	Products	Entropy units[1]
			per firm			
Mining and Quarrying	10-14	1.03	702	6.8	4.1	2.5
Food Products, Beverages and Tobacco	15-16	11.24	210	6.5	5.8	3.1
Textiles and Textile Products	17-18	4.63	155	5.7	5.5	3.1
Leather; luggage, handbags, saddlery, harness and footwear	19	0.46	144	3.4	3.3	2.1
Wood and of products of wood and cork, except furniture; etc.	20	1.82	143	3.8	3.7	2.1
Pulp, paper and paper products, publishing, printing	21-22	4.94	263	4.3	4.1	2.3
Coke and chemicals	23-24	4.19	660	12.2	10.8	4.3
Rubber and plastic products	25	3.55	332	5.2	4.8	2.7
Other non-metallic mineral products	26	4.06	238	5.1	3.9	2.4
Basic metals, fabricated metal products	27-28	9.73	267	4.5	4.2	2.5
Machinery and equipment n.e.c.	29	10.72	362	5.0	4.8	2.7
Electrical and optical equipment	30-33	6.86	519	5.3	4.7	2.6
Transport equipment	34-35	2.51	1 204	4.7	4.3	2.3
Manufacturing n.e.c; recycling	36-37	3.40	178	4.1	3.9	2.4
Total	Total	69.14	347	5.6	5.1	2.8

[1] Numbers equivalent entropy: Is usually smaller than the number of products of a firm, except in the case that all product specific sales have the same value.

Sources: Forschungsdatenzentrum der Länder; Calculations of DIW Berlin.

Since the systems are not directly comparable, any comparison of the findings for Germany with those for Canada (Baldwin et al. 2001) can only give a rough assessment. The compari-

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[4] Multi-product firms in the German manufacturing sector are in the majority of cases also multi-plant firms.

[5] It must be taken into account, however, that the strongly aggregated tabular comparison used here for reasons of data protection can only reflect the actual differences to a limited extent.

son is limited not only by certain incompatibilities on the respective (SIC or NACE) 2-digit level, but also by the different number of possible products within the respective 2-digit level and different product classifications. Nevertheless, as **Error! Not a valid bookmark self-reference.** shows, in addition to the above-mentioned differences in level, there are also structural differences in the degree of diversification of German firms in comparison to Canada. German firms are more diversified than Canadian ones as far as investment goods are concerned, while firms producing consumer goods tend to have a smaller product range in Germany.

Table 4: Diversification in Germany and Canada (multi-product firms)

Main production	NACE	SIC	Germany 1995 - 2001	Canada 1993
	Code		Entropy units[1]	
Food Products, Beverages and Tobacco	15-16	10-11	3.1	2.7 - 3.6
Leather, Textiles and Textile Products	17-19	17-24	5.3	2.4 - 4.4
Wood and of products of wood and cork, etc.	20	25-28	4.0	2.9 - 6.6
Chemicals a.o.	23-24	36-37	4.3	4.5 - 5.1
Rubber and plastic products	25	15-16	2.7	2.1 - 2.4
Basic metals, fabricated metal products	27-28	29-30	2.5	2.2 - 2.5
Machinery	29	31	2.7	2.5
Electrical and optical equipment	30-33	33	2.6	2.3
Transport equipment	34-35	32	2.3	2.3

[1] Numbers equivalent entropy: Is usually smaller than the number of products of a firm, except in the case that all product specific sales have the same value.

Sources: Forschungsdatenzentrum der Länder; Calculations of DIW Berlin.

For more in-depth studies, instead of a static comparison of firms with different degrees of diversification, it is useful to analyse the dynamics of the diversification processes in more detail. The question arises of how the degree of diversification of firms has developed longitudinally. In order to be able to answer this, of all the firms examined, only those for which it was possible to ascertain data for both 1995 and 2001 have been selected.

Table 5: Comparable firms, 1995 and 2001

Item	Dimension	1995	2001
Firms			
Total	Number	16 156	15 176
Comparable firms	Number	7 736	7 736
Other firms	Number	8 113	6 971
Employed persons			
Total	1000	5 081	4 720
Comparable firms	1000	3 469	3 355
Other firms	1000	1 613	1 365

Sources: Forschungsdatenzentrum der Länder; Calculations of DIW Berlin.

Only half of the 15,000 firms included in the annual census, i.e. around 7,400 firms, could be analysed. The other firms were either not producing throughout the entire period or were only included in the random sample of the cost structure census in one of the two years in question. The remaining *comparable firms* exhibit a strong selection bias. They are predominantly larger firms. Measured according to number of employees, they still comprise 63 % of overall employment in the reporting units of the cost structure census.

Table 6 clearly demonstrates that there are considerable differences between firms that changed their number of products compared to firms that made no changes to their product range. In contrast to the diversifying firms, those with higher specialisation dynamics were producing 30 % more products (7.7) at the beginning of the period of observation. The large difference between the number of products and the numbers equivalents of the entropy measure also clearly demonstrates that in these firms a relatively substantial share of the products do not contribute significantly to their turnover.

The findings show that increased specialisation still leads to an above-average degree of diversification. In 2001, the number of products was more than twice as high as that of firms that did not change their product range, and in any case significantly lower than for firms that diversified. Those that specialised also reduced the number of local units just as drastically as the number of products. Reduction of production plants and increasing specialisation are accompanied by a decrease in employment in these firms[6].

Despite the fact that diversifying firms expanded their product ranges, they also showed increased specialisation. Although the number of products increased by 2.5, additional products only made a minor contribution to higher turnover. The increase in entropy units was only 0.7. Firms that expanded their product range achieved higher productivity and a higher operating surplus than firms without product variation. Compared to firms with greater specialisation, the increase was significantly smaller. The number of production plants increased even more dramatically than the number of products. Employment expanded in the majority of these firms. As far as both value added and employment are concerned, diversifying firms had

[6] For a more in-depth evaluation, it must be taken into account that the reduction of a high degree of diversification for these firms does not necessarily indicate an economic deglomeration process. Instead, the increased specialisation of the firms studied may be accompanied by outsourcing production processes to other firms.

significantly higher growth than other firms analysed. This confirms findings from other sources (Berry 1975; Jacquemin/Berry 1979) which show that there is a close correlation between diversification and growth of firms.

Table 6: Diversification dynamics of comparable firms

Item	Dimension	Comparable firms[2]			
		Total	No product change	Reduction of products	Increase of products
Firms	Number	7 736	4 984	1 701	1 051
1995					
Plants	Number	36 848	14 240	15 325	7 283
Employed persons	mill.	3 469	1 147	1 710	612
Plants	Per firm	4.76	2.86	9.01	6.93
Employed persons	Per firm	448	230	1 005	582
Products	Per firm	4.10	2.62	7.43	5.71
Entropy units[1]	Per firm	2.29	1.80	3.36	2.89
Gross value added	1000 € per employee	47.88	47.14	49.28	49.13
Gross operating surplus	1000 € per employee	9.62	10.51	7.03	9.57
Gross operating surplus	Per 100 € sales	6.04	6.84	3.93	5.65
2001					
Plants	Number	35 396	14 340	10 648	10 408
Employed persons	mill.	3 355	1 176	1 543	636
Plants	Per firm	4.58	2.88	6.26	9.90
Employed persons	Per firm	434	236	907	605
Products	Per firm	3.92	2.62	5.06	8.26
Entropy units[1]	Per firm	2.19	1.76	2.63	3.53
Gross value added	1000 € per employee	58.81	56.45	64.09	61.48
Gross operating surplus	1000 € per employee	15.22	15.16	15.34	15.28
Gross operating surplus	Per 100 € sales	8.33	8.85	7.21	7.71
Changes					
Plants	Number	-1 452	100	-4 677	3 125
Employed persons	mill.	-114	28	-166	24
Plants	Per firm	-0.19	0.02	-2.75	2.97
Employed persons	Per firm	-15	6	-98	23
Products	Per firm	-0.17	0.00	-2.36	2.55
Entropy units[1]	Per firm	-0.10	-0.05	-0.73	0.64
Gross value added	1000 € per employee	10.93	9.31	14.81	12.36
Gross operating surplus	1000 € per employee	5.60	4.65	8.32	5.70
Gross operating surplus	Per 100 € sales	2.30	2.01	3.28	2.06

[1] Numbers equivalent entropy: Is usually smaller than the number of products of a firm, except in the case that all product specific sales have the same value.- [2] Firms, which reported 1995 and 2001.

Sources: Forschungsdatenzentrum der Länder; Calculations of DIW Berlin.

If firms with new products are compared with firms opening new production plants, there is a high degree of overlap. Of the 1,035 firms with new production plants, 959 also introduced new products. Only 30 firms introduced new products without opening a new production plant. There is also a similar correlation for firms that reduced their product range.

Firms with a changed product range and an above average employment level had a better performance with respect to productivity. In addition, they were able to increase this to a greater extent than firms that kept the same product range. This applies both to firms that reduced their number of products and those that increased them. Also, both for firms that specialised more and for firms that diversified, the operating surplus was greater than for firms that made no change to their product range.

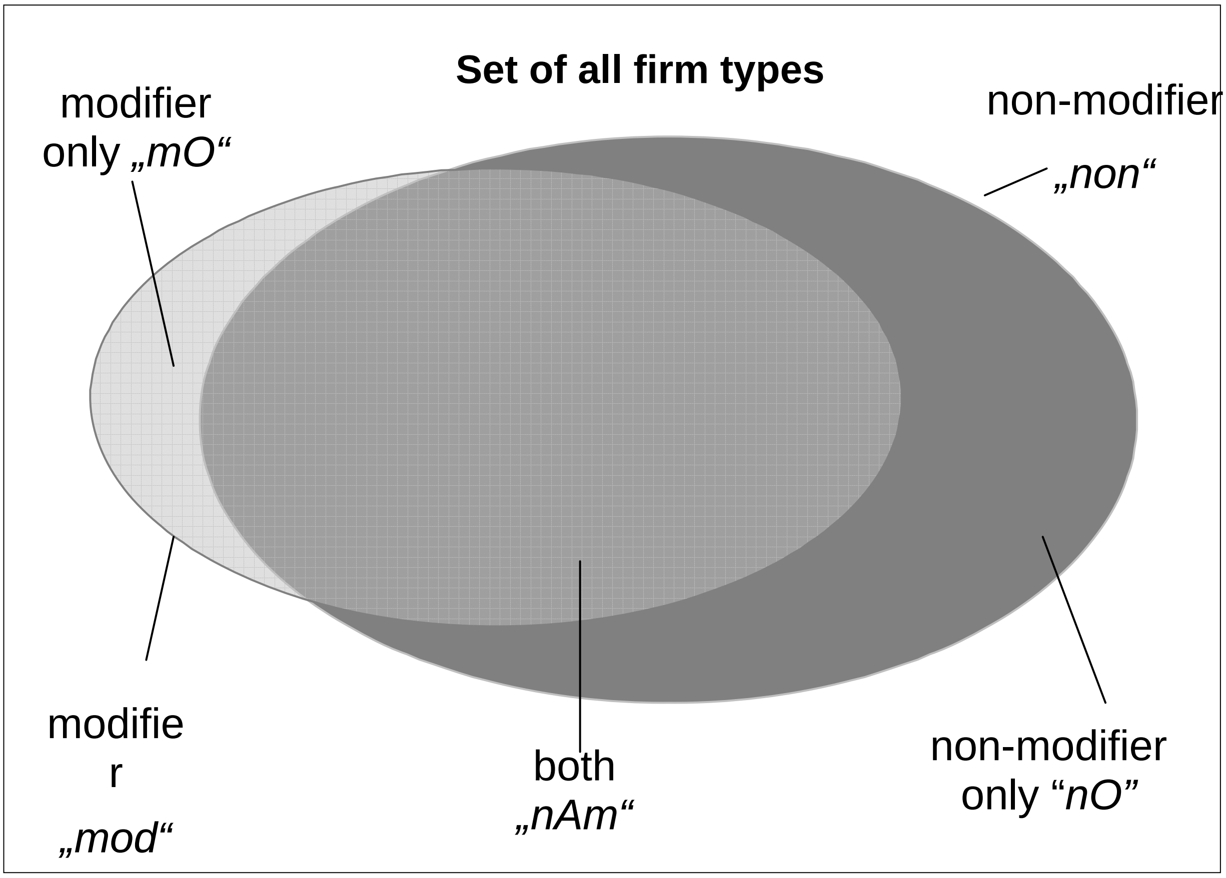
However, firms with higher specialisation dynamics started with a considerably lower level of operating surplus in 1995, both compared to the diversifying firms and to the average of all firms. The greater concentration of the product range for these firms appears to be closely linked to the pressure to increase profitability.

5 The decomposition methodology

To separate the impact of product policy from those of other determinants on the success of firms we employ a decomposition approach suggested by Nopo (2004) as a nonparametric extension of the widely-used Oaxaca-Blinder decomposition (Blinder 1973; Oaxaca 1973). Taking the productivity measure as given by value added per employee, we decompose the observed "raw" productivity differences between modifiers and non-modifiers of the product range into a "structural" and a "behavioural" component. The former contains the part of the raw difference attributable to the different composition of modifiers and non-modifiers with regard to employment size and sector. The latter is the "pure" productivity difference between modifiers and non-modifiers of comparable size and sector.

Starting point of our empirical analysis is the simple „raw" difference between the average productivity level for non-modifiers, $E[Y \mid non]$, and the average productivity level for modifiers, $E[Y \mid mod]$. This simple average productivity difference $E[Y \mid non] - E[Y \mid mod]$ is the focus of this analysis. It is computed as the difference of the average productivity of all enterprises found for non-modifiers and the average productivity of all enterprises found for modifiers. It is, however, only a very crude measure of the relative productivity setting in both groups of enterprises. In particular, it is not the same as the average non-modifiers/modifiers productivity differential between comparable enterprises. This is visualized in the Venn diagram of Figure 1.

Figure 1: Venn diagram of the sets of all possible and all existing types of firms



This diagram shows the set of all conceivable types of enterprises as a rectangular box. Some of the theoretically conceivable establishment types are neither found for modifiers nor for the Non-modifiers ("*neither modifiers nor non-modifiers").* Certain kinds of enterprises, however, are only observed for non-modifiers ("*nO*") and, therefore, their productivity levels are included in the non-modifiers average $E[Y \mid non]$ only. Similarly, certain types of enterprises (and the associated productivity levels) are found for modifiers only ("*mO*"). Both "exclusive" groups of enterprises have an influence on the average productivity in their own group of enterprises only and contribute in this way to the difference $E[Y \mid non] - E[Y \mid mod]$.

Conversely, the intersection "*nAm*" contains all establishment types found both for modifiers and for non-modifiers. These constitute, according to the particular classification of enterprises chosen, the set of comparable enterprises. The non-modifiers/modifiers productivity differential between the members of this set is therefore but one component of the “raw” difference $E[Y \mid non]$ - $E[Y \mid mod]$. Establishments belonging to the intersection of modifiers and non-modifiers enterprises do not only influence the difference $E[Y \mid non]$ - $E[Y \mid mod]$ because observably identical enterprises exhibit different productivity levels for non-modifiers than for modifiers. They influence $E[Y \mid non]$ - $E[Y \mid mod]$ in another way: the distribution of characteristics among the members of this set is potentially different in both groups of enterprises. That is, while large enterprises in manufacturing may be found both for modifiers and for non-modifiers, their share among all enterprises in their group of enterprises may be much higher for non-modifiers than for modifiers.

The informal discussion of the previous paragraph is made precise by the following decomposition proposed by Nopo (2002), who – building on the seminal work of Blinder (1973) and Oxaca (1973) – has shown that the difference $E[Y \mid non]$ - $E[Y \mid mod]$ can be broken down into four additive components:

$$E[Y \mid non] - E[Y \mid mod] = \Delta_{non} + \Delta_{mod} + \Delta_{type} + \Delta_{firm}$$

Each of these components is closely connected to one of the shaded areas in Figure 1. Nopo (2002) discusses how this decomposition and the estimation of its components are tied to the literature on estimating (causal) treatment effects from non-experimental data, in particular by using statistical matching. See also the related decomposition of the selection bias in Heckman, Ichimura, Smith and Todd (1998).

Now let $g^n(x)$ and $g^m(x)$ denote the average productivity for non-modifiers and Modifiers, respectively, for establishment type *x* and let $f^n(x)$ and $f^m(x)$ denote the corresponding fractions of enterprises of type *x* for non-modifiers and Modifiers, respectively. Using this notation, the unconditional average productivity for each group of enterprises can be written as a weighted sum of the type-specific averages:

$$E[Y \mid mod] = \sum_{x \in mO \cup nAm} g^m(x) f^m(x)$$

and

$$E[Y \mid non] = \sum_{x \in nO \cup nAm} g^n(x) f^n(x)$$

The four components comprising the difference between $E[Y \mid non]$ and $E[Y \mid mod]$ can now be shown to have the following precise form and interpretation:

The first component, Δ_{non}, is the component specific to the non-modifiers and corresponds to subset *nO* of Figure 1. It is the part of the simple non-modifiers/modifiers average productivity differential that can be attributed to those types of enterprises that can be found exclusively for non-modifiers. Δ_{non} is formally defined as the difference between the average productivity of the kinds of enterprises found for non-modifiers only, and the average productivity of those non-modifiers enterprises, whose type is also observed for modifiers, weighted by the fraction of non-modifiers enterprises with no match for modifiers, $P^n(nO)$:

$$\Delta_{non} = \left\{ \sum_{x \in nO} g^n(x) \frac{f^n(x)}{P^n(nO)} - \sum_{x \in nAm} g^n(x) \frac{f^n(x)}{P^n(nAm)} \right\} P^n(nO)$$

The second component, Δ_{mod}, is the component specific to the Modifiers and corresponds to subset *mO* of Figure 1. It is the part of the simple non-modifiers/modifiers average productivity differential that can be attributed to those types of enterprises that can be found exclusively for modifiers. Δ_{mod} is formally defined as the difference between the average productivity of modifier enterprises whose type can also be found for non-modifiers, and the average productivity of those modifier enterprises, whose type is exclusively observed for modifiers, weighted by the fraction of modifier enterprises with no match for non-modifiers, $P^m(mO)$:

$$\Delta_{mod} = \left\{ \sum_{x \in nAm} g^m(x) \frac{f^m(x)}{P^m(nAm)} - \sum_{x \in mO} g^m(x) \frac{f^m(x)}{P^m(mO)} \right\} P^m(mO)$$

The third component, Δ_{type}, corresponds to the subset *nAm* of Figure 1 and represents the part of the simple non-modifiers/modifiers productivity differential, that can be attributed to unequal distributions of common establishment types in both groups of enterprises. That is, it arises from the fact that some establishment types are found both for modifiers and the non-modifiers – but with unequal relative frequencies. Formally, Δ_{type} is the sum of the type-specific average productivity levels for non-modifiers, weighted by the difference of the distributions with which these establishment types are observed for non-modifiers and Modifiers, respectively:

$$\Delta_{type} = \sum_{x \in nAm} g^n(x) \left\{ \frac{f^n(x)}{P^n(nAm)} - \frac{f^n(x)}{P^m(nAm)} \right\}$$

Formally, the productivity gap between the two groups of enterprises could be defined by reversing the order, i.e. by considering $E[Y \mid non]-E[Y \mid mod]$. Reversing the order of the groups of enterprises implies changes in the precise definitions of Δ_{type} and Δ_{firm}. However, the particular order "non-modifiers minus modifiers" is suggested by the aim of the present paper: studying the adjustment of Modifiers productivity levels towards the reference level of non-modifiers productivity levels.

The fourth component, Δ_{firm}, also corresponds to subset *nAm* of Figure 1 and represents the part of the simple productivity gap $E[Y \mid non]-E[Y \mid mod]$, that can be attributed to the non-modifiers/modifiers differences in the productivity of the enterprises found in both groups of enterprises – i.e., to the "true" firm-specific productivity differential between observationally identical enterprises. Δ_{firm} is formally defined as the sum of the type-specific non-modifiers/modifiers productivity differentials, weighted by the fraction with which each type is found for modifiers:

$$\Delta_{firm} = \sum_{x \in nAm} \left\{ g^{m}(x) - g^{n}(x) \right\} \frac{f^{m}(x)}{P^{m}(nAm)}$$

Each of the formal definitions of the four components of $E[Y \mid non]-E[Y \mid mod]$ involves the conditional expectation functions $g^{m}(x)$ and $g^{m}(x)$. These functions spell out how average productivity levels for non-modifiers and Modifiers, respectively, vary with the establishment type x. Note that no particular functional form has been assumed for either $g^{m}(x)$ or $g^{m}(x)$. Instead, both regression functions are nonparametrically defined and estimated – the latter by computing average productivity levels for each type of establishment (and each group of enterprises) separately.

Alternatively, the regression functions $g^{m}(x)$ and $g^{m}(x)$ could be defined and estimated parametrically, for instance, by assuming that average productivity levels vary linearly with establishment characteristics. That is, a more standard approach would impose that $g^{n}(x) = \beta_n^T \; x$ and $g^{m}(x) = \beta_m^T \; x$ estimate the parameter vectors β_n^T and β_m^T by Least Squares. While estimating and interpreting this specification is straightforward, its desirable statistical properties hinge on the validity of the linearity assumption. The approach followed in this paper, to specify $g^{m}(x)$ and $g^{m}(x)$ nonparametrically, does not require to impose strong *a priori* restrictions on the way average productivity levels are allowed to vary with establishment characteristics. Moreover, the huge size of our sample (defined in the following section) ensures that the data-hungry nonparametric approach has sufficiently large samples to work with to compute the many establishment-type specific averages that form its estimates of $g^m(x)$ and $g^m(x)$.

The nonparametric decomposition defined above offers an additional advantage over the parametric approach as it explicitly includes the components of the raw difference in productivity levels between Non-modifiers and Modifiers due to establishment types found exclusively for non-modifiers or Modifiers, respectively. The corresponding parametric decomposition due to Blinder and Oaxaca, however, yields expressions for Δ_{firm} and Δ_{type} only. In the parametric case, $\Delta_{firm} = (\beta_n^T - \beta_m^T)\ \bar{x}_m$ and $\Delta_{type} = \beta_n^T\ (\bar{x}_n - \bar{x}_m)$ where $\bar{x}$ denotes a vector of sample averages of establishment characteristics. It ignores the components attributable to enterprises outside the “common support” of establishment types found in both groups of enterprises. It does so by using its linear functional form assumption to extrapolate into areas of establishment types not found in the data.

In order to analyse the differences in the degree of specialisation and/or differentiation of firms’ product ranges, the influences of differences in economic structure should be isolated by using a decomposition approach. There is a conflict of aims in terms of the degree of structural differences that should be taken into account with regard to firm size and sector. On the one hand, in order to be able to compare types of firms that are as similar as possible, it would be desirable to differentiate very clearly according to sector and size. On the other hand, in view of the statistical significance of the findings, as high a count of firm types as possible is required. On average, details of 15,000 firms are available for analysis every year. An appropriate compromise seems to be to differentiate 12 different sectors of the manufacturing industry on the basis of 2-digit figures in the industrial classification, and 7 size classes for persons employed. The classification is documented in the appendix. In control calculations, all firm types for which the total firm count was less than 10 were excluded.

6 Results

We find that almost 30% of all firms introduced at least one new product into their product range between 1995 and 2001. These modifiers enjoyed an average productivity advantage in 2001 of 13% over non-modifiers. The decomposition approach however reveals that, for the most part, this productivity difference is due to structural rather than behavioural differences between the two groups. That is, there is no significant difference between comparable modifiers and non-modifiers. The raw advantage of modifiers is due to the greater prevalence of firms in this group belonging to high-productivity sectors and size groups.

Table 7: Firm-level productivity and new products 1996 - 2001

	Number of firms	%	Gross value added per employee 2001		
			Average in 1000 €	Standard deviation	Coefficient of variation
All enterprises[1]	17736	100,0	58,81	99,81	169,72
Product-modifiers	2175	28,1	64,14	154,00	240,10
Non-modifiers	5561	71,9	56,73	67,61	119,18

[1]German manufacturing enterprises
Sources: Forschungsdatenzentrum der Länder; Calculations of DIW Berlin.

The data also show a much higher variance of observed productivity among modifiers, pointing to the risk involved in this strategy. While some firms do reap the intended above-average rent, numerous other firms don't – either because of a (temporary) loss in efficiency from readjusting production (Montgomery 1985) or because the new products failed to find a market.

Table 8; Non parametric analysis of firm-level productivity differences – 2001

	Difference in Average productivity	95% - Confidence – Interval	
	in 1000 €		
Raw difference	17,41	0,92	13,91
caused by differences in			
Market composition	6,51	2,34	10,68
Innovation behaviour	0,90	-2,74	4,54

[1] German manufacturing enterprises
Sources: Forschungsdatenzentrum der Länder; Calculations of DIW Berlin

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