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Abstract

The first part of this paper focuses on definition and description of value added, and its measurement and allocation amongst Danish food processors, wholesalers and retailers where summary statistics are presented illustrating the main characteristics of the recent development. In particular, the summary statistics include the development of value added both on sector- and industry-level during the period 1995 to 2003. Firm-level data on labour force are then used to calculate a relative measure for the industry labour productivity, in terms of value added per employee, which motivates the subsequent analysis of labour productivity convergence within the three food sectors under consideration: the processing industries, the wholesale and retail sector, respectively. The first part concludes by reviewing recent literature about factors affecting value added.

The second part presents two models and hypotheses for panel data estimation of firm-level factors affecting value added. While the first model refers to the estimation of a firm-level value added function within each of the three sectors which focuses on the main input factors as well as structural variables describing the industries, the second model refers to independent firm-level value added function estimations for each industry separately, regressing value added on all input factors. The primary focus of the sector-level model is directed towards the industry-specific total factor productivity level and growth, additionally taking the influence of the structural variables on value added into account. On the contrary, the industry-level model rather focuses on the firm-specific input factor elasticity coefficients.

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Preface

This Working Paper has been written as part of the project Value-added in the Danish food industry.

The first part of this paper focuses on definition and description of value added, and its measurement and allocation amongst Danish food processors, wholesalers and retailers where summary statistics are presented illustrating the main characteristics of the recent development. The second part presents two models and hypotheses for panel data estimation of firm-level factors affecting value added.

Senior research Derek Baker and Ass. professor Lars Otto has participated in the editing and revering of the paper.

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1. Introduction

1.1. Purpose of the study

This paper presents and analyses the development of value added in the Danish food marketing chain in the period 1995-2003. Its contributions pursue thereby a twofold goal: In the first place, the paper is aimed at explaining the driving forces behind the development of value added both over time and across industries. Employing value added as an appropriate firm-level performance variable, however, allows in a second step for estimating common measures for labour and total factor productivity TFP of the Danish food chain.

1.2. The "Food Chain Project"

This research is conducted under the auspices of the project *Perspectives and outlook for the Danish food marketing chain (phase 2)*[1], commonly known as *the food chain project*.[2] This project is funded under the Danish Innovation Law 2005[3] and administered by the Food Economy Directorate of the Danish Ministry of Agriculture (DFFE). The objectives of the project are to:

- measure changes in function, structure and commercial practice in the Danish food industry and compare and contrast these with developments in other countries;
- characterise vertical and horizontal relationships in the Danish food chain and their role in delivering optimal levels of food quality, variety and safety;
- evaluate the efficiency and competitiveness of the Danish food system at each stage of the marketing chain;
- review and evaluate instruments of Danish, EU and foreign public policy in the development of the food marketing chain; and
- communicate research results in a number of media.

1.3. Executive summary

The value added creation of the Danish food sector is characterized by moderate growth in terms of real prices. During the period 1995 to 2003, value added of the

[1] "Perspektiver for og udvikling af den danske fødevarekæde (fase 2)".
[2] Further information about the project are available from the author.
[3] "Innovationsloven for 2005".

processing and retail sale industries grew annually by 2 and 1.2% on average, respectively, while the wholesale industries are bottom of the league with 1.1% annual growth on average.

The distribution of value added follows a relatively stable path. Processing industries account for roughly 55% of the chain's value added creation, while retail sale and wholesale industries account for 30 and 15%, respectively.

The largest contributors among processing industries are *Production, processing and preserving of Pork* (151110) and *Operation of dairies and cheese making* who account for 30.9% on average of the whole sector's value creation. Among wholesale industries, *Non-specialized wholesale* (513900) and *Wholesale of fish and products thereof* (513810) account for 40.2% of the wholesale industries' value added while the by far largest fraction is held by *Supermarkets* (521130) and *Grocer's shops* (521110) which together account for 54.1% of the retail sale industries' value added.

It can be shown, however, that particularly smaller processing industries tend to grow faster on average than larger industries. The same result does not hold for wholesale and retail sale industries.

Relating value added to the number of employees reflects a common measure for labour productivity. Processing and wholesale industries turn out to be comparable in terms of the median value at 453.2 and 436.73 thousands DKK value added per employee annually, respectively. In strong contrast, retail sale industries achieve approximately half of it with 230.95 thousands DKK annually.

The within-stage differences in labour productivity, however, are huge. More productive industries grow faster than less productive industries implying that persisting labour productivity differences have become larger while the opposite is true for retail industries. One possible explanation for this result could be related to the fact that the technologies used to offer retail sale services are potentially similar. On the other hand, there are no a priori reasons to expect the technology of production to be the same or to converge over time in the case of processing industries.

Differences in the industries' value added performance can to large extent be explained by persisting differences in the respective total factor productivity (TFP) levels within each stage. On average, processing industries have the largest TFP levels, growing at an annual rate of approximately 1%, followed by wholesale industries with approximately 0.5% annual growth. Retail sale industries have generally the lowest TFP levels where non-specialized retail sale industries even decline by 1% annually while the specialized industries tend to stay at their initial levels.

The degree of concentration affects the value added performance negatively in the case of the retail industries and positively in the case of processing and wholesale industries. The result may be explained by the so-called efficiency hypothesis which then would not be applicable in the case of retail sale industries. If ongoing concentration and consolidation trends are interpreted as evidence for the existence of particularly productive firms, then this should be reflected by large TFP and labour productivity levels which does not hold in the case of retail industries.

Labour and raw material are the decisive factors for the value added creation. For all three sectors hold that the sum of the estimated elasticities exceeds unity, indicating the existence of increasing returns-to-scale. Capital plays apparently only a minor role and finally, market size does not qualify as determinant for the value added performance.

1.4. Background

Food industry value added has recently attracted considerable attention from policy makers and researchers. As globalisation and innovation are amongst the most discussed topics around the world, the Danish government has in recent years put increased effort into advancing the general debate on these topics (Government 2006). One of the main challenges identified is how Denmark can compete successfully in the global market place, both now and in the near future (*ibid*).

According to the Ministerial Committee on Globalisation (*ministerudvalget*), trade with other OECD countries accounts for more than 80% of Denmark's trade relations.[4] Of this, processing industries typically have the largest shares of import and export and only a few service industries have such shares above 10% their total value of production (Ministerial Committee 2005).[5] Import from low-labour-cost countries

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[4] According to *Statistics Denmark*.

[5] The Prime Minister established a high profile Ministerial Committee on the challenges of globalisation. The group was chaired by the Prime Minister and included the Minister for Economic and Business Affairs as deputy chairman, the Minister of Education, the Minister of Finance and the Minister of Science, Technology and Innovation. See also www.stm.dk/Index/dokumenter.asp?o=160&n=1&d=2293&s=1.

(LLCC) has remained relatively stable at below 5% of Denmark's GNP since the 1960s (*ibid*).[6] Danish investments in non-OECD countries, primarily Asia and Eastern Europe, constitute approximately 1.5% of the domestic private capital stock (*ibid*). In the short term, trade with high wage OECD countries is set to represent by far the largest fraction of Denmark's foreign trade relations, particularly for food processing firms (Fødevareindustrien 2006). To a large extent, high wage economies are comparable with respect to their factor endowment and trade comprises, in large part, so-called intra-industrial trade (trade of similar products but with different product attributes, such as design and quality). However, today's low-labour-cost countries, such as China, are expected to experience comprehensive productivity increases in the near future implying wage increases which then reduce their original cost advantages (Ministerial Committee 2005; Rae and Hertel 2000).

This background can clearly be seen as one of the main reasons for the broad political consensus in Denmark that "we cannot and must not compete on wages" as recently stated by the Danish Prime Minister (Prime Minister 2005) as this would be a temporary short-run strategy only. Rather, anticipating the coming development of today's low-labour-cost countries, small economies like Denmark are best advised to emphasise products with high value addition in order to reach and eventually to expand a competitive head start in terms of knowledge. Competition on selected niche markets should primarily be driven by knowledge and innovation (Prime Minister 2005; Leschly 2005). The focus of the processing industries' value added creation shifts thus from the pure physical production towards parameters such as product development, design, marketing and administration (Ministerial Committee 2005).

For two main reasons, the Government's general policy on globalization, promoting the focus on high quality value added products, applies in particular to the Danish food industries. Firstly, the export of food products plays an increasingly important role. Aside from pharmaceuticals, diary and food products constitute Denmark's largest export markets and amongst food processing firms exports accounted for some 60% of their total turnover in 2004 (Moody's Report 2006; Fødevareindustrien 2005). In recent years, new export markets in non-OECD countries such as Russia, India and China have grown faster on average than have Denmark's traditional export markets in OECD countries. The unexploited export potential, however, is estimated still to be larger in the latter, particular in EU15 countries (Fødevareindustrien 2006).

[6] While the importance of China steadily increases, other countries, such as Japan, do not primarily compete any longer on low wages due to larger productivity increases.

Secondly, Denmark occupies a strong position - and thus an information advantage - on so-called up-markets for food products with high value added.[7] In 2004, Denmark ranked fourth in the EU15 with 30% of its food products exported to up-markets (Fødevareindustrien 2005). If one looks at other Danish industries, however, food processing firms are positioned at the lower end only. While up-market products accounted for approximately 35% of the food processors' total turnover in 2004, the chemical industries' proportion, for instance, was almost 60%. Recent trends in consumer behaviour endorse, however, the importance of producing high value added food products. The demand for convenience and functional food products, addressing product attributes such as disease prevention, better taste or food product safety, continues to increase steadily, particularly in those markets where Danish food processors already have strong market positions (Fødevareindustrien 2005). Cautious estimates state that the demand for functional food products accounts for approximately 5% of the global food market (Bech-Larsen and Scholderer 2007).

The Danish food sector has been impacted by enormous structural changes involving concentration and consolidation trends which have taken place during the last decade, as for instance documented in Baker (2003), Nordic Council of Ministers (2004) and Hansen (2005) which has led to many so called big-small markets within the whole food chain (Rogers 2001; VIFU 2006). Changes in market power throughout the food marketing chain are widely reckoned to have affected allocation of value added (Gopinath 2003; Rogers 2001). Meanwhile, a changing consumer profile offers a large number of niche food market opportunities, especially in such big-small markets (Buhr 2004; Gould and Carlson 1998).

The increasing globalization requires thus a profound knowledge extracted from the analysis of value added in order to ensure a long-lasting international competitiveness of the food sectors (Moulton 1986; Sevcikova 2003; Winger 2005; Zugarramurdi 2004). Despite the currency of the issue, however, rather few studies have characterised the particular distribution of value added amongst food industry firms. Moreover, the characteristics of firms associated with high value addition have received less research attention. This may come as a surprise as the currently highly debated issues innovation and development of differentiated products are closely related to the discussion about value added and its determinants (Bosworth and Loundes 2002; Braad-

[7] According to the definition of the Confederation of Danish Industries (*Dansk Industri*), an up-market product is defined to be an (export) product where the Danish price is at least 15 percent above the EU15 average price for comparable products (Danish Industry 2006).

land 2003; Francis 2005) as well as the tight link between value added and productivity (Harrigan 1999; Bernard and Jones 1996; Gopinath 2003).

1.5. Outline of study

The first part of this paper focuses on definition and description of value added (section 2.1), and its measurement and allocation amongst Danish food processors, wholesalers and retailers where summary statistics are presented illustrating the main characteristics of the recent development (section 2.2). In particular, the summary statistics include the development of value added both on sector- and industry-level during the period 1995 to 2003. Firm-level data on labour force are then used to calculate a relative measure for the industry labour productivity, in terms of value added per employee, which motivates the subsequent analysis of labour productivity convergence within the three food sectors under consideration: the processing industries, the wholesale and retail sector, respectively. The first part concludes by reviewing recent literature about factors affecting value added (section 2.3).

The second part presents two models and hypotheses for panel data estimation of firm-level factors affecting value added (section 3). While the first model refers to the estimation of a firm-level value added function within each of the three sectors which focuses on the main input factors as well as structural variables describing the industries, the second model refers to independent firm-level value added function estimations for each industry separately, regressing value added on all input factors. The primary focus of the sector-level model is directed towards the industry-specific total factor productivity level and growth, additionally taking the influence of the structural variables on value added into account. On the contrary, the industry-level model rather focuses on the firm-specific input factor elasticity coefficients. The forth section presents and discusses results in the light of a priori hypotheses and the final section 5 presents conclusions.

2. Value added

2.1. Definition

The expression "value added" has several usages and so requires clarification. In many cases, the term colloquially refers to any activities that transform raw materials into food products, with an inferred linkage between value addition and differentiation. A second definition, from the business literature and confusingly referred to as "economic value added", is the excess of market value of a firm's capital over its book value (Stewart 1991), and requires an estimate of the value of firms' traded shares. In this context, the term value added is used as a performance measure addressing the true economic profit of a firm.

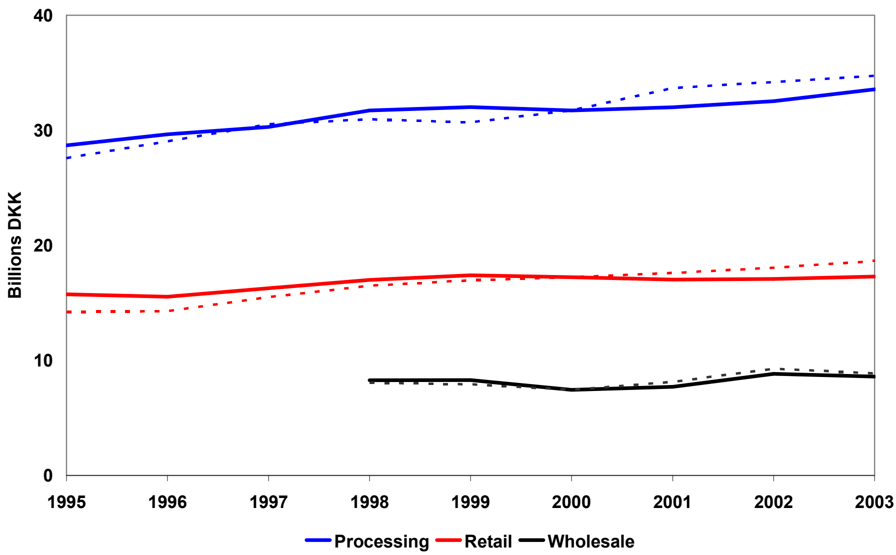
Finally, as a concept used in accountancy, value added is defined as the final value of a product, less the costs of all materials, inputs and services that are purchased from other firms. This latter definition is employed in the present study, namely value added as an accounting variable, following the definition of the Danish central bureau of statistics (*Statistics Denmark*). To some extent, one could also denote the latter definition of value added as the accounting related conceptualization of the first definition, given above. *Statistics Denmark* defines value added as firms' gross turnover minus consumption of goods and services purchased from other firms, of which raw material typically constitutes by far the largest fraction. Value added is commonly related to other variables (e.g. employee numbers or turnover) to generate size-or industry-neutral measures of performance or productivity.

2.2. Value added in the context of the Danish food industry

2.2.1. Aggregate value added on sector-level

The Danish food industry in this study includes the food processing industry, the food wholesale and food retail sector. Concerning the general trend of value added the contemplated period 1995 to 2003 could roughly be segmented into three sub-periods. The first sub-period from 1995 to 1999 is characterized by constant progression where - in terms of real prices - the food processing industry and the retail sector increased the amount of total annual value added by 12% from 29 in 1995 to DKK 32 bn in 1999 and by 11% from 16 to DKK 17 bn, respectively, as shown in Figure 1 below. Figure 1 shows the total amount of annual value added contributed by the three sectors in real prices (base year 2000). The dashed curves indicate the correlative series in current prices.

Figure 1. Total annual value added of the Danish food industry 1995 - 2003[8]



Source: Own calculations.

During the next sub-period from 1999 to 2001, however, all three sectors experienced a decline in total value, of which the wholesale sector has been affected most significantly by a 6.8% decrease compared to the 1999 level. The last sub-period starting at 2001 appear to mark the beginning of a recovery phase as all three sectors again undergo increases in value added. As before, the wholesale sector dashes forward most clearly by 11.3% by the end of 2003 compared to the 2001 level. For comparison, the processing industries and retail sale sector experienced during the same sub-period a 4.9% and 1.5% increase only, respectively.

In some cases - and to some surprise - the movement of value added contrasts thereby sharply the corresponding trend behaviour of the food industry's turnover as the numbers of Table 1 illustrate.

[8] Data for the wholesale sector are available for the period 1998 to 2003 only.

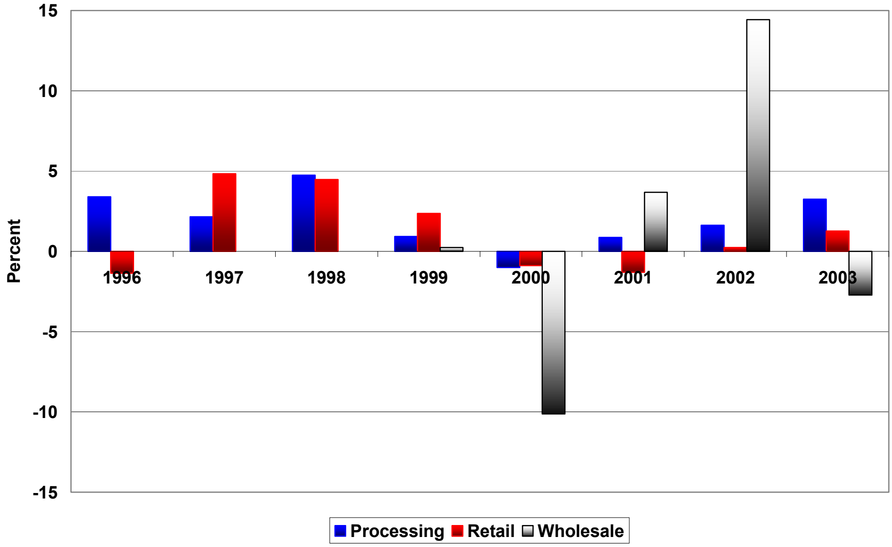
Table 1.	**The Danish food industry's turnover and value added 1995 – 2003 in real prices (2000)**					
			Turnover			
	Processing		**Retail sale**		**Wholesale**	
	Bn DKK	Change in %	Bn DKK	Change in %	Bn DKK	Change in %
1995	130.8		115.2			
1996	130.2		112.2			
1997	128.4		113.0			
1998	129.8		116.0		119.8	
1999	128.0	-2.1 (1995)	117.1	1.7 (1995)	110.0	
2000	133.4		120.2		102.8	
2001	139.6	9.1 (1999)	118.0	0.7 (1999)	102.2	-7.2 (1999)
2002	141.8		119.2		113.9	
2003	144.4	3.4 (2001)	117.4	-0.4 (2001)	116.3	13.8 (2001)
			Value Added			
	Processing		**Retail sale**		**Wholesale**	
	Bn DKK	Change in %	Bn DKK		Bn DKK	Change in %
1995	28.7		15.7			
1996	29.7		15.5			
1997	30.3		16.3			
1998	31.7		17.0		8.3	
1999	32.0	11.7 (1995)	17.4	10.6 (1995)	8.3	
2000	31.7		17.2		7.4	
2001	32.0	-0.1 (1999)	17.0	-2.2 (1999)	7.7	-6.8 (1999)
2002	32.5		17.1		8.8	
2003	33.6	4.9 (2001)	17.3	1.5 (2001)	8.6	11.3 (2001)

Source: Own calculations based on data material from *Statistics Denmark*.

As already mentioned above, while the processing industries experienced a decline in value added during 1999 to 2001, they raised the turnover by considerable 9.1% during the same sub-period. The same is true for the retail sale sector, even though not as such lucidly. The wholesale sector, on the contrary, exhibits the most stable positive correlation between value added and turnover.

Drawing the attention towards annual growth rates of value added, confirms most of the already stated observations. Figure 2, below, depicts the annual growth rates of value added, measured in real prices. One can easily observe the apparently cyclical movement the path of the growth rates of value added is following where all three sectors to greater or lesser extent move conjointly, even though the wholesale sector's amplitude exceeds the other two sectors' many times over.

Figure 2. Annual growth rates of value added

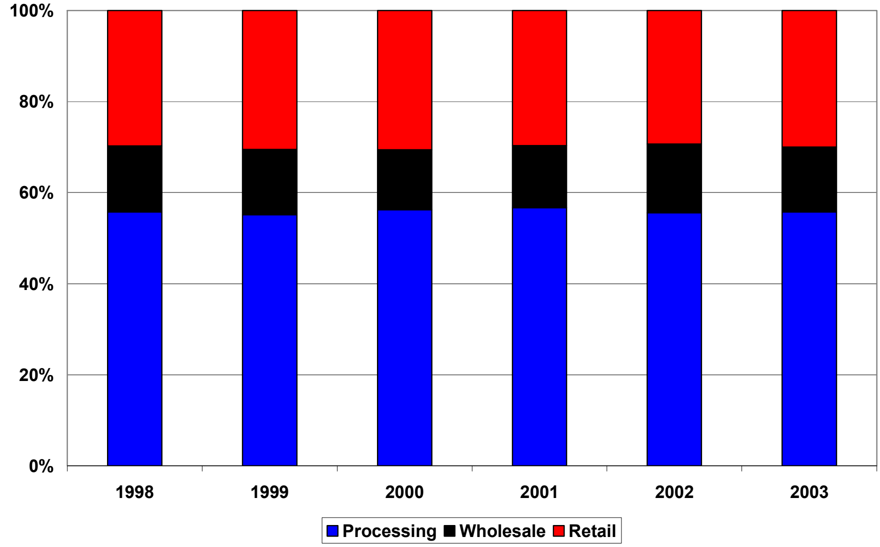


Source: Own calculations.

As cyclically the growth rates move, as stable the sectoral distribution of value added remains, as Figure 3 illustrates. The processing industries typically contribute most and accounts for 55.9% on its own of the whole food industry's total value added on average during 1998 to 2003 while the retail sector stands for 30.0% on average during the same period. The wholesale sector is bottom of the table by adding 14.2% on average of total value added.[9]

[9] This somehow stable distribution over time may motivate the following *half-of-the-half* rule where the wholesale sector produces approximately half of the retail sector's value added which itself accounts for approximately half of the food processors' value added contribution.

Figure 3. The sectoral distribution of total value added 1998 – 2003



Source: Own calculations.

The aggregation of data on such high level, however, lets lose sight of the structural diverseness among the involved industries within the three sectors, respectively. In some cases, two contiguous industries may be closer linked together than others due to some technological, economic or structural reasons which then also may imply a certain similarity in terms of the respective value added performance. In general, however, the industries can hardly be compared with each other as each industry produces and deals specific products or product groups. Thus, the involved industries typically differ in technology, size, number of companies - among others - which also affect the industry-specific value added performance both in terms of the average industry share of total sector value added as well as the average industry growth over time.

2.2.2. Aggregate value added on industry-level

Industry performance

In order to identify the leading industries within each sector, the so far presented data are disaggregated from sector-level down to industry-level and eventually classified according to some common criteria. The proposed classification system should thereby serve for illustrative purposes only and alternative gradings would lead to slightly different results. In particular, the industries within each of the three sectors are classified according to two criteria, the average annual (real) growth rate of the industry's total value added and the average annual share of value added of that sector the industry belongs to. The average refers to the observed period 1995 to 2003 for the processing industries and the retail sector and to 1998 to 2003 for the wholesale sector, respectively. The two criteria define then four groups as follows:

- *Big Players*: Positive growth and a share above 10%
- *Growing industries*: Positive growth and a share below 10%
- *Dinos*: Negative growth and a share above 10%
- *Shrinking industries*: Negative growth and a share below 10%

In the processing sector, only 6 industries account for approximately 60% of the sector's total value added production with *Production, processing and preserving of pork* (151110) and *Operation of dairies and cheese making* (155110) as the top leading industries, as it can be seen in Table 2a. The value added production of those 6 industries grew on average by 3.0% each year. The majority of industries with positive growth on average, however, hold only a small value added share each between 0.0 and 3.3% of the sector's value added production. Of those industries with negative growth on average, *Baker's shops* (158120) and *Production, processing and filleting of fish and fish products* (152010) account for nearly 11% of total value added.

Table 2a. Industry performance

	Processing industries 1995 – 2003		
	Industry[1)]	Average annual share in %	Average annual growth in %
Big players	Pork (151110)	19.0	0.9
	Dairies and cheese making (155110)	11.9	5.5
Growing industries	Beer (159600)	8.4	3.0
	Sugar (158300)	7.8	3.0
	Other food products n.e.c. (158900)[2)]	6.0	2.3
	Bread and other bakery products (158110)	4.0	3.6
	Prepared meat dishes (151310)	3.3	7.0
	Cocoa, chocolate and sugar confectionery (158400)	3.2	3.3
	Prepared feeds for agriculture and fur farming (157110)	2.3	30.0
	Mineral waters and soft drinks (159800)	2.1	8.2
	Poultry meat (151200)	2.1	5.6
	Other meat products (151390)	1.9	2.3
	Rusks and biscuits; preserved pastry goods and cakes (158200)	1.8	4.2
	Fruit and vegetables n.e.c. (153300)	1.5	8.4
	Prepared pet feeds (157200)	1.2	3.0
	Fish smokehouses (152020)	1.2	10.5
	Grain mill products (156100)	1.0	9.1
	Refined oils and fats (154200)	0.9	4.3
	Beef (151120)	0.7	2.3
	Potatoes (153100)	0.7	8.2
	Starches and starch products (156200)	0.6	6.7
	Fruit and vegetable juice (153200)	0.5	4.9
	Distilled potable alcoholic beverages (159100)[3)]	0.5	3526.5
	Condiments and seasonings (158700)	0.5	11.3
	Tea and coffee (158600)[3)]	0.5	95541.8
	Margarine and similar edible fats (154300)	0.3	3.7
	Malt (159700)	0.3	22.2
	Prepared feeds for fish hatcheries (157120)[4)]	0.1	187.2
	Crude oils and fats (154100)	0.1	45.3
	Homogenised food preparations and dietetic food (158800)[4)]	0.1	476.6
	Macaroni, noodles, couscous and similar farina-ceous products (158500)	0.1	23.4
	Cider and other fruit wines (159400)	0.0	25.9
Shrinking industries	Baker's shops (158120)	6.5	-0.6
	Fish and fish products (152010)	4.4	-1.2
	Bone fishmeal (152030)	1.1	-4.3
	Ice cream (155200)	1.0	-8.1
	Gut dressing factories (151130)	0.9	-0.7

Source: Own calculations.

1) Some industries are not included at all for various reasons: During the period under consideration, there are only three non-consecutive observations for *Manufacture of wines* (159300). *Production of ethyl alcohol from fermented materials* (159200) as well as *Manufacture of other non-distilled fermented beverages* (159500) has never been recorded in the account statistics. *Manufacture of condensed milk* (155120) stopped in 2000. Finally, *Processing of animal offal and production of bone meals* (151140) is not recorded from 1997 to 1999.

2) *Manufacture of other food products n.e.c.* (158900) has been split up into *Manufacture of dietary supplements* (158910) and *Manufacture of other food products n.e.c.* (158920) in 2003 which has been neglected.

3) While the industry *Manufacture of distilled potable alcoholic beverages* (159100) has been recorded in the account statistics during the whole period 1995-2003, it apparently first has started operating seriously from 1999 onwards which explains the extraordinary high growth rate. For analogous reasons, this does also hold *Processing of tea and coffee* (158600).

4) Both industries *Manufacture of prepared feeds for fish hatcheries* (157120) and *Manufacture of homogenised food preparations and dietetic food* (158800) are small industries, consisting of a few companies only which are typically more exposed to fluctuations.

The wholesale sector is clearly dominated by two large industries, namely the *Non-specialized wholesale of food, beverages and tobacco* (512900) and *Wholesale of fish and products thereof* (513810) which together account for 40.2% of the whole sector's value added production. While the meat processing industry holds 27.9% of the sector's value added production with a (weighted) average rate of 2.1% annual growth, *Wholesale of meat and meat products* which after all accounts for 13.9% of the wholesale sector's value added production declines by 3.0% annually, as it can be seen in Table 2b.

Table 2b. Industry performance

Wholesale 1998 - 2003

	Industry[1)]	Average annual share in %	Average annual growth in %
Big Players	Non-specialized wholesale (513900)	26.3	2.0
	Fish and products thereof (513810)	13.9	1.9
Growing industries	Fruit and vegetables (513100)	9.1	4.3
	Wine and spirits (513420)	8.4	0.9
	Dairy produce, eggs and edible oils and fats (513300)	8.0	14.1
	Beer and soft drinks (513410)	3.9	4.4
	Sugar, chocolate and sugar confectionery (513600)	3.8	13.5
	Other specialized wholesale (513890)	3.4	8.6
	Health food products (513830)	2.8	0.1
	Tobacco products (513500)	1.2	2.7
	Fruit and vegetable juice etc. (513490)	0.4	7.8
Dinos	Meat and meat products (513200)	13.9	-3.0
Shrinking industries	Coffee, tea, cocoa and spices (513700)	3.8	-12.0
	Bread, cakes and biscuits (513820)[1)]	1.2	-7.1

Source: Own calculations.

1) Bread, cakes and biscuits dropped out as independent industry in 2003.

The retail sale sector depicts a somehow different picture compared to both the processing and wholesale sector, respectively. The by far largest players are *Supermarkets* (521130), *Grocer's shops* (521110) and *Variety stores* (521210) which on their own account for 78.2% of the retail sale sector's value added. However, while supermarkets and groceries grow at a (weighted) rate of 8.1% annually, variety stores decline by 2.1% All other industries are significantly smaller in terms of their value added share and the next largest industry does hold 4.6% only, as can be seen in Table 2c.

Table 2c. Industry performance

	Retail sale 1995 - 2003		
	Industry[1)]	Average annual share in %	Average annual growth in %
Big players	Supermarkets (521130)	36.2	9.2
	Grocer's shops (521110)[1)]	17.9	5.8
Growing industries	Alcoholic and other beverages (522500)	0.6	5.7
	Health food (522730)	0.3	3.8
	Other retail sale in specialized stores (522790)	0.2	4.8
Dinos	Variety stores (521210)	24.1	-2.1
Shrinking industries	Department stores (521220)	4.6	-5.5
	Tobacco products (522600)	4.3	-6.4
	Meat and meat products (522200)	4.3	-1.6
	All-night shops (521120)	3.4	-3.6
	Chocolate and sugar confectionery (522420)	1.4	-3.3
	Fruit and vegetables (522100)	1.2	-1.3
	Fish, game, crustaceans and molluscs (522300)	0.9	-0.3

Source: Own calculations.
1) Discount stores became an independent industry from 2003 on (521140) which is disregarded in Table 2c.

Convergence

A common examination concerns the question whether smaller industries generally grow faster on average than larger industries in terms of the industry specific value added performance (Bernard and Jones 1996; Harrington 1999; Romer 2001). Regressing the processing industries' growth rate g^p on the average value added share s^p yields in fact a negative but non-significant coefficient as the following estimation result shows. The rather low value for R^2 may indicate, however, that a non-linear relation might better apply in this case. Regressing the growth rate g^p on the log of s^p instead yields a much better result:

Table 3. Convergence of processing industries

Model	Intercept	s^p	R^2
Linear	9.9086***	-0.7583	0.08
	(2.2527)	*(0.4570)*	
Log	8.8245***	-4.2148***	0.2682
	(1.6659)	*(1.2712)*	

Note: Standard errors in parentheses.

The above regression result does not include the four extreme outliers 158600, 159100, 157120 and 154100 as the corresponding observations can be explained by some kind of obvious conspicuity in the account statistics. The coefficient for the log of s^p becomes highly significant in this case and the R^2 increases even though one should exercise caution in directly comparing both goodness of fit measures with each other. The result complements the so-called *niche-market* hypothesis stating that industries in smaller markets produce relatively more value added as compared to larger industries. Table 3 confirms then that smaller industries also grow faster than large, established industries.

Compared to the processing industries, there could not be found a significantly statistical relation between the share and the growth rate within the retail sale sector. Apart from *Retail sale of alcoholic and other beverages* (522500), *Retail sale of health food* (522730) and *Other retail sale of food and beverages in specialized stores* (522790), all other specialized retail sale industries are declining. The obvious dominance of supermarkets and groceries might therefore have implied a positive relationship between the value added share s^r and its growth rate g^r which could not have been confirmed, however. The same is true for the wholesale sector where no statistically meaningful and significant relation could be found either, which might be explained by the shorter time period.

2.2.3. Labour productivity

Value added per employee

The disaggregation from sector-level to industry-level revealed the leading industries within each sector, measured in absolute value added shares. Without any information about the number of involved firms or employees within the industries under consideration, however, it remains still impossible to draw specific conclusions about the presented numbers, other than, for instance, supermarkets' value added share is more than twice the grocer's shops value added share or supermarkets grow nearly twice as fast as grocer's shops.

In order to compare the industries with each other more meaningfully, the absolute numbers have to be normalized by some appropriate normalization variable. One possibility in order to overcome this particular comparison problem consists in relating each industry's value added contribution with the total number of employees within the industry. Equivalently, one might in a first step relate each individual firm's value added contribution to the number of its employees and eventually calculate a weighted average for all firms within the same industry. The resulting two measures allow a more accurate comparison both among each other and within industries. Differently interpreted, the latter procedure includes the calculation of two commonly used value added productivity measures, namely the individual firm's labour productivity as well as each industry's average labour productivity (Bernard and Jones 1996; Cobbold 2003; Huang 2003).

According to Table 2a, *Production, processing and preserving of pork* (151110) is the largest value added contributor among all processing industries. However, without further information it is not possible to explain this leading position which it basically may have achieved by two different reasons: Either because the industry is simply larger than all others which also may be related to its relative capital intensity or the industry is significantly more productive in terms of the value added produced, compared to others.

Table 4a to 4c depicts for the three sectors the average annual value added per employee and the average annual growth of value added per employee for each industry, respectively. The averages have been calculated as follows: For each year 1995 to 2003 and for each recorded firm in the financial account statistics, the amount of annual value added was divided by the number of employees.[10] For each year and each industry, a weighted average for the industry was then calculated by using the number of employees as the corresponding weights.[11] These two calculation steps result in the weighted average value added per employee for each industry and each year. In a final step, it becomes then possible for each industry to calculate the arithmetic mean with respect to the whole period (column 2 of Table 4) and to calculate the arithmetic mean of the annual growth rates (column 3 of Table 4).[12] The number in squared brackets refers to the ranking concerning the average annual share in Table 2.

[10] The period for the wholesale sector is restricted to 1998 – 2003.

[11] The weighted average is equivalent to dividing – for each industry - the total amount of annual value added by the total number of employees.

[12] For instance, in the industry *Manufacture of starch and starch products* (156200), an average employee's productivity (value added per employee) amounts annually DKK 1444600 and its productivity rose annually by 21.11% on average during the period 1995 to 2003.

Table 4a. Value added per employee

	Processing industries 1995 – 2003	
Industry	**Average annual value added per employee in thousands DKK**	**Average annual growth rate in %**
[26] Starches and starch products (156200)	1443.6	21.1
[32] Malt (159700)	999.6	19.3
[19] Bone fishmeal (152030)	753.6	7.9
[4] Sugar (158300)	676.6	10.6
[3] Beer (159600)	622.4	3.9
[34] Crude oils and fats (154100)	600.3	27.6
[6] Other food products n.e.c. (158900)	548.0	4.8
[36] Macaroni, noodles, couscous and similar farinaceous products (158500)	528.9	14.7
[33] Prepared feeds for fish hatcheries (157120)	510.9	36.4
[37] Cider and other fruit wines (159400)	500.1	21.2
[12] Mineral waters and soft drinks (159800)	489.7	6.2
[11] Prepared feeds for agriculture and fur farming (157110)	488.0	3.2
[22] Refined oils and fats (154200)	480.2	6.7
[20] Grain mill products (156100)	471.7	1.6
[2] Dairies and cheese making (155110)	453.2	1.1
[21] Ice cream (155200)	446.5	2.1
[27] Fruit and vegetable juice (153200)	443.9	5.4
[8] Bread and other bakery products (158110)	440.9	2.4
[17] Prepared pet feeds (157200)	425.2	3.6
[25] Potatoes (153100)	416.3	3.5
[9] Meat dishes (151310)	413.4	2.3
[24] Beef (151120)	412.6	2.4
[1] Pork (151110)	412.2	2.8
[31] Margarine and similar edible fats (154300)	404.3	5.0
[30] Tea and coffee (158600)	400.3	347.5
[16] Fruit and vegetables n.e.c. (153300)	395.9	1.5
[14] Other meat products (151390)	367.7	4.2
[35] Homogenised food preparations and dietetic food (158800)	359.9	19.5
[29] Condiments and seasonings (158700)	358.0	0.5
[10] Cocoa, chocolate and sugar confectionery (158400)	354.6	2.7
[15] Rusks and biscuits, preserved pastry goods and cakes (158200)	342.4	2.1
[7] Fish and fish products (152010)	338.8	5.5
[23] Gut dressing factories (151130)	316.6	1.8
[28] Distilled potable alcoholic beverages (159100)	299.9	-13.9
[13] Poultry meat (151200)	283.4	2.5
[18] Smoking and salting of fish (152020)	280.5	5.1
[5] Bakers' shops (158120)	261.6	2.2

Source: Own calculations.

During the period 1995 to 2003, the industry-specific annual value added per employee on average ranges from a low 261.6 (*Baker's shops*) to 1443.6 (*Starch and starch products*) with its median for all industries lying at 425.26. As a somehow striking observation, 7 industries among the first 10 positions in Table 3a belong to the group of small industries in terms of Table 2a where the focus was directed onto the absolute value added contribution. Those 7 industries account annually on average only for 2.3% of the sector's total value added during 1995 to 2003 while the remaining 3 industries of the top-10 industries account annually on average for 22.2% Considering the whole sample, however, an obvious relation between the absolute (Table 2a) and relative (Table 4a) value added performance can only be identified to less extent. The Spearman correlation between both tables' ranking lies at -0.12.

The second observation concerning the top-10 industries relates to the higher-level grouping where 6 industries either belong to the group *Manufacture of beverages* (15.9) or to the group *Manufacture of other food products* (15.8). Particularly the latter group deserves attention as 5 industries of the same group belong to the bottom-10 industries, which indicates how inhomogeneous this group is. Finally, the two leading industries in Table 2a, *Production, processing and preserving of pork* (151110) and *Operation of dairies and cheese making* (155110) have to content themselves with medium positions only in terms of the relative value added per employee performance. The first one, lying at 412.2, ranks even below the median value at 425.26 while the latter industry lies slightly above the median at 453.2.

Table 4b. Value added per employee

Industry	Wholesale 1998 – 2003: Average annual value added per employee in thousands DKK	Average annual growth rate in %
[9] Wholesale of coffee, tea, cocoa and spices (513700)	502.1	-0.6
[13] Wholesale of tobacco products (513500)	482.9	7.5
[3] Wholesale of meat and meat products (513200)	477.9	1.1
[2] Wholesale of fish and products thereof (513810)	469.5	4.3
[11] Wholesale of health food products (513830)	467.1	-2.1
[6] Wholesale of dairy produce, eggs and edible oils and fats (513300)	464.2	3.0
[5] Wholesale of wine and spirits (513420)	442.3	4.5
[8] Wholesale of sugar, chocolate and sugar confectionery (513600)	431.2	7.2
[14] Wholesale of fruit and vegetable juice etc. (513490)	428.8	2.2
[10] Other specialized wholesale of food, beverages and tobacco (513890)	420.4	10.1
[1] Non-specialized wholesale of food, beverages and tobacco (513900)	405.7	6.6
[4] Wholesale of fruit and vegetables (513100)	399.3	6.6
[7] Wholesale of beer and soft drinks (513410)	362.3	6.5
[12] Wholesale of bread, cakes and biscuits (513820)	332.0	5.3

Source: Own calculations.

As one immediately can see in Table 4b, the distribution of value added per employee is by far less spread than compared to the processing industries. The values range here from the lowest observation at 332.0 for *Wholesale of bread, cakes and biscuits* (513820) to 502.1 for *Wholesale of coffee, tea, cocoa and spices* (513700). Nevertheless, the median value at 436.73 corresponds roughly to the median value for the processing industries. Similarly to the processing industries, there is even less correlation between the wholesale industries' ranking in Tables 2b and 4b, respectively, where the correlation lies at –0.01.

Table 4c. Value added per employee

Industry	Retail sale 1995 – 2003 Average annual value added per employee in thousands DKK	Average annual growth rate in %
[6] Variety stores (521210)	281.3	0.9
[1] Supermarkets (521130)	280.9	1.7
[2] Grocer's shops (521110)	260.0	0.8
[8] Retail sale of tobacco products (522600)	246.1	0.8
[3] Retail sale of alcoholic and other beverages (522500)	242.9	3.4
[9] Retail sale of meat and meat products (522200)	238.2	0.7
[7] Department stores (521220)	235.6	-1.6
[14] Retail sale of cheese (522710)	230.9	3.4
[13] Retail sale of fish, game, crustaceans and molluscs (522300)	219.1	1.3
[15] Retail sale of bread, cakes and flour confectionery (522410)	215.4	2.8
[10] All-night shops (521120)	210.7	-0.8
[11] Retail sale of chocolate and sugar confectionery (522420)	210.4	1.3
[5] Other retail sale of food and beverages in specialized stores (522790)	194.5	0.1
[4] Retail sale of health food (522730)	180.5	11.0
[12] Retail sale of fruit and vegetables (522100)	171.9	3.8

Source: Own calculations.

Contrary to processing and wholesale industries, value added per employee is significant lower for retail sale industries, as it can be seen in Table 4c. The values range from the least productive industry *Retail sale of fruit and vegetables* (522100) at 171.9 to the most productive industry *Variety stores* (521210) at 281.3. The median value for retail sale industries lies at 230.95, which is approximately half the processors' and wholesale industries' median value.

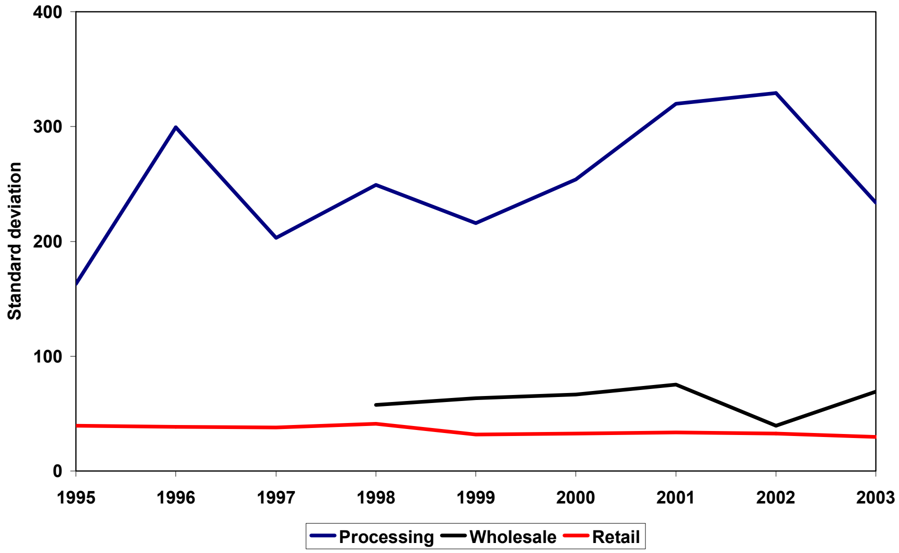
There is another crucial difference in comparison to both processing and wholesale industries. Retail sale industries constitute the only sector where there exists the highest measurable correlation between absolute and relative value added performance which lies at 0.45. In other words, those industries which contribute most in absolute terms are also those who are most productive in terms of value added per employee. The final statement illustrates once more the dominance of the non-specialized retail sale, in particular.

Convergence

σ-convergence

As already mentioned above, the spread of value added per employee differs significantly within the three sectors. Processing industries obviously have the by far largest spread, followed by the wholesale sector and the retail sector at the bottom. However, Tables 2 and 4 presents the averages for the whole period 1995 to 2003 only, where it cannot be seen whether the gap between the industries within each of the three sectors increases or decreases over time.

Figure 4. σ-convergence of labour productivity in the Danish food chain 1995 – 2003



Source: Own calculations.

Figure 4 depicts the evolution of the standard deviation of the industries' annual value added per employee for the three sectors which typically refers to as σ-convergence (σ-divergence) if the standard deviation - of any productivity measure - decreases (increases) over time (Bernard and Jones 1996; Romer 2001). The processing industries show thereby the most noticeable behaviour. Firstly, the standard deviation fluctuates over time while its mean apparently seems to be constant. With other words, the gap concerning the processing industries' value added related productivities becomes once larger then narrower. Secondly and more important, the gap has significantly increased over time, as Table 5 confirms. Compared to 1995, the gap among the processing industries became larger by 43.5% in 2003.

Table 5. Change of standard deviation: σ-convergence 1995 – 2003

	Average annual change of standard deviation in %	Change 1995 - 2003 in %[1)]
Processing industries	9.8	43.5
Wholesale	11.0	8.6
Retail sale	-3.1	-24.6

Source: Own calculations.1) Wholesale sector 1998 – 2003.

Figure 4 confirms also an earlier observation that already has become clear from Tables 4b and 4c. The standard deviation among wholesale and retail sale industries is significantly lower compared to processing industries. In addition, the retail sector is the only sector within the Danish food industry where σ-convergence actually can be observed, as Table 5 shows. Compared to 1995, the standard deviation there has decreased by 24.6% in 2003 with an average annual rate at 3.1%. Alternatively stated, existing differences among the retail sale industries' value added related labour productivity become smaller over the period under consideration.

The wholesale sector, on the contrary, follows the trend of the processing industries concerning an increased standard deviation if all industries are included. With reference to 1998, the standard deviation has increased by 8.6% in 2003 even though the fluctuation is less unstable compared to the processing industries. There is, however, one single observation in 2003 for one single industry that significantly affects the overall results for the whole sector, namely *Wholesale of tobacco products* (513500). From 2002 to 2003, this industry increases its value added per employee by 43.1% from 459.6 up to 657.5. In addition, the second largest industry lies at 521.6, which increases the measured standard deviation particularly in 2003 if *Wholesale of tobacco products* is included.[13]

Performing the same calculations without the particular industry under consideration, even for 2003 only, changes the overall picture for the wholesale sector significantly. In 2003, the measured standard deviation decrease to 44.5 instead of 68.9. In effect,

[13] The second largest industry is *Other specialized wholesale of food, beverages and tobacco* (523890).

the relative change from 1998 to 2003 changes its sign as there now can be observed a decrease in the standard deviation by 13.8%.[14] This result is important in order to understand the estimation results concerning β-convergence, to be explained and presented below.

β-convergence

The final remark concerns the interesting question what might have caused σ-convergence in the retail sale sector and σ-divergence in the two others. Referring to a commonly tested hypothesis (Bernard and Jones 1996; Romer 2001) stating that industries with lower value added per employee levels possibly grow faster on average than those industries already being on higher levels, the following regression regresses the average annual growth rate of value added per employee (Table 4, column 3) on the logarithm of the initial level of value added per employee in 1995 for the processing and retail sale sector and 1998 for the wholesale sector, respectively.[15] In principle, the calculation corresponds to that of Table 3 regarding industry-level convergence, as presented in section 2.2.2.2. The procedure follows the typical treatment of the so-called β-convergence (Gopinath 2003; Harrigan 1999; Bernard and Jones 1996).[16]

Table 6. β-convergence 1995 – 2003

Dependent variable: Average annual growth rate of value added per employee

Sector	Intercept	Log (initial level of value added per employee)	R-squared	Number of industries (observations)
Processing	-0.5159 *(0.3054)*	0.0987* *(0.0512)*	0.0985	36
Wholesale	0.8619** *(0.3154)*	-0.1368** *(0.0528)*	0.3591	14
Retail sale	0.6370*** *(0.1016)*	-0.1154*** *(0.0190)*	0.7397	15

Note: Standard errors in parentheses.

The estimation results for the processing and retail sale industries are in line with the observations concerning σ-convergence. The slope coefficient for processing indus-

[14] The other years are not affected qualitatively by the fact whether *Wholesale of tobacco products* is included or not.

[15] Column 2 of Table 4 shows – for each industry - the average for all years under consideration. The initial level is thus the first observation that enters the calculation of the presented averages.

[16] The denotation β-convergence refers to the typically chosen name for the slope coefficient in the linear regression of the type $y = \alpha + \beta x$.

tries is positive and significant at the 10% level. This implies that the increased standard deviation among processors can be explained by the fact that productive processors in terms of value added per employee grew faster than less productive processors during the observed period 1995 to 2003.

The same result holds basically for retail sale industries, just with opposite signs. The slope coefficient is negative and significant at the 1% level implying that less productive retail sale industries in terms of value added per employee grew faster than more productive retail industries.

The result for the wholesale sector has to be interpreted taking the above mentioned irregularity concerning *Wholesale of tobacco products* into account. In principle, the same result as in the case of the retail industry applies stating that less productive wholesale industries grew faster than more productive wholesale industries during the observed period 1998 to 2003. Under regular assumptions, this result must necessarily imply a decrease of the measurable standard deviation.[17] As mentioned above, however, the extraordinary increase in value added per employee of *Wholesale of tobacco products* from 2002 to 2003 let the decrease of the sector's overall standard deviation disappear.

2.3. Literature review: Factors affecting value added

In general, there are two different methodological approaches concerning the analysis of the firms' value added performance, the direct, value added functional approach as opposed to the indirect, rather structural approach.[18] Both approaches have, independently of each other, spawned an enormous amount of scientific contributions while first in recent years attempts have been made bringing the two literature branches together by appropriately combining both methodological approaches.

The direct approach relates the firms' value added performance directly to the input factors labour and capital. Firms invest capital in production sites and they hire labour in order to create value added by processing intermediate goods. In this context, researchers typically examine to what extent the firms made effectively use of their input factors by comparing the value added performance on country-, sector-, industry- or firm-level.

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[17] Not considered are cases where initially less productive wholesale industries become even more productive than the remaining industries.

[18] The chosen concepts are rather arbitrary and serve for illustration purposes only.

The indirect approach, on the contrary, takes the input factors as given while focusing on structural variables, as for instance, the degree of competition, the involvement in foreign trade, firm size, market shares, or the stage affiliation, among others, in order to analyse and measure the effect of those variables on the value added performance.

The methodology employed in this report concerning the econometric models, to be presented in sections 3 and 4, follows the recent developments, that is, employing the combined approach. As the structural approach nonetheless gives meaningful insight about the firms' value added performance, the following literature review begins by presenting this approach.

Finally, value added is frequently related to turnover as the ratio "value added to turnover". This ratio is established in the economic literature either as a measure for the level of processing, as a pure economic performance measure, or a measure for the degree of vertical integration.

2.3.1. The structural approach

In general, the literature on value added seems to be dominated by U.S. studies as the establishment of value added as an economic variable relies on a longer tradition there.[19] There are to be found, however, also a number of European studies, in particular from Norway, which reveals a likewise long standing interest in value added, similarly to the U.S. The primary focus of the Norwegian studies was directed towards the product or product group related allocation and distribution of value added through the whole food chain (Strand 1996; Strøm 1999; Løyland et al. 2001) while not explicitly analysing the particular factors determining value added.

Increasing attention has recently been drawn to the link between value adding activities and globalization as successful marketing and product development typically are regarded as essential aspects of long-term sustainability in global markets, both for highly industrialized (Winger 2005), developing (Zugarramurdi 2004) and transition countries (Sevcikova 2003; Gregory and Lazarev 2004). In the Argentine case study by Zugarramurdi (2004), the costs of value adding activities for selected fishery commodities are compared with each other at consecutive stages within the food chain. The costs, however, are mainly affected by the available technology, labour

[19] The Economic Research Service (ERS) of the U.S. Department of Agriculture has published the "Farm Food Marketing Bill" statistics since 1913 which also includes information about the food industries' value added.

productivity, availability of resources and the costs of both financing working capital and new investments in human and physical capital, among others, which may vary from country to country. The effective evaluation of which type of value added products are more convenient is thus the strong recommendation, particularly in the case of developing countries if they want to stay in business. Interpreting effective demand and regional variation in the context of exports, Winger (2005) showed that New Zealand food manufacturers' value added is positively associated with their export activities. Sevcikova (2003) analyses the industry-specific relation between value added and intermediate consumption and investment in fixed assets, respectively, in the case of the Slovak agri-food sector and compares the results with the corresponding outcomes for highly industrialized countries. According to Sevcikova, one explanation for unstable value added growth in Slovakia might be related to volatile disparities between input and output prices. In addition, too large fixed assets ratios in the food sector may indicate the need for new investments. Gregory and Lazarev (2004) examine structural changes in the Russian economy during the recent post-communism period. They report on declining value added shares for the agricultural and industrial sectors as opposed to the continuously growing service sector. Since the related adjustment process concerning the corresponding labour shares are lagging behind, however, undesirable productivity decreases occur which delay the economic catch-up.

Aggregate value added has been shown to be highly correlated with market shares by Rogers (2001). According to his study, the leading 20 U.S. food and tobacco companies have value added to shipments ratio of 54% in 1992, much higher than the 41% of the next 30 largest firms. Rogers also investigated the relationship between firm size and value addition for U.S. food processing, as did Gould and Carlson (1998) for the U.S. cheese industry. They found that where market structure features a few large firms and an increasing number of small firms, the so-called big-small model, the small firms may adopt value adding activities as a competitive strategy while large firms favour cost savings through economies of scales. The study, presenting a survey of 47 Wisconsin cheese plants, shows that the overwhelming majority of the firms' strategic management has embraced product differentiation, value added products and new product development as the main important survival strategies.

Similarly, Buhr (2004) examined U.S. pork producers who engaged in multiple stages of pork production including direct retailing of pork products to consumers. His findings confirm Gould and Carlsons' (1998) result that firms regard differentiating, marketing and merchandizing strategies in order to create competitive niches as the main key to survive. However, a crucial difference between Buhr (2004) and Gould and Carlson (1998) concerns the assumptional framework. Whereas Gould and Carlson consider small-sized firms in concentrated markets, considers Buhr small-scale firms within an otherwise competitive environment.

Addressing concentration directly, Francis (2005) and Braadland (2000) discuss the impact of the competitiveness of the market on value addition in the context of innovation. One claim is that a competitive market discourages value addition because firms cannot differentiate products and reap rewards. A competing one is that fewer buyers and/or sellers will make customers easier to identify in a supply chain format and ease value addition. Christy and Connor (1989) explored the economic, technological and institutional factors shaping value added in US food industries. Their main focus was on regional distributions of structural change in markets, and found them to be significant determinants of regional differences in the number of plants, number of employees and turnover in the US food industry. They identify regional variation in effective demand, input prices, the business climate and managerial preferences for observed regional and firm-level variation.

2.3.2. The value added functional approach

Value added is commonly used as the explanatory variable in connection with the construction of productivity measures by estimating so-called value added functions (Gopinath 2003; Harrigan 1999; Bernard and Jones 1996). Value added is then defined as a function of the firms' capital stock and the level of employment.

In a seminal paper, Bernard and Jones (1996) examine the role of 6 sectors in aggregate convergence for 14 OECD countries (including Denmark) during 1970 to 1987. Their main contribution consists in the construction of a new measure of multifactor productivity which subsequently has inspired many other authors. Their main finding is that the manufacturing sector shows little evidence of convergence as opposed to the service sector which drives the aggregate convergence result. Methodologically, they employ a Hicks-neutral Cobb-Douglas production function with constant returns-to-scale where capital and labour explains value added.

Harrigan's (1999) main contribution consists in taking the possibility for both returns-to-scale and imperfect competition into account in the Bernard and Jones (1996) model. Bernard and Jones (1996) used labour and capital shares as an approximation for the elasticities of value added with respect to labour and capital, respectively. This procedure requires, however, the assumption about perfect competition whereas Harrigan (1999) estimated the elasticities of labour and capital directly. Employing his model on a panel data set of 11 OECD countries during the 1980s, he confirms Bernard and Jones (1996a) result regarding large and persistent differences in total factor productivity across sectors and countries. In addition, existing economies of scale are not large enough in order to be capable of explaining those differences.

Gopinath (2003) employed Harrigan's (1999) model for the particular case of food industries based on a panel data set consisting of 13 developed countries (including Denmark) covering the period 1975-1995. His results suggest significant differences in technology across countries and decreasing returns to scale. Finally, the levels and growth rates of productivity are inversely related.[20]

2.3.3. The combined approach

The combined approach is characterized by basically referring to the production functional approach while extending the classical Cobb-Douglas function by additional variables which also may include structural determinants. Bosworth and Loundes (2002) estimate the determinants of value added as part of a study of productivity of Australian firms. Their results suggest a positive relationship between value added and both, exports and market share, a negative relationship between value added and concentration ratio and finally, no relationship between advertising and value added.

There exist a number of empirical studies focussing on the productivity especially of Danish firms. Dilling-Hansen et al. (1998) examine a 1993 cross section of Danish manufacturing firms, also including food processing firms. They extend the standard Cobb-Douglas production function which typically addresses labour and capital by including additional variables indicating the industry-specific degree of competition and some firm-specific characteristics such as size, age and ownership. Among others, their results show a positive relationship between the firm's market share, the industry's degree of concentration and productivity. The authors remark, however, that the positive relationship might also be caused by the particular choice of data which is limited to one cross section only.[21] In addition, the larger firms experience financial

[20] According to his results, Denmark turns out to be the most laggard country with its TFP level only 15% that of the United States.

[21] The authors' comment refers to Nickell et al. (1997) who found a strongly negative relationship between the firms' productivity and the degree of competition among 670 UK companies over the period 1975 to 1986.

pressure, the more productive they operate. Finally, stock companies operate generally more successfully.

Based on the observation that IT related industries attain the largest amount of value added per employee and the largest growth rate in value added per employee, Dilling-Hansen et al. (2002) analyses the behaviour of Danish IT related firms compared to the remaining firms within the Danish manufacturer and service sector at three independent years within the period 1990 to 1998.[22] Basically using the same model as in Dilling-Hansen et al. (1998), the major difference constitutes, however, the inclusion of dummies for IT-related firms. The results state a positive relationship between affiliation to IT-related industries and productivity and they confirm the negative relationship between solvency and productivity and the positive relationship between the degree of concentration among manufacturing firms and productivity, as already observed in Dilling-Hansen et al. (1998). When including service firms, however, the measured relationship concerning the degree of competition changes its sign significantly.

Dilling-Hansen et al. (2003) found evidence for significantly higher total factor productivity for firms located in so-called industrial clusters in a panel data set of Danish firms covering the period 1990 to 2000. A classical Cobb-Douglas production function with labour and capital as its input is extended by a dummy variable indicating whether firms belong to clusters. There could, however, not be found a statistically significant relation between cluster affiliation and firms belonging to the food sector.

2.3.4. Value added to turnover

The business research company BIS Shrapnel prepared a comprehensive report on the Australian food and beverage sector covering the period 1997 to 2001 (BIS Shrapnel 2003). As an indicator for the level of processing, data on value added to turnover were collected for the main food processing industries. To a large extent, the ranking of Australian food industries corresponds thereby to that presented in Figure 3. At aggregate level, Australian food processors reached a ratio of 28% on average during the period of observation, which is larger than the corresponding Danish ratio. Their results show considerable variation across industries turnover and value added growth rates, which in turn explain differences in the ratio value added to turnover. Among the price development of purchases and other intermediate goods expenses, labour

[22] The study contains three independent estimations for the years 1990, 1994 and 1998, respectively.

productivity increases (for meat, dairy, oils and fats, and other food products) and increases in labour to boost output (fruit and vegetable processing, flour milling, cereals, malt and beverages) are regarded as the main reasons for the variation in turnover and value added growth rates.

A related interpretation of the ratio value added to turnover as a measure for the level of processing is employed in studies of the structure, conduct and performance of the European food sector (Viaene and Gellynck 1995; Corsani et al. 1990). In general, food processing industries operating at the first stage of transformation have lower ratios of value added to turnover than those operating at the second stage. Examples for the former type are grain milling and slaughtering, and for the latter chocolate and biscuit confectionary, and brewing.

As a relative measure for the degree of value-adding, a study on the relationship between high-technology and value added reports on a positive correlation between value added to turnover ratios and the extent of high technology in the service sector, but not necessarily in the manufacturing sector (Götzfried 2004), apart from some exceptions which are not relevant for the present study. A second result is related to the observation that so-called SME firms are more likely to innovate in-house as compared to large companies who rather draw on external services. As a consequence, SME firms have larger value added to turnover ratios, *ceteris paribus*.[23]

As an economic performance measure, value added to turnover is used in a study on EC agricultural cooperatives on three food sub-sectors, namely meat, milk and cereal processing-farm input supply (Mauget and Declerck 1996). These authors identify three main explanations for better performance: first, cost leadership (mainly attempted by meat cooperatives); second, product differentiation (implemented successfully by diary cooperatives); and finally ongoing concentration through merger and acquisitions in order to finance capital-intensive expansions that were necessary for large export activities.

[23] SME: small and medium-sized enterprises (10 to 249 persons employed).

A lower ratio of value added to turnover can also be an indication for the degree of vertical integration (Zeile 1998). A study on the comparison of U.S. affiliates of foreign owned manufacturing companies with domestically owned firms shows significantly lower value added shares for U.S. affiliates than for the domestically owned counterparts, indicating that the production of affiliates tends to be much less vertically integrated, as suggested by the author. Differences in the ratios of value added to turnover reflect then the firms' so-called "make or buy" decision (*ibid*)

3. Model and hypotheses

3.1. Introduction

Section 3 presents two econometric models of a value added function where the first model includes all firms within the same sector, which in the following will be denoted as the sector-level model. The second model then comprises of all firms within the same industry, analogously referred to as the industry-level model. The value added function in both models allows thereby for two independent economic interpretations. Firstly, it becomes possible to estimate elasticities of value added with respect to various input factors and structural variables. Secondly, and quasi as a by-product of the particular model specification under consideration, it allows for conclusions about the development of the firms' total factor productivity TFP which subsequently can be compared with the results concerning the earlier calculated labour productivity.

The value added function to be presented here differs though form the classical approach by the explicit inclusion of all input factors, also the intermediates apart from labour and capital.[24] Normally, the intermediates typically enter so called gross output productivity measures where the value of shipment or turnover is related to the number of employees, rather than value added. Since the differences between both approaches have been discussed extensively in the economic literature, both theoretically and empirically, the next subsection presents is devoted to a brief overview of the ongoing discussion by pointing out the main methodological advantages and disadvantages concerning the two different TFP measures. A more comprehensive presentation can be found in the excellent review article by Cobbold (2003).

3.2. Value added versus gross output productivity measures

In general, productivity measures relate some output variables to some input variables and a larger ratio is then interpreted as higher productivity, *ceteris paribus*. In the case of TFP productivity measures, two output variables are commonly used, namely gross output or value added. In the former, gross output is related to capital, labour and intermediate inputs, whereas in the latter, value added is related to capital and labour only. The conceptual differences of both measures require some caution when com-

[24] In this study, the terms *intermediates* and *goods and services* (CGS) are used synonymously. The former is more convenient in the economic literature whereas the latter corresponds to the official notion of *Statistics Denmark*.

paring them with each other, either on industry, sector- or country-level. The differences become though smaller the higher the level of aggregation as intermediate usage tends to be a much higher proportion of gross output at industry- or sector-level (Cobbold 2003).

The value added related TFP productivity measure is an appropriate measure for comparing industries within specific sectors with each other as they do not take inter-industry flows of inputs into account (OECD 2001). In addition, the value added approach is closer related to the firms' profit maximisation aim as lower-cost intermediates yield a larger amount of value added (Wiel 1999). The approach may, however, lead to biased estimates due to two reasons.

Firstly, the formal definition of value added (VA), as used in this study, being the difference between gross output (Y) - measured in terms of turnover - and consumption of goods and services (CGS) purchased from other firms, implicitly assumes the underlying production function to be additive-separable of the form Y = VA + CGS. This assumption imposes restrictions on the generality concerning the firms' behaviour and the role of technology (Gollop 1979). It neglects substitution possibilities between capital and labour on the one side and goods and services on the other side which becomes relevant, for instance, if the prices of output and those of goods and services do not rise at the same rate (Jorgensen et al. 1978). In addition, it implies that goods and services cannot be source of productivity growth (Gollop 1979).

Secondly, it can formally be shown that TFP productivity growth, measured by the value added approach, systematically exceeds the corresponding gross output measure by a factor equal to the ratio of gross output to value added (Diewert 2001). As a consequence, the estimates affect then also growth trends for inter-temporal comparisons (Gullickson and Harper 1999) as well as for inter-industry comparisons (Wiel 1999). Several empirical studies have confirmed the overestimation of the value added approach, as for instance, Oulton and O'Mahony (1994) for UK manufacturing firms, Wiel (1999) for Dutch industries or a recent study on industry growth in Australia (ABS 2003).

One may, however, be less concerned about the second conceptual disadvantage for following reasons. Firstly, the implementation of an industry production function within growth accounting may be considered as a flawed concept, independently which approach is chosen since it assumes a representative firm (Cobbold 2003). There are to be found, however, numerous empirical studies having confirmed persistent productivity differences among firms within the same industry (Bailey et al. 1992; Bartelsmann and Doms 2000; Barnes and Haskel 2000). Secondly, the formal relationship between both approaches, as shown by Diewert (2001), would allow for an appropriate correction, if this was necessary. Thirdly, there is some evidence for both measures are consistent anyway in showing whether TFP productivity growth is either in- or decreasing, the value added approach is then likely to overestimate the extent of the changes, if they occur at all (Cobbold 2003; Oulton and O'Mahony 1994). Finally, the purpose of this study is to compare industries and firms with each other. According to the recommendations of the OECD (2001), the value added approach is more useful then. On the contrary, the gross output approach is considered as the more appropriate one in terms of estimating sectoral contributions to aggregate productivity estimates (Cobbold 2003; OECD 2001).

The preceding discussion does not affect labour productivity measures - as presented and discussed in section 2.2.3 - in the same way, independently which approach is chosen and the recommendations are thus somehow mixed. In fact, the value added approach is the more favourable one in the case of outsourcing since it is sensitive to substitution between inputs and goods and services (Huang 2003; Cobbold 2003).

3.3. The model

3.3.1. The sector-level model

Assume for a particular firm *i* in industry *j* at time *t* within the same sector, the real value added y_{it} can be represented by a function of the real capital stock k_{it}, the real expenses for raw material r_{it} and the number of employees l_{it}:

(1) $$y_{it} = f_{jit}(k_{it}, r_{it}, l_{it})$$

The assumption of Hicks-neutral technology differences across firms and over time implies rewriting the above equation as:

(2) $$y_{it} = \beta_{jt} g_{it}(z_{it}^{k})$$

where β_{jt} denotes an industry-specific index of TFP at time *t* and z_{it} refers to all *k* inputs. The assumption of Hicks-neutral technology differences may be rigid, it allows nevertheless for an easy interpretation of the causes of productivity changes (Huang 2003). The suggested set-up follows basically Bernard and Jones (1996), Harrigan

(1999) and Gopinath (2003), with the exception of one crucial difference as follows. Raw material enters into the function as an explanatory variable which does not alter the function into a gross product function as value added remains the dependent variable on the left side. The inclusion, however, does not solve the additive separability problem, which still has to be assumed (Gollop 1979). The main advantage of the inclusion becomes clear when differentiating (2) with respect to time:

$$\frac{dy_{it}}{dt}\frac{1}{y_{it}} = \frac{d\beta_{jt}}{dt}\frac{1}{\beta_{jt}} + \sum\nolimits_k \frac{\partial g_{it}}{\partial z_{it}^k}\frac{z_{it}^k}{g_{it}}\frac{dz_{it}^k}{dt}\frac{1}{z_{it}^k} \tag{3}$$

Equation (3) shows the rate of change in value added as the sum of the rate of change in TFP and a weighted average of the change in various inputs, also that of raw material. Thus, the inclusion of raw material weakens one of the main objections against the value added approach - as pointed out in section 3.2 - since it explicitly takes the effect of raw material into account (Gollop 1979).

Under the assumption of a Cobb-Douglas technology, (1) can be estimated as:

$$\ln y_{it} = \alpha_{0t} + \alpha_1 \ln k_{it} + \alpha_2 \ln r_{it} + \alpha_3 \ln l_{it} \tag{4}$$

Subtracting $\ln l_{it}$ from both sides yields:

$$\ln\frac{y_{it}}{l_{it}} = \alpha_{0t} + \alpha_1 \ln\frac{k_{it}}{l_{it}} + \alpha_2 \ln\frac{r_{it}}{l_{it}} + \gamma \ln l_{it} \tag{5}$$

where

$$\gamma = \alpha_1 + \alpha_2 + \alpha_3 - 1\,. \tag{6}$$

Equation (5) represents now value added per employee. Observe that $1 + \gamma$ reflects the firms' returns to scale implying that the coefficient γ indicates deviations from constant returns to scale.

On sector-level, it is reasonable to assume the TFP index varies across industries and over time (Bernard and Jones 1996; Harrigan 1999; Gopinath 2003). For that reason, accounts for both the industry affiliation and the time dimension. A statistical model emerges thus as:

(7) $$\ln\frac{y_{it}}{l_{it}} = \beta_{0j} + \beta_{1j}t + \alpha_1 \ln\frac{k_{it}}{l_{it}} + \alpha_2 \ln\frac{r_{it}}{l_{it}} + \gamma \ln l_{it} + \varepsilon_{it}$$

where β_{0j} denotes industry level of TFP at time $t = 0$ while β_{1j} refers to the industry-specific constant average annual growth rate of TFP and ε_{it} is the error term. The coefficients α_k denote the elasticity of value added with respect to the input factors. The fact that all variables are divided by l_{it} does not change the interpretation of the α_k. When adding industry-specific structural variables to the model, as for instance the industry-specific market concentration μ_{jt} at time t, (1) changes to:

(8) $$y_{it} = f_{jit}(z_{it}^s, l_{it})\mu_{jt}^{\delta}$$

where $s = 1,...,k - 1$ and where δ denotes the elasticity of μ_{jt} with respect to the structural variable μ_{jt}. This leads to the final sector-level equation to be estimated:

(9) $$\ln\frac{y_{it}}{l_{it}} = \beta_{0j} + \beta_{1j}t + \sum_s \alpha_s \ln\frac{z_{it}^s}{l_{it}} + \gamma \ln l_{it} + \delta \ln \mu_{jt} + \varepsilon_{it}$$

3.3.2. The industry-level model

In principle, the industry-level model is analogous to the sector-level model apart from two changes: First, industry-specific structural variables lose their explanation power. Thus, the industry-level model does not include structural variables. Secondly, the assumption on industry-specific TFP levels and growth rates applies analogously, that is, within industries, it is reasonable - and in the case of the industry-level model actually feasible - to assume TFP varies across firms and over time. This modification, however, improves one critical assumption of the sector-level model. It does not need the assumption of a representative firm, as pointed out on section 3.2 (Bailey et al. 1992; Bartelsmann and Doms 2000; Barnes and Haskel 2000).

Otherwise analogous arguments as above lead to the following equation to be estimated:

(10) $$\ln\frac{y_{it}}{l_{it}} = \beta_{0i} + \beta_{1i}t + \alpha_1 \ln\frac{k_{it}}{l_{it}} + \alpha_2 \ln\frac{r_{it}}{l_{it}} + \gamma \ln l_{it} + \varepsilon_{it}$$

More input factors can easily be added. For both models hold that it is not possible to impose (6) as an estimable restriction since α_3 is not explicitly identified by the regression.

The motivation for two independent estimations depends mainly on the central assumption concerning the elasticities α_k. The assumption on fixed coefficients for all industries within the same stage is in the first place a somehow restrictive assumption that lacks both theoretical as well as empirical evidence. Allowing the coefficients to vary across industries, however, would require allowing for all elasticity coefficients to vary in the general case. The joint estimation of all firms within the same stage, however, would then become nearly useless, as opposed to pure industry-level estimation. On the other hand, and as already mentioned above, industry-specific structural variable lose their explanation power. Secondly, if the coefficients α_k differ across industries or firms, comparison of the TFP measure can be misleading. The problem with β_{it} as a TFP measure is that it is incomplete. The assumption of Hicks-neutral technology does not take into account that the technology of production varies with the parameters α_k as well as with the β_{it} (Bernard and Jones 1996).

As a compromise, the primary focus of the sector-level model is directed towards the industry-specific TFP level and growth as well as towards the influence of the structural variables on value added while accepting the assumption on fixed elasticity coefficients. On the contrary, the industry-level model focuses rather on the firm-specific elasticity coefficients as well as on the firm-specific TFP levels and growth rates. Both models have thus an independent agenda which do not counteract. Finally, the restriction to sector-level estimation as opposed to chain-level estimation is mainly due to obvious significant structural differences between processing, wholesale and retail sale firms concerning the character of typical production processes, relation to down- and upstream markets and similarly related features.

3.4. Hypotheses

On the one hand, the individual firm's value added performance is certainly affected by internally related efficiency considerations concerning the most effective use of the firm's input factors. Firms within the same industry, however, may similarly be affected by industry-specific factors regarding production processes and plants, seller- and buyer-markets, raw materials and so on. Those industry-specific factors are thus expected to determine the value added creation for all firms within the same industry systematically. Many of the recent international productivity studies assume country-or sector-specific determinants which are capable of explaining existing differences in the countries' or sectors' value added creation (Harrigan 1999; Bernard and Jones 1996; Gopinath 2003). The same argument, however, applies one level below as well. A few numbers of firm-level studies, particularly Danish firm-level studies, identified significant differences due to industry affiliation (Dilling-Hansen et al. 1998; Dilling-Hansen et al. 2002).[25] In addition, the preliminary analysis in section 2.2.2 has already revealed considerable differences in the sector-specific labour productivities in terms of value added per employee as well as a significant indication for divergence of industries within in the processing sector and convergence of industries within the wholesale and retail sale sector. Both arguments together imply thus:

Hypothesis 1: The value added performance of Danish food firms depends significantly on their specific industry affiliation.

Many authors have examined the relationship between value added or turnover and the degree of concentration, with opposite results in nearly equally shares in terms of the number of publications. Dilling-Hansen et.al (1998) estimated a positive relationship for Danish manufacturer due to the efficiency hypothesis. Analogously, Rogers (2001) shows the strong association between market shares and value added among U.S. food processors after comprehensive concentration and consolidation trends in the U.S. food industry which has led to the occurrence of so-called big-small markets. In addition to the efficiency hypothesis, large firms exercise their market power which increases their value added shares. While the latter two arguments apply for large firms in big-small markets, Gould and Carlson (1998) argue that intensive product differentiation activities in so-called niche markets may constitute the appropriate survival strategy for the very small firms in exactly the same big-small markets due to the need for competition with large firms in areas others than costs.

On the contrary, Nickell et al. (1997) estimated a negative relationship for UK firms as well as Bosworth and Loundes (2002) argue for Australian firms that a lower degree of competition restricts the individual firm's possibilities to raise the prices, thus the degree of concentration and value added is negatively related. Buhr (2004) applies the above mentioned product differentiation argument for particularly competitive environments where product differentiation is regarded as the effort to ensure competitive niches, according to the well-known theory on monopolistic competition.

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[25] In particular, Dilling-Hansen et al. (1998) estimated a significantly positive relationship between the firms' value added performance and affiliation to the Danish food sector's industries.

Similarly to the recent developments in the U.S., however, the Danish food sector has also been impacted by enormous structural changes involving concentration and consolidation trends which have taken place during the last decade, as for instance documented in Baker (2003) or Nordic Council of Ministers (2004), which has led to many big-small markets within the whole food chain (VIFU 2006) implying thus:

Hypothesis 2: The degree of concentration affects the value added performance positively.

The following argument is an implication from the potential correctness of the proceeding hypothesis. If the degree of concentration affects the value added performance positively, in accordance with the above mentioned efficiency and market power theory, then one should observe increasing returns-to-scale. Dilling-Hansen et al. (1998) reports on weakly increasing returns-to-scale among Danish manufacturer. VIFU (2006) conjectures increasing returns-to-scale as the main reason for the ongoing consolidation among Danish food firms.

Hypothesis 3a: The Danish food sector has increasing returns-to-scale.

The following two sub-hypotheses are closer specifications of hypothesis 3a: Firstly, increasing returns-to-scale in food industries is not a newly observed phenomenon. Gould and Carlson (1998) report on significant increasing returns-to-scale in the U.S. cheese industry. Hayenga (1998) shows increasing returns-to-scale in the U.S. pork slaughter industry as Rogers (2001) does for selected industries in the U.S. food sector. One possible explanation for the existence, apart from the otherwise well-know natural monopoly hypothesis, is presented by Ethier (1982) stating that trade costs (tariffs and transport) can explain increasing returns-to-scale as intermediate goods become cheaper in large markets. The Danish food markets are obviously different in size as not for all industries the subadditivity property holds. The latter two arguments imply:

Hypothesis 3b: Not all industries in the Danish food sectors have increasing returns-to-scale.

Secondly and as a direct consequence, as increasing returns-to-scale are associated with concentration and consolidation, it may thus become possible partly to explain differences in the industry-specific firm (net) exit rates if an exact identification of those industries with increasing returns-to-scale is feasible. For instance, the overall exit rate among Danish processors lies approximately at 4% annually on average during the period 1995 to 2003 (see also Baker 2003 and Hansen 2005). On industry-level, however, one can observe industries with 10% annual increases in the number of firms as well as industries with 10% annual decreases. Similar observations hold for the wholesale and retail sale sectors. Thus:

Hypothesis 3c: The identification of those industries with increasing returns-to-scale explains differences in firm exit rates during the period 1995 – 2003

As already mentioned above, cheaper trading costs let firms in larger markets operate more efficiently as compared to smaller markets (Ethier 1982). In addition, a simple theoretical argument justifies the following reasoning. For a given market share, together with the assumption on increasing returns-to-scale, possible efficiency advantages become relatively larger, the larger the market is, which consequently enhances the firms' value added performance. Thus:

Hypothesis 4: The market size affects the value added creation positively.

Production functional oriented studies on value added typically include capital and labour as the only input factors. In most cases, this may be explained by data availability problems. To the author's best knowledge, no such study exists, which also explicitly includes all other input factors such as energy, external services and raw material. As a consequence, little is known about the value added related input factor elasticities, which makes it more difficult to formulate appropriate a priori hypotheses.

This lack of knowledge may surprise, especially in the light of Christy and Connor (1989) who claimed the vector of input prices (raw material, business services, energy) to be one of four main factors affecting the long-term growth of any industry.[26] In addition, the price development of some particular input factors may force the industries to structural efficiency enhancing investments, as, for instance, reported by Hansen (2005) in the case of energy costs.

In addition, models who only take capital and labour into account may systematically overestimate the influence of capital on value added as the estimated elasticities with

[26] The other three factors are effective demand for foods and beverages, business climate and the mix of industries, respectively. See Christy and Connor (1989), page 19.

respect to capital may also contain parts of the corresponding elasticities of other input factors. This principle problem is solidly recognized and well documented in the literature (Barro and Sala-i-Martin 1992; Mankiw, Romer and Weil 1992). For instance, Dilling-Hansen et al. (1998) estimates capital elasticities at the range of 0.117 to 0.153 for Danish manufacturer, Dilling-Hansen et al. (2002) estimates elasticities no less than 0.117, depending on the specific model under consideration for Danish service and manufacturing firms. Gopinath's (2003) lowest estimate lies at 0.226 in a model for food processors covering the period 1975 to 1995. Taking all input factors into account may therefore imply:

Hypothesis 5: The elasticity of value added with respect to capital is typically overestimated.

This section concludes by briefly discussing why other, apparently obvious hypotheses are not going to be tested in this report. In all cases, data and data related problems have been the main reason for not specifying further hypotheses.

Among others, Dilling-Hansen et al. (1998) verify a u-shaped relationship between firm size and value added performance among Danish manufacturer. However, the inclusion of industry-specific and size dummies in the data set at hand has shown to lead to some undesirable linear dependencies in those cases where industries exclusively consist of plants which all fall into the same size category. The individual firms' market share has not been included either due to the high correlation with labour force. In the data set under consideration, the overall correlation between the market share and labour among processors, for instance, lies at 83%. In more than one industry, however, the industry-specific correlation coefficient climbs up to 98%. Finally, compatible firm-level data on export and import have only been available for the period 2001 to 2003.

4. Estimation

4.1. Data and choice of variables

The data material in this study comes from Denmark's Bureau of Statistics *Statistics Denmark* comprising individual firm-level data of the annual industry accounts statistics (*regnskabsstatistik*). The included firms belong to the food processing and food retail sector covering the period 1995 to 2003 and to the food wholesale sector covering the period 1998 to 2003. The data are not publicly available due to confidentiality.[27]

The annual industry accounts statistics contains aggregated numbers on the firms' annual sales, purchases and expenses which can be used to calculate the firms' profits, value added and total costs. The appendix contains a complete list of all variables, inclusive their internal labelling at *Statistics Denmark*, and a description of what the derived variables are composed of.

For empirical estimation, the dependent variable y is the logarithm of value added over the number of employees. The set of explanatory variables are constructed from available data on firms' input factor expenses and selected industry-specific structural variables.

For the stage-level estimation, the firm's capital stock, raw material and labour have been chosen. The structural variables include the industry market size and the industry 4-firm concentration ratio. For the industry-level estimation, no structural variables are included. Instead, all available input factors, in addition to the already above mentioned have been chosen. The following Table 7 provides a summary of the variables used.

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[27] However, summaries and aggregated numbers on industry-level can be found on http://www.statbank.dk/statbank5a/default.asp?w=1024

Table 7. List of variables

Variable	Definitions and notes
Value added	*Turnover plus other operating income minus consumption of goods and services* where turnover represents the net sales plus capitalised work performed by the firm for its own purposes and all charges (transport, packaging, etc.) passed on to the customer. Turnover excludes reductions in prices, rebates, discounts, VAT and excise duties, other operating income, financial income and extraordinary income in company accounts. Consumption of goods and services includes purchases of goods, services, energy and adjustments to account for changes in stocks.
Number of employees	Number of full-time-equivalent employees hired.
Raw material	Expenditures for raw material.
Energy	Expenditures for energy.
External Costs	External costs include expenses for cleaning, on-the-job training, stationeries, communication, lawyers, business travels and advertising.
Other Costs	Expenditures for all other costs include rent payments, costs of subcontractors, minor equipment and other secondary charges.
Capital	Book value of capital.
4-firm concentration ratio	The market share of the 4 largest firms which has not been adjusted for import and export.
Market size	The total of all firm's turnover within the same industry

4.2. Data issues

The lower bounds for being recorded in the industry account statistics have changed in 1999. Up to 1998, all firms with paid employment or an annual turnover of at least DKK 20 thousand have been listed in the statistics. From 1999 on, however, the lower bounds have been raised such that firms with at least 0.5 annual full-time equivalent units or an annual industry-specific minimum profit have been considered only. The industry-specific calculation of the necessary minimum profit is related to the firms' typical annual turnover. For processing industries, the borderline lies at DKK 150 to 200 thousand annual turnover whereas for wholesale firms the borderline lies at approximately DKK 300 thousand annual turnover. This change affected the number of recorded firms significantly. However, the economic effect is negligible, as confirmed by *Statistic Denmark*.

For comparison purposes, the annual data in current prices have been deflated. There are generally two dimensions which have to be taken into account. Firstly, firms belong to different stages within the food chain and secondly, some of the data are related to the firms' output whereas others are related to the firms' input factors. After looking for appropriate deflators, the above mentioned criteria could not have been incorporated in all cases properly as explained below.

In general, all input factors of the processing industry (capital, raw material, energy, external costs and other costs) have been deflated with the Danish raw material price index.[28] The processing industries' value added has been deflated with the Danish food industry price index which also has been used to deflate the input factors of the retailer firms as the retailers' input typically consists of the processors' output.[29] The retailers' value added has been deflated with the net food price index.[30]

Unfortunately, there does not exit an appropriately applicable wholesale price index. For that reason, both the input factors and the value added of all wholesale firms have been deflated with the Danish food industry price index. In the light of the lack of an appropriate index, this choice can be stood up for following reasons: First, similarly to the retail sector, the wholesale firms' input consists mainly of the processing firms' output. Secondly, it is not uncommon that processing firms establish sales subsidiaries which then operate as a wholesale firm in a legal sense. This kind of vertical integration may let the wholesale industry being closer related to the food processing industry than to the end consumer.

In some cases, one could have employed more disaggregated price indexes. There exist a couple of specific deflators for certain product groups or even single products. In addition, some of the secondary input factors might have been deflated with specific price indexes such as in the case of energy, for instance. However, as raw material typically constitutes the by far largest input factor within all stages, other secondary input factors have been disregarded concerning this question, last but not least, in order to keep the deflational manipulations clearly, taking into account the huge amount of available data.

4.3. Estimation method and econometric issues

Even though based on both theoretical grounds and empirical evidence, it turned out that the assumption on industry- and firm-specific TFP growth rates in equations (7) and (10) in some cases has led to insufficient estimation results. In fact, the estimation results in those cases could have been improved considerably by dropping this par-

[28] Can be found at *Statistics Denmark*: Sub-index *Raw material for other industries, total* of PRIS10: Price index for Domestic Supply (2000=100) by commodity group and Danish/imported.
[29] Can be found at *Statistics Denmark*: Sub-index *15009 Manufacture of food, beverages and tobacco* of BRPRIS01: Industrial output price index (2000=100) by industry.
[30] Can be found at *Statistics Denmark*: Sub-index *0.01 Food* of PRIS7: Net price index (2000=100) by commodity group.

ticular assumption. For this reason, the stage model has generally been estimated twice both with industry-specific parameter β_{1j}, where j refers to the industries, and common growth rate β_1 for all industries. The former model is referred to as model 1 while the latter specification is referred to as model 2. Analogously, models 3 and 4 refer to the corresponding industry estimations, respectively.

A feasible estimator for the analysis of panel data is the FGLS estimator (Wooldridge 2002; Harrigan 1999; Gopinath 2003; Green 2003).[31] In particular, the stage models 1 and 2 have generally been estimated as random effects models where firm-specific differences are assumed to be distributed randomly. The industry affiliation is captured by β_{0j}. This specification, however, was equivalent to the term $\beta_0 + d_j$ which pinpoints a structural problem. The Hausman test statistic becomes useless in the case of the stage estimation, as the Hausman test statistic compares the actual random effect specification, as specified by equation (7), with the corresponding firm-related fixed effects model. The firm-related fixed effects model, however, does not correspond to the intended model specification as presented in sections 3.3.1 and 3.3.2.

The estimations have been carried out with the SAS procedure TSCSREG which does not allow for clustering. Alternatively, industry-specific means concerning all involved variables have been calculated and subsequently been estimated while comparing a fixed effects industry model against a random effects stage specification without industry effects. If the Hausman test rejects the random effect version of this industry-level estimation, one may use the result concerning the question whether to include industry-specific dummies in a random effect firm-level estimation. In all cases, the fixed industry specification has turned out to be the superior specification.[32]

The proposed procedure is not based on flawless econometric textbook reasoning, as it constitutes a pure practical solution in order to avoid the handling of roughly 6000 individual fixed firm effects. An additional economic argument justifying this procedure, however, will be presented in the paragraph after the next one aimed at arguing for which criteria one reasonably might consider as being relevant concerning the grouping of firms.

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[31] Alternatively, the REML estimator would become feasible if the error term ε_{it} in (7) has a multivariate normal distribution with mean zero.

[32] The author is grateful to Prof. J. Wooldridge from Michigan State University for suggesting this practical help when discussing and presenting this specific problem on a NOVA workshop on panel data estimation in Helsinki, Finland, June 2007.

Concerning the individual industry estimations, the problem in relation to the Hausman test statistic does not occur and the random effects specification has been chosen in case of at least 10% rejection level. This particular borderline at 10% is arbitrary and other borderlines would have yield different specifications in some cases. For unexplainable reasons, however, the test statistics turned out either to be every low or very high in most of the cases which makes the discussion about the actually chosen borderline less relevant.

A legitimate objection to the fixed or random effects model specification is its disregard for the possibly of contemporaneous correlation in the data, making SUR estimation preferable. Indeed, there may be groups of industries closely related to each other. In the general case, however, this is debatable and does not adequately support the use of models other than the fixed and random effects models in the industry-level dataset. With respect to the firm-level dataset, the issue does not arise. However, the relevant question then concerns the (likely) correlation between firms. The current study assumes that this correlation - or similarity of firms - is mainly due to industry affiliation. This issue is addressed by the inclusion of fixed industry dummies.

It may not surprise that some firms have entered the industry after the beginning of the observed period 1995 to 2003 as well as some firms may have exited the industry before 2003. From this follows that the data set at hand obviously is unbalanced. The data used for the industry estimations are just the respective subsets of the overall dataset. In principle, efficiency and consistency of the used FGLS estimators is based on the assumption of balanced data. The SAS software package, however, corrects for this problem appropriately.

Since the depending variable is the log of value added per employee, negative value added generates undefined values. In addition, SAS software package requires for each cross section at least two consecutive time observations. All firm observations, not satisfying those two assumptions have thus been removed from the original dataset. In terms of the number of firms, the actual effect is below 5% and in terms of the affected value added, the actual effect is even lower as typically economically less active firms have dropped out.

A final comment concerns the specified value added function of Cobb-Douglas type. This particular functional relationship is a special case of the more flexible trans-log function and there is no a priori reason to assume the Cobb-Douglas type to be the superior functional relationship. Various tests and preliminary estimations have shown, however, that the trans-log specification did not yield sufficiently satisfactory results. There have been some industries where the trans-log specification indeed showed better results. In the majority of cases, however, the degree of significance was very low. In addition, multi-collinearity between input factors became a serious problem. For those reasons, the Cobb-Douglas specification has been chosen for the final model estimations.

4.4. Results

4.4.1. Sector estimation

Processing industries

The results on sector level show that differences in value added per employee to large extent can be explained by persisting differences in the industries' TFP levels. This result holds generally for all three sectors. Table 8 summarizes the results for the processing industries.

Recall from sections 3.3.1 and 4.3 that model 1 refers to the specification with jointly fixed TFP growth rate β_1 for all industries while model 2 refers to the specification with individual growth rate β_{1j} for each industry *j*. For both models holds that the intercept coefficient β_{0j} refers to the TFP level. The coefficients for capital and raw material denote the elasticities with respect to value added and the coefficient for returns-to-scale γ depicts the degree of deviation from constant returns-to-scale. If γ is positive (negative), then the industry is characterized by increasing (decreasing) returns-to-scale.

According to model 1, the TFP level ranges from a low 2.0284 for *Manufacture of condensed milk* (155120) to 3.6197 for *Baker's shops* (158120). The top 3 leading industries comprise *Baker's shops* (158120), *Manufacture of starch and starch products* (156200), and *Manufacture of malt* (159700). In only two cases out of 39 included industries, the estimated parameters for the TFP level are not statistically significant, namely *Manufacture of refined oils and fats* (154200) and *Manufacture of cider and other fruit wines* (159400). Both industries, however, consist of a very few number of firms, which may explain the insignificance.[33] All industries' TFP levels grow on average by approximately 1% annually.

[33] The former industry consists of 5 recorded firms at most whereas the latter one consists of one individual firm only.

Table 8. Sector-level estimation results processing industries 1995 – 2003

	Model 1	Model 2	
Industry	**TFP level** β_{0j}	**TFP level** β_{0j}	**TFP growth** β_{1j}
Production, processing and preserving of pork (151110)	2.259664***	2.795382***	0.03588***
	(0.3127)	*(0.4043)*	*(0.00954)*
Production, processing and preserving of beef (151120)	2.460057***	2.854718***	0.044922***
	(0.2974)	*(0.3706)*	*(0.0105)*
Gut dressing factories (151130)	2.934552**	3.382127*	0.017213
	(1.4734)	*(1.7657)*	*(0.0359)*
Processing of animal offal and production of bone meals (151140)	2.648098***	3.537834***	-0.03536
	(0.3431)	*(0.6323)*	*(0.0572)*
Production, processing and preserving of poultry meat (151200)	2.293788***	2.942883***	-0.01674
	(0.5881)	*(0.7169)*	*(0.0164)*
Production of prepared meat dishes (151310)	2.252211***	2.650783***	0.050633***
	(0.2805)	*(0.3599)*	*(0.0121)*
Other production, processing and preserving of meat products (151390)	2.357567***	2.938938***	0.008379
	(0.2662)	*(0.3442)*	*(0.00525)*
Production, processing and filleting of fish and fish products (152010)	2.615854***	3.244379***	0.013436**
	(0.2903)	*(0.3745)*	*(0.00567)*
Smoking and salting of fish (152020)	2.535573***	3.187631***	-0.00312
	(0.2723)	*(0.3433)*	*(0.00725)*
Production of bone fishmeal (152030)	2.778388***	3.353574***	-0.01344
	(0.3134)	*(0.3850)*	*(0.0179)*
Processing and preserving of potatoes (153100)	2.416206***	2.801938***	0.012489
	(0.3767)	*(0.4568)*	*(0.0183)*
Manufacture of fruit and vegetable juice (153200)	2.066413***	2.516618***	0.011922
	(0.3827)	*(0.4556)*	*(0.0217)*
Processing and preserving of fruit and vegetables n.e.c. (153300)	2.674788***	3.055686***	0.025899***
	(0.3143)	*(0.3820)*	*(0.00955)*
Manufacture of crude oils and fats (154100)	2.396824***	3.679472***	-0.10509***
	(0.3264)	*(0.4147)*	*(0.0282)*
Manufacture of refined oils and fats (154200)	2.043638	2.246042	0.089628**
	(1.2853)	*(1.5457)*	*(0.0374)*
Manufacture of margarine and similar edible fats (154300)	2.100918***	2.382745***	0.035579**
	(0.3224)	*(0.3962)*	*(0.0171)*
Operation of dairies and cheese making (155110)	2.457118***	2.937151***	0.042034***
	(0.3321)	*(0.4171)*	*(0.00703)*
Manufacture of condensed milk (155120)	2.028366***	2.348399***	0.040214
	(0.5906)	*(0.7866)*	*(0.0666)*
Manufacture of ice cream (155200)	2.304434***	2.702084***	0.042713**
	(0.5563)	*(0.6883)*	*(0.0180)*
Manufacture of grain mill products (156100)	2.339081***	2.862562***	0.017737
	(0.3292)	*(0.3969)*	*(0.0121)*
Manufacture of starches and starch products (156200)	3.494168***	3.900155***	0.029639*
	(0.9193)	*(1.1078)*	*(0.0171)*
Manufacture of prepared feeds for agriculture and fur farming (157110)	2.549349***	3.092524***	0.016902
	(0.2908)	*(0.3466)*	*(0.0104)*
Manufacture of prepared feeds for fish hatcheries (157120)	2.335244***	2.765398***	0.014368
	(0.2970)	*(0.3891)*	*(0.0331)*
Manufacture of prepared pet feeds (157200)	2.335206***	2.933743***	-0.01166
	(0.3358)	*(0.4092)*	*(0.0178)*
Manufacture of bread and other bakery products (158110)	2.91232***	3.528837***	0.001281
	(0.2621)	*(0.3416)*	*(0.00806)*
Bakers' shops (158120)	3.619716***	4.3963***	0.003718**
	(0.3038)	*(0.3815)*	*(0.00156)*
Manufacture of rusks and biscuits; manufacture of preserved pastry goods and cakes (158200)	2.815362***	3.360308***	0.012066
	(0.2696)	*(0.3513)*	*(0.0105)*
Manufacture of sugar (158300)	2.81515*	3.421766*	0.005493
	(1.4806)	*(1.7800)*	*(0.0337)*
Manufacture of cocoa, chocolate and sugar confectionery (158400)	2.793412***	3.280298***	0.028707***
	(0.2908)	*(0.3644)*	*(0.00748)*
Manufacture of macaroni, noodles, couscous and similar	2.898925***	3.426301***	-0.03427

farinaceous products (158500)	*(0.3248)*	*(0.3732)*	*(0.0255)*
Processing of tea and coffee (158600)	2.38034*	2.332958	0.08501
	(1.2842)	*(1.6402)*	*(0.0788)*
Manufacture of condiments and seasonings (158700)	2.595374***	3.151434***	-0.00617
	(0.2637)	*(0.3315)*	*(0.0128)*
Manufacture of homogenised food preparations and dietetic food (158800)	2.55213*	2.007322	0.157264***
	(1.4690)	*(1.7639)*	*(0.0401)*
Manufacture of other food products n.e.c. (158900)	2.741271***	3.218133***	0.033446***
	(0.2748)	*(0.3568)*	*(0.00794)*
Manufacture of distilled potable alcoholic beverages (159100)	2.428021***	2.700525***	0.041316
	(0.3331)	*(0.5932)*	*(0.0626)*
Manufacture of cider and other fruit wines (159400)	2.808043	3.091465	0.014834
	(2.5296)	*(3.0250)*	*(0.0464)*
Manufacture of beer (159600)	2.786646***	3.280801***	-0.00757
	(0.3684)	*(0.4514)*	*(0.0144)*
Manufacture of malt (159700)	2.981057**	3.319971**	0.035763*
	(1.2800)	*(1.5348)*	*(0.0205)*
Production of mineral waters and soft drinks (159800)	2.655779***	3.219636***	-0.01734
	(0.3153)	*(0.3837)*	*(0.0146)*
TFP growth	0.009193***		
	(0.00120)		
Capital	0.028504***	0.028202***	
	(0.00178)	*(0.00178)*	
Raw Material	0.428375***	0.429527***	
	(0.00531)	*(0.00533)*	
Returns-to-scale	0.05444***	0.049736***	
	(0.00662)	*(0.00667)*	
Market Size	0.001042	-0.03488*	
	(0.0157)	*(0.0212)*	
Concentration	0.202889***	0.2589***	
	(0.0314)	*(0.0331)*	
R-squared	0.5695	0.5188	
Number of cross sections	3119	3119	
Time periods	9	9	
DF	16814	16776	

Notes: 1) ***, **, * denote significance at the 1, 5 and 10% level, respectively. 2) Standard errors in parentheses.

According to Table 8, the estimated elasticities of value added per employee with respect to capital and raw material are 0.03 and 0.43, respectively. Processing industries are characterized by increasing returns-to-scale as the coefficient for labour has a significantly positive sign. From (6) it follows that the elasticity of value added per employee with respect to labour thus lies approximately at 0.59.[34] Labour and raw material are thus the driving forces for the firms' value added creation whereas capital does play a minor role only. The degree of concentration affects the value added performance positively. The estimated parameter is positive and highly significant at the 1% level. The estimated parameter concerning the market size is positive, as expected, but statistically not significant. A final comment concerns the R-squared of model 1. Estimating the same model but with untransformed variables, that is, not re-

[34] In fact, the parameter has not been estimated. The approximation is thus based on the fact that the parameters concerning labour, capital and raw material are highly significant.

lated to labour force, leads to the principally same parameter estimates while the R-squared jumps up to 0.7703.[35]

Switching from model 1 to model 2 does not change the results considerably. Model 2 includes an industry-specific TFP growth rate as the only modification. The estimated elasticity parameters are approximately of the same size. The parameter concerning concentration has slightly increased and the parameter concerning market size has shifted its sign and has even become statistically significant which makes an appropriate interpretation difficult. It was not expected, that the order of the estimated TFP level parameters in model 2 exactly matches the order of model 1. The Spearman rank correlation between model 1 and model 2 lies, however, at 81.6% which can be regarded as sufficient. Only 16 industries, or 41% of all involved industries, exhibit a statistically significant TFP growth rate. In two cases, out of those 16 industries, the estimated TFP growth rate lies below the value of the joint growth rate of model 1. In all other cases, however, the inclusion of an industry-specific TFP growth rate seems to catch all those industries with a significantly higher TFP growth rate. The leading industries in terms of TFP growth are *Manufacture of homogenised food preparations and dietetic food* (158800) with approximately 16% annual growth and *Manufacture of refined oils and fats* (154200) with nearly 9% annual growth. During the observed period, however, both industries consisted of three firms at most which puts those extraordinarily high growth rates into perspective. The group of regular industries in terms of the number of included firms is elsewise headed by *Production of prepared meat dishes* (151310) and *Production, processing and preserving of beef* (151120) with 5 and 4% annual TFP growth, respectively.

By comparing both models with each other it turns out that in model 2 nearly 40% of the included industries exhibit significant TFP growth rates. At the same time, however, the adjusted R-squared decreases from 0.57 to 0.52. Re-estimating model 2 with growth rate dummies only for the statistically significant industries implies two effects. Firstly, the R-squared increases to 0.54 and the estimated parameter for market size becomes insignificant while still being negative. Taking into account the general uncertainness about the appropriate interpretation of the market size parameter, both approaches may thus be considered as virtually equivalently specified.

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[35] The regression yields a direct estimate of the elasticity of value added per employee with respect to labour which lies at 0.5976.

One interesting aspect of model 2, however, concerns the β-divergence result of labour productivity among the processing industries, as shown in Table 6 of section 2.2.3.2.2. Doing the analogous calculations with respect to TFP, it turns out that the opposite is true in this case. Regressing the TFP growth rate estimates from model 2 on the estimated TFP levels across industries yields the following result, as Table 9 shows:

Table 9. β-convergence of TFP levels among processing industries 1995 – 2003

Dependent variable: Average annual TFP growth rate (model 2)				
Sector	**Intercept**	**Log (TFP level)**	**R^2**	**Number of industries (observations)**
Processing	0.1878*** *(0.0330)*	-0.0556*** *(0.0107)*	0.4219	39

Note: Standard errors in parentheses.

The coefficient for the log of the initial TFP level is negative and highly significant. The estimation result does not depend on whether all industries are included, as in Table 9, or only those 16 industries with significant growth rate. In the latter case, the intercept coefficient increases slightly and the R-squared increases even to 0.4659. The coincidence of β-divergence of labour productivity on the one side and β-convergence of TFP levels on the other may most likely be explained by simultaneously occurring capital accumulations unevenly distributed across industries if this effect is strong enough to outweigh the converging TFP.

Wholesale

Table 10 summarizes the results for the wholesale sector. Contrary to the case of the processing industries, the estimation of model 2 does not yield sufficient results at all. There is only one industry with significant TFP level and only three industries with significant TFP growth rate. For that reason, only model 1 is discussed in the following as it is considered the more appropriate specification.

The TFP level ranges from 0.8624 for *Wholesale of sugar, chocolate and sugar confectionery* (513600) to 1.8261 for *Wholesale of beer and soft drinks* (513410). The range lies thus strictly below the lowest TFP level of all processing industries. In addition, the estimated growth rate constitutes only a third of the processing industries' growth rate.

Table 10. Sector-level estimation results wholesale sector 1998 - 2003

	MODEL 1	MODEL 2	
Industry	**TFP level**	**TFP level**	**TFP growth**
Wholesale of fruit and vegetables (513100)	1.291592**	-0.64571	-0.0042
	(0.5354)	*(0.6920)*	*(0.00877)*
Wholesale of meat and meat products	1.407034**	-0.62627	0.004855
(513200)	*(0.5579)*	*(0.7528)*	*(0.00986)*
Wholesale of dairy produce, eggs and edible	1.586559***	-0.21964	-0.01099
oils and fats (513300)	*(0.5408)*	*(0.6785)*	*(0.0163)*
Wholesale of beer and soft drinks (513410)	1.82606***	-1.19979*	0.176671***
	(0.5049)	*(0.6766)*	*(0.0234)*
Wholesale of wine and spirits (513420)	1.261269**	-0.84211	0.01423
	(0.5342)	*(0.7022)*	*(0.00979)*
Wholesale of fruit and vegetable juice etc.	1.558699***	-0.07623	0.040248
(513490)	*(0.5662)*	*(0.7457)*	*(0.0473)*
Wholesale of tobacco products (513500)	1.398639**	-0.3545	0.030741
	(0.5883)	*(0.7273)*	*(0.0345)*
Wholesale of sugar, chocolate and sugar	0.862426*	-0.81628	-0.0018
confectionery (513600)	*(0.5124)*	*(0.6576)*	*(0.0164)*
Wholesale of coffee, tea, cocoa and spices	1.606918***	-0.253	0.033484*
(513700)	*(0.5022)*	*(0.7011)*	*(0.0199)*
Wholesale of fish and products thereof	1.417743**	-0.91107	0.016585*
(513810)	*(0.5715)*	*(0.7420)*	*(0.00861)*
Wholesale of bread, cakes and biscuits	1.592211***	-0.06019	0.006769
(513820)	*(0.5070)*	*(0.6973)*	*(0.0289)*
Wholesale of health food products (513830)	1.385629***	-0.20324	-0.00328
	(0.5135)	*(0.6531)*	*(0.0181)*
Other specialized wholesale of food, bever-	1.215628**	-0.59998	0.018484
ages and tobacco (513890)	*(0.5231)*	*(0.6608)*	*(0.0168)*
Non-specialized wholesale of food, bever-	1.0338*	-1.05379	0.015581
ages and tobacco (513900)	*(0.5809)*	*(0.7521)*	*(0.0103)*
TFP growth	0.003517		
	(0.00372)		
Capital	0.02019***	0.022984***	
	(0.00219)	*(0.00221)*	
Raw Material	0.394181***	0.394573***	
	(0.00744)	*(0.00739)*	
Returns-to-scale	0.067922***	0.067223***	
	(0.0116)	*(0.0113)*	
Market Size	0.086115***	0.188136***	
	(0.0321)	*(0.0430)*	
Concentration	0.227087**	-0.08118	
	(0.0344)	*(0.0633)*	
R-squared	0.8130	0.8443	
Number of cross sections	2215	2215	
Time periods	6	6	
DF	9307	9294	

Notes: 1) ***, **, * denote significance at the 1, 5 and 10% level, respectively. 2) Standard errors in parentheses.

Apart from the significant parameter for market size, the other estimated parameters correspond to greater extent to the results for the processing industries. Also the wholesale sector has increasing returns-to-scale and the elasticities of value added per employee with respect to capital and raw material are 0.02 and 0.39, respectively. From equation (6) one can conclude the corresponding labour elasticity approximately to be at 0.65. The degree of concentration enters value added per employee positively as it does market size. The latter result, however, should be handled with care. Alternative specifications with a random effect for the TFP level, rather than fixed industry effects as in model 1, have shown the market size parameter significantly to switch its sign, while all other parameters being unaffected by this modification. Finally, the degree of concentration affects value added per employee significantly positively.

Retail sale

The obvious problems in connection with the specification of model 2 for the wholesale sector have completely carried forward to the retail sale sector. In addition, the results for the retail sector may to large extent depend on whether considering specialized or non-specialized retail sale, as it already has become apparent in section 2.2. For those reasons, Table 11 presents only the results for model 1 which, however, has been estimated for specialized and non-specialized retail sale separately.

The results exhibit a couple of principle differences compared to those for both the wholesale and processing sector. Firstly, the degree of concentration has now a negative impact on value added per employee. This relationship is statistically highly significant and robust against alternative model specifications which have been estimated in preparation for the present study. Secondly, the retail sector is generally characterized by the lowest TFP, referred to the whole food chain, where the non-specialized retail sale distinctly ranks at the bottom of the scale. The parameter concerning the log of the TFP level for the non-specialized retail sale ranges from -2.0071 for *Grocer's shops* (521110) to -1.4426 for *Department stores* (521220) whereas the corresponding parameter for the specialized retail sale ranges from 0.6405 for *Retail sale of alcoholic and other beverages* (522500) to 1.0448 for *Retail sale of meat and meat products* (522200). Moreover, the TFP of the non-specialized retail sale decreases annually by 1% while model 1 exhibit a TFP growth rate for the specialized retail sale not being significantly different from zero.[36]

[36] Also this result is robust against alternative specifications with one exception. A model with joint TFP level and growth rate for all industries yields a significantly positive growth rate at approximately 0.5% annual growth for the specialized retail sale.

Table 11. Industry-level estimation results retail sale 1995 - 2003

INDUSTRY	MODEL 1	
	Non-specialized retail sale	Specialized retail sale
Grocer's shops (521110)	-2.00709***	
	(0.4051)	
All-night shops (521120)	-1.79053***	
	(0.3659)	
Supermarkets (521130)	-1.90525***	
	(0.4189)	
Variety stores (521210)	-1.78258***	
	(0.4329)	
Department stores (521220)	-1.44256	
	(0.9711)	
Retail sale of fruit and vegetables (522100)		0.705261*
		(0.3677)
Retail sale of meat and meat products (522200)		1.04481***
		(0.3938)
Retail sale of fish, game, crustaceans and molluscs (522300)		0.924921***
		(0.3528)
Retail sale of bread, cakes and flour confectionery (522410)		0.771945**
		(0.3274)
Retail sale of chocolate and sugar confectionery (522420)		0.894459**
		(0.3591)
Retail sale of alcoholic and other beverages (522500)		0.640489*
		(0.3553)
Retail sale of tobacco products (522600)		0.889033**
		(0.3952)
Retail sale of cheese (522710)		0.890516***
		(0.3340)
Retail sale of health food (522730)		0.64076*
		(0.3284)
Other retail sale of food and beverages in specialized stores (522790)		0.711623**
		(0.3167)
TFP growth	-0.01251***	0.000574
	(0.00138)	*(0.00151)*
Capital	0.032243***	0.022519***
	(0.00101)	*(0.000825)*
Raw Material	0.689915***	0.751753***
	(0.00425)	*(0.00369)*
Returns-to-scale	0.047867***	0.125548***
	(0.00689)	*(0.00698)*
Market Size	0.121957***	-0.0583**
	(0.0235)	*(0.0251)*
Concentration	-0.04973***	-0.08315***
	(0.0153)	*(0.0120)*
R-squared	0.7705	0.8930
Number of cross sections	6478	7308
Time periods	9	9
DF	28796	32744

Notes: 1) ***, **, * denote significance at the 1, 5 and 10% level, respectively. 2) Standard errors in parentheses.

Thirdly, while the elasticities of value added per employee with respect to capital roughly correspond to the estimates for the processing and wholesale industries, the elasticities with respect to raw material increase considerably. The values for the non-specialized and specialized retail sale jump up to 0.69 and 0.75, respectively. At the same time the deduced elasticities with respect to labour decrease to 0.33 and 0.35, respectively. Thus, the driving forces behind value added per employee are still raw material and labour, as in the case of the processing and wholesale industries, but the weights have almost turned around.

The retail sale industries exhibit also increasing returns-to-scale. Finally, the usual caution concerning the market size parameter applies here as well. The estimation of model 1 yields in fact a significantly positive and negative relationship for non-specialized and specialized retail sale industries, respectively. The result, however, is not robust against other specifications. For example, if one alternatively allows for a joint industry intercept, rather than fixed intercepts for all industries, the sign of the market size parameter changes its sign significantly in the case of specialized retail sale industries.

4.4.2. Industry estimation

Due to the large number of individual estimations, the presentation of the results concerning the industry estimation in this section is limited on pointing out the most important aspects. Contrary to the joint sector estimation which allows for a meaningful comparison of the industry-specific parameters, as presented above, the individual industry estimations allow analogously for a firm-specific comparison within the same industry. Recall that model 3 refers to the estimation with joint TFP growth rate for all firms within the same industry whereas model 4 refers to the estimation which allows for an individual firm-specific growth rate, which however, has not been performed for all retail sale industries, for computational reasons.

It turned out, however, that the inclusion of a firm-specific TFP growth rate did not show sufficient results. While all other parameter estimates have only been affected marginally by the choice of either model 3 or 4, the relative significance of the firm-specific TFP growth rates was surprisingly low. Among the processing industries and whole sale industries, the average ratio of the number of significant TFP growth rate estimates to the number of involved firms within the industry was 23.1 and 16.4%, respectively.[37] One reason for the generally low significance ratios refers to the large number of entry and exit into and out of the industries which increases the number of recorded cross sections. The even lower value for wholesale industries can additionally be explained by the shorter time horizon (6 periods instead of 9) and the by far greater volatility of TFP growth, compared to the processing industries. For those reasons, the following presentation refers to model 3 only. The complete results for both model 3 and 4 can be found in Appendix 2 which includes all 53 individual industry estimations.

TFP level and growth rate

One immediate observation concerns the distribution of random and fixed effects estimations. While the random effects model turned out to be the superior specification in 52% of the 25 estimated processing industries, there are only 7% random effects specifications within all wholesale and retail sale industries together.[38] In other words, the estimated differences in the TFP level of 48% of all processing industries and 93% of all wholesale and retail sale industries are not randomly distributed. And the industry-specific ratios of the number of involved firms and the number of significant TFP level estimates are considerably larger as compared to the corresponding ratios in the case of the TFP growth rate. Among all processing industries with fixed effects specification, the ratio is 97%, for wholesale industries 86% and finally, for retail sale industries still 56%.

One interesting aspect concerns the comparison of the industry-specific variance concerning the (statistically significant) TFP firm levels in those cases where the fixed effect estimation turned out to be superior. The variance indicates how close the firms within the industries under consideration are located around the corresponding TFP means. A large variance could thus be a reasonable indication for unevenly distributed access to technology.

[37] Below the 10% significance level.

[38] The borderline for choosing random effects was at the 10% level of the Hausman specification test.

Table 12a. TFP levels of fixed effects processing industries

INDUSTRY	TFP LEVEL		SIGNIFI-CANCE RATIO	CROSS SECTIONS
	Mean	Variance		
Beef	2.9939	0.3680	100	35
Other meat products	2.0794	0.3418	98.8	173
Fish and fish products	3.1703	0.2480	100	141
Smoking and salting of fish	1.5918	0.2004	97.8	91
Fruit and vegetables	6.2905	1.0409	100	45
Dairies and cheese making	1.8343	0.1330	100	83
Starches and starch products	8.2154	1.9941	100	8
Prepared feeds for agriculture and fur farming	2.9660	0.2833	100	64
Baker's shops	1.6434	0.0740	99.9	1953
Rusks and biscuits, manufacture of preserved pastry goods and cakes	3.1507	0.1888	100	38
Cocoa, chocolate and sugar confectionery	1.2411	0.1651	82.3	79
Dietary supplements and other food products	4.3724	1.2331	100	74

Table12b. TFP levels of fixed effects wholesale industries

INDUSTRY	TFP LEVEL Mean	TFP LEVEL Variance	SIGNIFI-CANCE RATIO	CROSS SECTIONS
Fruits and vegetables	1.1333	0.1893	80.4	301
Meat and meat products	4.2484	0.4301	100	317
Diary products, eggs and edible oils and fats	2.5393	1.0647	100	153
Beer and soft drinks	0.7667	0.1337	37.3	150
Wine and spirits	0.7573	0.4267	32.4	253
Bread, cakes, sugar, chocolate and sugar confectionery	4.4998	0.4320	100	90
Coffee, tea, cocoa and spices	4.1985	0.2745	100	81
Fish and products thereof	1.6420	0.1784	97.2	323
Bread, cakes and biscuits (terminated in 2002)	3.9184	0.2208	97.8	46
Health food products	3.5105	0.5449	100	71
Other specialized wholesale	2.8481	0.2841	100	102
Non-specialized wholesale	1.7412	0.2401	95.7	301

Tabel 12c. TFP levels of fixed effects retail sale industries

INDUSTRY	TFP LEVEL		SIGNIFI-CANCE RATIO	CROSS SECTIONS
Grocer's shops	0.7404	0.1328	83.4	3739
All-night shops	-1.1881	0.0859	99.3	1874
Supermarkets	3.4214	0.1536	100	914
Variety stores	-1.3161	0	2.9	35
Fruit and vegetables	-0.0312	0.3766	18.3	1374
Meat and meat products	0.6859	0.0960	79.7	1412
Fish, game, crustaceans and molluscs	-0.2291	0.1973	37.8	513
Bread, cakes and flour confectionery	0.7875	0.1081	68.9	209
Chocolate and sugar confectionery	0.7020	0.1391	64.0	833
Alcoholic and other beverages	0.9909	0.1134	91.2	388
Tobacco products	1.3155	0.1404	98.0	1842
Cheese	0.1781	0.4018	20.5	234
Health food	-0.3028	0.2992	18.9	343
Other retail sale	0.5910	0.5421	20.4	191

As Table 12a shows, the largest spreads in the TFP levels among processing industries can be observed at *Starches and starch products* (156200), *Dietary supplements and other food products* (158900) and *Fruit and vegetables* (153300).[39] These indus-

[39] The ranking of *Starch and starch products* requires, however, a comment: There are 8 cross sections of which 2 firms are recorded for 2 and 6 periods only, respectively, both of them having considerably lower TFP levels than all other firms within the same industry. Ignoring those 2 firms, the industry-specific variance would decrease to 0.1856 which then would be among the sector's lowest variances.

tries, however, are also those with the largest average TFP levels within this particular sub-group of processing industries. Regressing the variance of the firm TFP level on its mean confirms this impression as Table 13 shows. A similar relation cannot be found for the other sectors, however.

Table 13. The relation between TFP level mean and variance

		Dependent variable: Variance of TFP level		
Sector	**Intercept**	**Mean of TFP level**	**R^2**	**Number of industries (observations)**
Processing industries	-0.3405** *(0.1281)*	0.2619*** *(0.0332)*	0.8613	12

Note: Standard errors in parentheses.

On average, the variance among processing industries equals 0.52, for wholesale and retail sale industries 0.37 and 0.17, respectively.

Elasticities

The estimated parameters for capital, raw material, energy, external and other costs in the industry estimations correspond to the elasticities of value added with respect to the various input factors. It does not matter that value added has been normalized by labour as also the input factors have been normalized in the same way. The elasticities indicate by how much percent value added marginally increases as the input factor under consideration is increased by 1%. The elasticities then show how effectively the input factors contribute to the total value added creation.

Under the assumption of perfect competition and constant returns-to-scale, the factor elasticities correspond to their shares of payment.[40] There are different reasons why this identity may not be observed in reality. Firms may have market power on output markets (seller concentration) as well as on input markets (buyer concentration). In many cases, input factors cannot freely be substituted for each other and some input factors can only be consumed in fixed quantities. Finally, the firms may be vertically integrated which also affect the relation between the elasticity and the share of payment.

[40] This result follows from the profit maximization problem of a competitive firm.

The average shares of factor payment illustrate the clear dominance of raw material and labour as the main input factors. Table 14 depicts the annual average shares of payment as a fraction of turnover, aggregated by stages.

Table 14. Shares of payment

	Processing	Wholesale	Retail
Raw Material	0,63	0,87	0,76
Energy	0,02	0,00	0,01
External Costs	0,11	0,04	0,06
Other Costs	0,01	0,01	0,02
Wages	0,15	0,05	0,11
Capital	0,08	0,02	0,04

Source: Own calculations based on data from *Statistics Denmark*.

The sum of the bottom two lines, wages and capital, corresponds to the fraction of value added to turnover. The processing stage contributes thus most in terms of value added per turnover (23%), followed by the retail industries (15%) and the wholesale industries (7%). The share of capital, however, is overestimated as corporation taxes are not subtracted.[41]

As it can be seen in Table 14, the largest part of value added is paid as wages as opposed to the payment for capital. Concerning the remaining input factors, raw material and external costs constitute the by far largest fraction. On the contrary, the firms have on average spent 3% of turnover at most for energy and other costs, depending on which stage the firms belong to.

Table 15 summarizes the estimation results concerning the elasticities of value added with respect to the input factors capital, raw material, external and other costs and finally, energy. For instance, the 25 separate estimations of processing industries yielded in 17 cases a statistically significant parameter for the capital elasticity.[42] Column 4 of Table 15 contains the arithmetic mean of those 17 estimates, which is compared with the corresponding mean of the calculated shares of payment (column 3). The absolute difference is shown in the last column.

The model specification does not yield a direct estimate for the elasticity with respect to labour. In contrast to the stage estimation, where the generally high significance of

[41] The data have not been available.
[42] Below the 10% significance level.

the estimated parameters allowed for an arguable derivation of the labour elasticity, the analogous procedure would fail in the case of the industry estimations as in many cases the estimated parameters are not sufficiently statistically significant. As a consequence, the parameter for the labour elasticity would not be identifiable.

Tabel 15. Comparison of mean shares of payment with estimated factor elasticities

	Significant industries	Share of payment	Estimated elasticity	Difference
Processing industries (25 industries)				
Capital	17	0.0927	0.0671	0.0256
Raw Material	22	0.5834	0.4047	0.1787
External Costs	13	0.1300	0.0357	0.0943
Energy	12	0.0150	0.1106	-0.0954
Other Costs	9	0.0160	0.0317	-0.0157
Sum		**0.8371**	**0.6498**	**0.1875**
Wholesale (14 industries)				
Capital	6	0.0319	0.0551	-0.0230
Raw Material	14	0.8215	0.3682	0.4533
External Costs	2	0.1272	-0.0573	0.1845
Energy	10	0.0019	0.0363	-0.0345
Other costs	5	0.0066	0.1351	-0.1285
Sum		**0.9891**	**0.5374**	**0.4518**
Retail sale (14 industries)				
Capital	11	0.0805	0.0242	0.0564
Raw Material	14	0.6789	0.6736	0.0053
External Costs	8	0.0755	0.0344	0.0411
Energy	10	0.0097	0.0324	-0.0228
Other Costs	5	0.0246	0.0427	-0.0182
Sum		**0.8692**	**0.8073**	**0.0618**

As one can see in Table 15, the differences between the factor shares of payment and the estimated elasticities are largest for the wholesale sector, nearly negligible for the retail sector and somewhere in the middle for the processing industries. The result requires several comments.

Firstly, there is a clear problem concerning the low degree of significance particularly in the cases of external and other costs. This may to some extent surprise as especially external costs does not constitute an insubstantial input factor. Similarly, the elasticity of value added with respect to energy seems to systematically exceed the corresponding share of payment.

Secondly, drawing the attention to the more relevant factors, namely raw material and capital, the most striking observation concerns the huge difference between the raw material elasticity and the corresponding share of payment in the case of wholesale industries. Taking the shorter horizon into account, the result nevertheless states that wholesale firms pay nearly worth twice as much as raw material's marginal contribution. In contrast, the difference between the share of payment and the corresponding elasticity is nearly zero in the case of retail sale industries. Possible explanations for this phenomenon are discussed in the concluding section 5, below. Finally and as already mentioned above, the share of payment for capital is systematically overstated which partly explains the difference between the share of payment and the corresponding elasticity.

Returns-to-scale

As explained above, the estimated parameter of the labour variable in the industry estimation can be interpreted as an indication for the existence of returns-to-scale. If γ is positive (negative), then there are increasing (decreasing) returns-to-scale, respectively. There are 25 estimated processing industries, 14 wholesale and 14 retail sale industries and 29 of them have an estimated parameter for γ significantly different from zero.[43] Among the processing industries, there are both increasing and decreasing returns-to-scale. There exist, however, no apparent patterns which might explain the existence of returns-to-scale in particular industries. Apart from *Wholesale of meat and meat products* (523200) and *Retail sale of tobacco products* (522600), all other significantly estimated industries within the wholesale and retail sale sector have increasing returns-to-scale, however.

[43] Below the 10% significance level. In particular, 20 industries out of the 29 significant ones are below the 1% significance level.

Table 16. Returns-to-scale

Industry	γ	Average net exit rate in %
Processing industries		
Pork (151110)	0.1152	-4.21
Poultry meat (151200)	0.1232	-7.71
Prepared meat dishes (151310)	0.1003	-1.79
Fish and fish products (152010)	-0.1437	-6.62
Fruit and vegetables n.e.c. (153300)	-0.4541	-2.26
Dairies and cheese making (155110)	0.073	-2.96
Ice cream (155200)	0.1699	0.39
Starches and starch products (156200)	-0.7469	-1.37
Bread and other bakery products (158110)	0.0999	-5.42
Baker's shops (158120)	0.1121	-3.89
Cocoa, chocolate and sugar confectionery (158400)	-0.1176	0.94
Dietary supplements and other food products n.e.c. (158900)	-0.3534	0.94
Beer (159600)	0.1075	-1.84
Wholesale		
Fruits and vegetables (513100)	0.1993	-12.77
Meat and meat products (513200)	-0.1249	-8.35
Wine and spirits (513420)	0.1076	-10.17
Fish and products thereof (513810)	0.0613	-4.81
Bread, cakes and biscuits (513820), (terminated in 2002)	0.2542	-11.14
Non-specialized wholesale (513900)	0.0748	-5.54
Retail sale		
Grocer's shops (521110)	0.0246	-4.62
All-night shops (521120)	0.1084	-0.20
Fruit and vegetables (522100)	0.0693	-5.75
Meat and meat products (522200)	0.2567	-4.09
Fish, game, crustaceans and molluscs (522300)	0.2043	-3.99
Bread, cakes and flour confectionery (522410)	0.1067	-6.18
Chocolate and sugar confectionery (522420)	0.2057	-6.42
Tobacco products (522600)	-0.1540	-8.41
Cheese (522710)	0.0892	-5.80
Health food (522730)	0.0823	-7.87

The case of increasing returns-to-scale constitutes one of the classical explanations for the existence of natural monopolies. Increasing returns-to-scale within the food chain may then partly explain the ongoing consolidation and concentration trends. As one can see in Table 16 above, the industries are characterized by different annual net exit rates of firms into and out of the industries even though most of the industries are declining on average. For instance, *Production, preserving and processing of pork* (151110) experienced during the observed period 1995 to 2003 a net decline in the number of firms by 4.21% annually on average. Only in 3 cases out of the 29 significant industries, the net exit rate is positive, that is, more firms have entered the industry compared to the number of exiting firms. If returns-to-scale are adapted for explaining exit rates, one would thus expect, regressing the average annual net exit rate on the estimated parameters concerning returns-to-scale to yield a negative relationship.

Table 17. The relation between returns-to-scale and exit rates

Dependent variable: Net exit rate

Sector	Intercept	γ	R^2	Number of industries (observations)
Significant industries	-4.7697***	-5.5207*	0.1223	29
	(0.6227)	*(2.8463)*		
All industries	-3.7502***	-6.0667	0.0475	53
	(0.6308)	*(3.8041)*		

Note: Standard errors in parentheses.

The estimation result can be interpreted in the following way: If there are non-constant returns-to-scale, then increasing returns-to-scale explain to some extent larger net exit rates. The estimated parameter in the case of the 29 significant industries is negative, as expected, and significant at the 10% level. The relatively low R-squared should not disconcert as it simply indicates that also other determinants affect the exit rates' size which have not been taking into account in this regression. The second estimation illustrates this point apparently. If all industries are included, the returns-to-scale parameter loses its significance as for all those cases the hypotheses that γ equals zero cannot be rejected. In other words, only in the case of non-zero returns-to-scale, the estimated parameter enters significantly as it in this particular case is endued with sufficiently explanatory power.

5. Discussion and Conclusions

The preliminary data analysis in section 2.2 has shown that the value added creation of the Danish food sector is characterized by moderate growth in terms of real prices. During the period 1995 to 2003, value added of the processing and retail sale industries grew annually by 2 and 1.2% on average, respectively, while the wholesale industries are bottom of the league with 1.1% annual growth on average.[44] The moderate growth on average may not belie the strong cyclical volatility which actually affects the industries' value added performance throughout the chain where especially the years 2000 to 2001 constitute a period of strictly negative growth. Despite the volatility, however, the distribution of value added follows a relatively stable path. Processing industries account for roughly 55% of the chain's value added creation, while retail sale and wholesale industries account for 30 and 15%, respectively.

Disaggregating the data down to industry level enables identifying the leading industries within each sector. *Production, processing and preserving of Pork* (151110) and *Operation of dairies and cheese making* account for 30.9%. on average of the processing industries' value added. Among wholesale industries, *Non-specialized wholesale* (513900) and *Wholesale of fish and products thereof* (513810) account for 40.2% of the wholesale industries' value added while the by far largest fraction is held by *Supermarkets* (521130) and *Grocer's shops* (521110) which together account for 54.1% of the retail sale industries' value added. For processing industries, however, it could be shown that particularly smaller industries tend to grew faster on average than larger industries.

Relating value added to the number of employees creates a more appropriate measure in order to compare the industries' value added performance directly. Processing and wholesale industries turned out to be comparable in terms of the median value at 453.2 and 436.73 thousands DKK value added per employee annually, respectively. In strong contrast, retail sale industries achieve approximately half of it with 230.95 thousands DKK annually. The within-stage differences, however, are huge and confirm illustratively *Hypothesis 1*. In the case of processing industries, it could be shown that more productive industries grew even faster than less productive industries implying that persisting labour productivity differences have become larger while the opposite is true for retail industries. One possible explanation for this result could be related to the fact that the technologies used to offer retail sale services are potentially similar. On the other hand, there are no a priori reasons to expect the tech-

[44] The average rate of annual growth of the wholesale industries refers to the shorter period 1998 to 2003.

nology of production to be the same or to converge over time in the case of processing industries.

The former result regarding processing industries is additionally interesting since it parallels the earlier result that smaller industries grew faster on average than larger industries. The ranking of Table 4a, however, has shown that labour productivity is not generally associated with industry size, measured in terms of the absolute value added contribution. One can find both small and large industries among the top-10 leading industries, measured in relative terms as labour productivity, which explains why both results can hold at the same time.

The stage estimations have shown that differences in the industries' value added performance to large extent can be explained by persisting differences in the respective TFP levels within each stage. On average, processing industries have the largest TFP levels, growing at an annual rate of approximately 1%, followed by wholesale industries with approximately 0.5% annual growth. Retail sale industries have generally the lowest TFP levels where non-specialized retail sale industries even decline by 1% annually while the specialized industries tend to stay at their initial levels.

It comes therefore not as a surprise that the degree of concentration affects the value added performance negatively in the case of the retail industries and positively in the case of the two other stages. According to *Hypothesis 2*, the efficiency hypothesis may apply for processing and wholesale industries, while the opposite is true for retail industries. If ongoing concentration and consolidation trends are interpreted as evidence for the existence of particularly productive firms, then this should be reflected by large TFP and labour productivity levels which obviously has not been the case for retail industries.

Labour and raw material are the decisive factors for the value added creation. For all three sectors hold that the sum of the estimated elasticities exceeds unity, indicating the existence of increasing returns-to-scale. Capital plays apparently only a minor role.

The comparison of Tables 2 and 4 indicate why the results concerning market size have been such unclear, according to *Hypothesis 4*. On the one hand, there is a clear correlation between large markets in terms of turnover and large fractions of value added (Rogers 2001). On the other hand, the relative value added performance in terms of labour productivity is not necessarily related to the market size. The rank correlation between the absolute and relative value added performance has generally been poor, independently which stage has been under consideration. According to the results of the present study, market size does therefore not qualify as determinant for the value added performance and *Hypothesis 4* fails.

The result concerning the correspondence of the shares of payment with the estimated elasticities is interesting and it motivates at the same time further research in order to explain the observations more thoroughly. In case of seller concentration, economic textbook theory predicts an outcome where the elasticities exceed the shares of payment since the firms sell their products at a point where marginal costs equal marginal revenue as opposed to the perfect competition case where marginal costs equal a given market price. The nearly perfect match of the estimated elasticities and the calculated shares of payment for the retail sale industries, however, should not lead to the wrong conclusion that retail sale industries behave perfectly competitive. The CR-4 concentration ratios indicate indeed lower concentrations on average for retail sale industries compared to processing industries, for instance. The existing concentration within the retail sale stage, however, has strengthened the firms' position, and in particular, the firms' buying power (The Nordic Council of Ministers 2004). Buying power may lead to lower prices for consumers. If, on the other side, buying power on input markets is associated with seller power on output markets, the measurable impacts on the relation between the factor elasticities and the shares of payment may outweigh each other. Assuming considerable buyer concentration among processing industries would additionally explain the result concerning the obvious mismatch of the estimated elasticities in the case of processing industries. The results illustrate clearly the high relevance of future research activities particularly focussing on buyer concentration in the Danish food chain.

In order to make the food sector competitive, relevant policy decisions have to ensure the necessary food chain restructuring and make its technologies and distribution channels as efficient as possible. The economic success of the Danish food chain can only be achieved through long-lasting growth in real terms. The purpose of relevant policy decisions must therefore primarily be aimed at harmonising the chain's value added performance with the relative weights of the involved industries in terms of employment. Labour and capital has become much more mobile and from a social planner's point of view, differences in value added per employee should not exceed some critical threshold as large differences may be the indication for less efficient use of input factors.

References

ABS (Australian Bureau of Statistics) (2003): "*Estimating Industry-level Multifactor Productivity: Further Experimental Results and Consistency Issues*", Paper presented to the ABS Economic Statistics User Group, 20 November.

M. N. Bailey, C. Hulten and D. Campell (1992): "The distribution of productivity in manufacturing plants", *Brookings Papers on Economic Activity: Microeconomics*, pp. 187-249.

Baker, D. (2003): "The Danish food marketing chain", University of Copenhagen, Faculty of Life Sciences, Institute of Food and Resource Economics, Report No.154.

Baltagi, B. H. and Chang, Y. (1994): "Incomplete Panels: A Comparative Study of Alternative Estimators for the Unbalanced One-way Error Component Regression Model", *Journal of Econometrics*, Vol. 62 (2): 67-89.

Barnes, M., and J. Haskel (2000): "Productivity in the 1990s: Evidence from British plants", London: Queen Mary.

Barro, R. and X. Sala-i-Martin (1992): "Convergence", *Journal of Political Economy*, Vol. 100: 223-251.

Bartelsmann, E.J and M. Doms (2000): "Understanding productivity: Lessons from longitudinal microdata", *Journal of Economic Literature*, Vol. 83 (3): 569-594.

Bech- Larsen, T. and J. Scholderer (2007): **"**Functional foods in Europe: consumer research, market experiences and regulatory aspects", *Trends in Food Science & Technology*, Vol. 18 (4): 231-234.

Bernard, A.B. and C.I. Jones (1996): "Comparing apples to oranges: Productivity convergence and measurement across countries", *American Economic Review*, Vol. 86 (5): 1216-1218.

BIS Shrapnel (2003): "National Food Industry Strategy", Report, downloadable at http://www.nfis.com.au/Market_trends.html.

Bosworth, Derek and Joanne Loundes (2002): "The dynamic Performance of Australian Enterprises", Melbourne Institute Working Paper No. 3/02, ISBN 0-7340-1527-5.

Braadland, T. (2000): "Innovation in the Norwegian food system", RISE Project Report, STEP working paper A-05, STEP group, Oslo.

Buhr, Brian L. (2004): "Case studies of direct marketing value added pork products in a commodity market", *Review of Agricultural Economics*, Vol. 26 (2): 226-279.

Christy, Ralph D. and John M. Connor (1989): "Economic forces influencing value added food industries: implications for southern agriculture", *Southern Journal of Agricultural Economics*, Vol. 21 (1): 13-22.

Cobbold, T. (2003): "A Comparison of Gross Output and Value-Added Methods of Productivity Estimation", Productivity Commission Research Memorandum, Canberra.

Corsani, A., Bocquelet, H. and J. Nefussi (1990) : (*In French*) "*Economie des Industries Agro-Alimentaires en Europe et Japon*". Paris: Institut National Agronomique de Paris-Grignon, Commissariat Général du Plan.

Danish Industry (2006): (*in Danish*) "Danske produkter i toppen af kvalitetshierarki", downloadable at www.di.dk/NR/rdonlyres/7D514F76-BAE8-48B6-8E5A-DC490D9B4AE5/0/upmarketprodukter.pdf.

Diewert, E.W. (2001): "Productivity trends and determinants in Canada", Discussion paper No. 01-15, Department of Economics, University of British Columbia.

Dilling-Hansen, M., Madsen E. S. and V. Smith (2003): "Industrial clusters, firm location and productivity", Aarhus school of Business, Department of Economics, Working Paper 03-26.

Dilling-Hansen, M., Madsen E. S. and V. Smith (2002): "Does the New Economy Create higher Productivity?", University of Copenhagen, Centre for Industrial Economics, CIE Discussion Paper 2002-10.

Dilling-Hansen, M., Erikson, T., Madsen E. S. and V. Smith (1998): (*in Danish*) ”Konkurrenceforholdenes betydning for danske virksomhedernes produktivitet”, *Nationaløkonomisk Tidsskrift*, Vol. 136 (1): 138-151.

Ethier, W. (1982): “National and international returns to scale in the modern theory of international trade”, *American Economic Review*, Vol. 72: 389-405.

Francis, M. (2005): “Two Genres of Product Development Literature”, Cardiff University Innovative Manufacturing Research Centre Working Paper WP-03.

Fødevareindustrien (2005): (*in Danish*) “Fremtidens fødevareindustri”, downloadable at fi.di.dk/Tal%20og%20statistik/.

Fødevareindustrien (2006): (*in Danish*) “Fødevareindustrien – kort fortalt”, downloadable at fi.di.dk/Tal%20og%20statistik/.

Gollop, F.M. (1979): ”Accounting for intermediate input: The link between sectoral and aggregate measures of productivity growth”, in National Research Council, *Measurement and Interpretation of Productivity*, National Academy of Sciences, Washington, pp. 318-333.

Gopinath, Munisamy (2003): “Cross-country Differences in Technology: The case of the Food Processing Industry”, Canadian Journal of Agricultural Economics, Vol. 51 (1): 97-107.

Götzfried, A. (2004): “High-technology and knowledge-intensity leading to more Value added, Innovation and Patents”, *Statistics in focus – Science and Technology*, Eurostat, European Communities, August 2004.

Gould, Brian W. and Kurt A. Carlson (1998): “Strategic management objectives of small manufacturers: A case study of the cheese industry”, *Review of Agricultural Economics*, Vol. 20 (2): 612-630.

Government (2006): “Progress, Innovation and Cohesion. Strategy for Denmark in the Global Economy – Summary”, downloadable at http://www.globalisation.dk.

Green, W.H. (2003): “*Econometric analysis*”, New Jersey: Prentice Hall.

Gregory, Paul R. and Valery Lazarev (2004): "Structural change in Russian transition", Center Discussion Paper no. 896, Yale University.

Gullickson, W and J. Harper (1999): "Possible measurement bias in aggregate productivity growth", *Monthly Labor Review*, February: 47-67.

Hansen, H. O. (2005): (*in Danish*) "*Vækst i fødevareindustrien*", Copenhagen: Handelshøjskolens Forlag.

Harrigan, J. (1999): "Estimation of cross-country differences in industry production functions", *Journal of International Economics*, Vol. 47 (2): 267-293.

Hayenga, M. L. (1998): "Cost structures of Pork Slaughter and processing Firms: Behavioral and performance Implications", *Review of Agricultural Economics*, Vol. 20: 574-583.

Huang, K.S. (2003): "Food Manufacturing Productivity and its Economic Implications", United States Department of Agriculture, Technical Bulletin No. 1905, October, downloadable at http://www.ers.usda.gov.

D. W. Jorgensen, F. M. Gollop and B. M. Fraumeni (1987): *Productivity and U.S. Economic Growth*, Cambridge: Harvard University Press.

Leschly, Jan (2005): "Globalization and innovation – A new playing field" speech held before the Globalization Council on December 8th 2005, downloadable at www.globalisering.dk/multimedia/Globalization_and_Innovation_-_Jan_Leschly_-_Dec_8_2005.pdf.

Løyland, Jon et al (2001): (*in Norwegian*) "Kjøttpriser fra bonde til butikker", Norwegian Agricultural Economics Research Institute, Report No. 10-2001.

Mankiw, N. G., Romer D. and D. N. Weil (1992): "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics*, Vol. 107: 407–37.

Mauget, R. and F. Declerck (1996): Structures, Strategies and Performance of EC Agricultural Cooperatives", *Agribusiness*, Vol. 12 (3): 265-275.

Ministerial Committee (2005): (*in Danish*) "Hovedtræk af globaliseringen for Danmark", Working Paper prepared for the Globalization Council, downloadable at www.globalisering.dk/multimedia/Hovedtraek_af_globaliseringsprocessen.pdf.

Moody's Report (2006): "Denmark", downloadable at www.nationalbanken.dk/C1256B730054214F/sysOakFil/Rapport%202006%20Moodys/$File/Moodys%20rapport%202006_1.pdf.

Moulton, Kirby (1986): "The potential for value-added exports", *Increasing Under:standing of Public Problems and Policies 1986*, Farm Foundation: 61-67.

Nickell S. D., D. Nicolitsas and N. Dryden (1997): "What makes firms perform well?", *European Economic Review*, Vol. 41: 783-796.

Nordic Council of Ministers (2004): "Nordic food Markets", Report from the Nordic competition authorities, ISBN 87-7029-345-7.

OECD (2001): "*Productivity Manual: A guide to the measurement of Industry-Level and Aggregate Productivity Growth*", Paris: OECD.

Oulton, N. and M. O'Mahony (1994): "*Productivity and Growth*", Cambridge: Cambridge: University Press.

Prime Minister (2005): "New Goals", Government Platform downloadable at www.stm.dk/publikationer/UK_reggrund05/New_Goals.pdf.

Rae, A. and T. Hertel (2000): "Future developments in global livestock and grain markets", *The Australian Journal of Agricultural and Resource Economics*, Vol. 44 (3): 393-422.

Ramana, D. Venkata. (2005): "Market Value Added and Economic Value Added: Some Empirical Evidences", 8th Capital Markets Conference, Indian Institute of Capital Markets Paper, available at SSRN: ssrn.com/abstract=871404.

Rogers, Richard T. (2001): "Structural change in U.S. Food manufacturing, 1958-1997", *Agribusiness*, Vol. 17 (1): 3-32.

Romer, D. (2001): "*Advanced Macroeconomics*", New York: McGraw-Hill.

Sevcikova, M. (2003): "Comparison of the value added development in the agricultural and food sectors and the efficiency of its creation", *Agric Econ / Czech*, Vol. 49 (1): 22-29.

Stewart, G. Bennet (1991): "*The quest for value: the EVA management guide*", New York: Harper Business.

Strand, M. M. (1996): (*in Norwegian*) "Matvarepriser i endring. Meieri-, kjøtt- og grøntvarer", National Institute for Consumer Research SIFO, Report No. 3-1996.

Strøm, Øystein. (1999): (*in Norwegian*) "Matens pris", Norwegian Agricultural Economics Research Institute, Report No. 4-1999.

Viaene, J. and X. Gellynck (1995): "Structure, conduct and performance of the European food sector", *European Review of Agricultural Economics*, Vol. 22: 282-295.

VIFU (2006): (*in Danish*) "Småskala fødevareproduktion", Report from *Videncenter for fødevareudvikling*, downloadable at www.vifu.net.

Wiel, H.P. van der (1999): "Sectoral Labour Productivity Growth", Research Memorandum No. 158, CPB Netherlands Bureau for Economic Policy Analysis.

Winger, Ray J. (2005): "A study into the level of value-added products in New Zealand food and beverage exports", 2005 update, Report for New Zealand Trade and Enterprise.

Wooldridge, J.M. (2002): "*Econometric analysis of cross section and panel data*", Cambridge: MIT Press.

Zugarramurdi, A. (2004): "Competitiveness of value adding in developing countries", FAO Fisheries Report No. 744: 137-145.

Appendix 1. The variables

The original variables

The following table shows and explains the original variables utilised in this study. The first column lists the internal variable names employed at *Statistics Denmark* in conjunction with the official balance questionnaire.[45] During the period 1995 to 2003, the variable system has been modified and adjusted no less than twice (1999 and 2002) even though the actual changes are of minor nature only. The table refers to the effective version for the years 2002 and 2003. The implemented modifications are explained below.

Table A1. Variable names of Danish balance questionnaire

Variable	Explanation
BESK	Number of employees on the payroll in full-time equivalent units.
OMS	Turnover (net sales), excluding discounts, VAT and excise duties.
AUER	Capitalised work performed by the firm itself for own purposes.
ADR	Other operating income.
DLG	Changes in stocks (raw materials, finished products etc.).
KRH	Purchases of goods for resale.
KRH	Purchases of raw materials, consumables and packaging materials.
KENE	Purchases of energy products (electricity and fuels, excl. for registered motor vehicles).
KLOE	Cost of subcontractors and other work done by others on the firm's materials (by non-employees).
UDHL	Rent paid (excl. heating bill).
UASI	Cost of minor equipment and fixtures not capitalised.
UDVB	Payments for temporary workers provided from another enterprise (e.g. agencies).
ULOL	Payments for long-term rental and operational leasing of goods.
EKUD	Other external charges (excl. secondary).
LGAG	Wages and salaries.
ANMI	Value adjustments in respect of fixed assets (depreciation charges etc.).
NOAK	Value adjustments in respect of current assets (in excess of normal adjustments).
SEUD	Other operating charges (of a non-trading type).
GRBY	Land and buildings.
ATAM	Production machinery and equipment.
AADI	Other plant and equipment.

Data for the ordinary write-offs in respect on debtors (OTDE), pension costs (PUDG) and other social security costs (AUDG) have not been available. Concerning the ordinary write-offs, however, the real effect is negligible. According to *Statistics Denmark*, the estimated effect constitutes at most a couple of tenths of a percent of total

[45] The currently valid Danish version (2008) of the balance questionnaire can be found on http://www.dst.dk/Vejviser/Indberetning/Emneopdelt.aspx?si=11&msi=7

turnover. The firms' expenses for pension and other social security costs have alternatively been calculated as:

$$\text{PUDG} + \text{AUDG} = \left[\left(\frac{\text{LGAG}}{1 - x} \right) * 100 \right] - \text{LGAG}$$

where x denotes the average fraction of pension and social security costs over total cost of labour (LGAG + PUDG + AUDG) for the food processing, wholesale and retail sector, respectively. The sectoral averages have been provided by *Statistics Denmark* as specified in the following table:

Table A2. Pension and social costs as a percentage of total labour cost

Year	Processing	Wholesale	Retail
1995	4.1		5.2
1996	4.7		5.8
1997	5.5		6.2
1998	5.9	5.9	6.9
1999	6.0	6.8	7.3
2000	6.8	6.2	7.0
2001	7.6	6.5	7.4
2002	8.0	8.1	8.0
2003	8.4	8.4	8.5

Source: Statistics Denmark.

The above mentioned modifications concerning the variable system affected the treatment of the so-called residual costs. In general, the residual costs include payments for temporary workers from other enterprises (UDVB), long-term rental and operational leasing of goods (ULOL), ordinary write-offs (OTDE) and other external charges (EKUD). During the period 1995 to 1998, however, the variables EKUD, UDVB and ULOL have been handled as a joint variable named OEEU and during the intermediate period 1999 to 2001, EKUD has been handled together with OTDE under the name ANEU. In effect, UDVB and ULOL have initially become single-handed balance sheet items since 1998 and OTDE has not been independent balance sheet item during the intermediate period 1999 to 2001.

The derived variables

Value Added

Following the standard definition of Statistics Denmark, value added in this study is defined as t*urnover plus other operating income minus consumption of goods and services*. In terms of the above given variable list, turnover plus other operating income is composed of the sum of OMS, AUER, ADR and DLG. The composition of consumption of good and services is given by the sum of KRH, KENE, KLOE, UDHL, UASI, SEUD and (i) OEEU for the sub-period 1995 to 1998, (ii) ANEU + UDVB + ULOL for the sub-period 1999 to 2001 and finally, (iii) EKUD + UDVB + ULOL for the remaining sub-period 2001 to 2003.[46]

Capital

Capital is calculated as the book value of the sum of land and buildings (GRBY), production machinery and equipment (ATAM) and other plant and equipment (AADI). Not included are stocks, receivable debts and cash.

Costs

Most of the cost items are directly related to original variables without any modification. This applies to raw material (KRH), energy (KENE) and external costs (EKUD, ANEU, OEEU). Other costs are defined as the sum of KLOE, UDHL, UASI and SEUD.

[46] In fact, *Statistics Denmark* subtracts 0.0079*TGT from turnover during the sub-period 1999 to 2001 in order to take into account that OTDE – which does not enter the calculation of value added - has not been handled as an independent balance sheet item during this period. TGT refers to receivable debts and is used as a proxy for OTDE. This correction has been neglected in this study.

Correlation

Table A3. Correlation

		Time	Capital	Raw Material	External Costs	Energy	Other Costs	Labour
Processing	Time	1.00	0.04	0.02	0.11	0.15	0.08	0.06
	Capital		1.00	0.25	0.25	0.25	0.05	0.12
	Raw Material			1.00	0.79	0.69	0.17	0.29
	External Costs				1.00	0.69	0.22	0.26
	Energy					1.00	0.32	0.23
	Other Costs						1.00	-0.04
	Labour							1.00
Wholesale	Time	1.00	-0.06	-0.03	0.02	-0.09	-0.21	0.03
	Capital		1.00	0.14	0.14	0.21	0.18	0.11
	Raw Material			1.00	0.68	0.48	0.55	-0.01
	External Costs				1.00	0.61	0.58	0.16
	Energy					1.00	0.57	0.21
	Other Costs						1.00	0.07
	Labour							1.00
Retail	Time	1.00	0.05	0.12	0.23	0.14	0.11	0.08
	Capital		1.00	0.19	0.17	0.15	0.10	0.09
	Raw Material			1.00	0.81	0.73	0.70	0.25
	External Costs				1.00	0.75	0.74	0.13
	Energy					1.00	0.68	0.14
	Other Costs						1.00	0.12
	Labour							1.00

Appendix 2. Detailed estimation results

Individual industry estimations

Tables B1 to B53 of sections 8.2 to 8.4 contain all individual industry estimations for processing industries, wholesale and retail sale, respectively.

Random effects estimation has been chosen in case of a 10% rejection of Hausman‘s *m*-statistic, or alternatively, if the P-value was above 0.1 (P > m). The entry *Random Intercept* shows then a single intercept for all firms within the same industry (see, for instance, Table B1: Model 3).

In case of fixed effects estimation, the corresponding entry *Fixed Intercept* depicts the number of firms with a significant intercept coefficient, sorted in descending order according to the 10, 5 and 1% level of significance. The first number in the second line of the same entry indicates then the arithmetic mean of all firms' intercept while the number in brackets refers to the arithmetic mean of those firms only with a significant intercept coefficient (see, for instance, Table B2: Model 3).

Recall that model 3 specifies a joint TFP growth rate β_1 for all firms within the same industry. On the contrary, model 4 assumes an individual firm-specific TFP growth rate β_{1i}. The corresponding entry *Time Dummy* is then built up in the same way as the entry *Fixed Intercept*, as explained above.

The last row of each table indicates the number of degrees of freedom *DFE* which varies considerably across industries, and finally, the number in italics below parameter estimates shows the corresponding t-value.

Processing

Table B1. Production, processing and preserving of pork (151110): 50 firms

	MODEL 3	MODEL 4
Random Intercept	1.2001***	1.3136***
	(3.35)	*(3.12)*
Time	0.0245**	
	(2.41)	
Time Dummy		12-11-8
		0.0035 (-0.0724)
Capital	0.2462***	0.2284***
	(6.82)	*(5.90)*
Raw Material	0.3386***	0.3584***
	(4.77)	*(4.97)*
External Costs	0.0458	0.0683
	(0.77)	*(1.13)*
Energy	0.0409	0.0399
	(1.08)	*(1.19)*
Other Costs	0.0105	0.0059
	(1.23)	*(0.61)*
Returns-to-scale	0.1152***	0.0410
	(3.61)	*(0.82)*
R-squared	0.5133	0.6898
Hausman P > m	0.4315	0.9215
DFE	243	194

Table B2. Production, processing and preserving of beef (151120): 35 firms

	MODEL 3	MODEL 4
Fixed Intercept	35-35-35	28-27-22
	2.9939	2.3382 (2.5667)
Time	0.0256**	
	(2.41)	
Time Dummy		11-11-7
		0.0100 (-0.0213)
Capital	0.1933***	0.1864***
	(5.36)	*(4.65)*
Raw Material	0.2048***	0.3390***
	(3.43)	*(5.14)*
External Costs	0.1668***	0.1561***
	(2.78)	*(2.82)*
Energy	-0.1744***	-0.1955***
	(-5.12)	*(-5.63)*
Other Costs	0.0183*	0.0031
	(1.74)	*(0.32)*
Returns-to-scale	-0.0781	-0.1346
	(-1.12)	*(-1.47)*
R-squared	0.9981	0.9991
Hausman P > m	0.0172	<.0001
DFE	146	112

Table B3. Production, processing and preserving of poultry meat (151200): 22 firms

	MODEL 3	MODEL 4
Random Intercept	2.7523***	2.5500***
	(6.22)	*(5.37)*
Time	-0.0191	
	(-1.44)	
Time Dummy		5-3-3
		0.0333 (-0.0004)
Capital	0.0177	-0.0104
	(1.19)	(-0.81)
Raw Material	0.2889***	0.3356***
	(3.96)	*(4.62)*
External Costs	-0.0313*	0.0232
	(-1.86)	*(1.49)*
Energy	0.1911**	0.0390
	(2.15)	*(0.45)*
Other Costs	0.0289***	0.0127
	(2.70)	*(1.37)*
Returns-to-scale	0.1232***	0.1543**
	(2.89)	*(2.43)*
R-squared	0.4497	0.7032
Hausman P > m	0.3586	0.6951
DFE	91	70

Table B4. Production of prepared meat dishes (151310): 26 firms

	MODEL 3	MODEL 4
Random Intercept	4.0028***	3.7278***
	(7.04)	*(3.53)*
Time	0.0365***	
	(2.65)	
Time Dummy		4-2-1
		-0.0458 (-0.0761)
Capital	-0.0259*	-0.0590***
	(-1.68)	*(-2.88)*
Raw Material	0.3578***	0.3804***
	(3.44)	*(2.77)*
External Costs	-0.2459***	-0.1300
	(-2.70)	*(-1.21)*
Energy	0.0353	-0.0046
	(0.39)	*(-0.04)*
Other Costs	0.0124	0.0675
	(0.52)	*(1.35)*
Returns-to-scale	0.1003***	0.1379**
	(3.63)	*(2.24)*
R-squared	0.2237	0.3515
Hausman P > m	0.4673	0.9459
DFE	127	102

Table B5. Other production, processing and preserving of meat products (151390): 173 firms

	MODEL 3	MODEL 4
Fixed Intercept	171-170-167	128-122-111
	2.0615 (2.0794)	2.4042 (2.7525)
Time	0.0022	
	(0.27)	
Time Dummy		30-27-10
		0.0352 (0.1718)
Capital	0.0765***	0.0528***
	(5.66)	*(3.36)*
Raw Material	0.4924***	0.4423***
	(7.92)	*(6.34)*
External Costs	-0.1596	-0.1307
	(-2.23)	*(-1.53)*
Energy	0.0294	0.0298
	(1.07)	*(0.91)*
Other Costs	0.0131	-0.0059
	(1.20)	*(-0.45)*
Returns-to-scale	0.0893	-0.0917
	(1.33)	*(-0.97)*
R-squared	0.9943	0.9965
Hausman P > m	0.0001	0.0064
DFE	654	482

Table B6. Production, processing and filleting of fish and fish products (152010): 141 firms

	MODEL 3	MODEL 4
Fixed Intercept	141-141-141 3.1703	
Random Intercept		3.4312*** *(8.91)*
Time	0.0047 *(0.56)*	
Time Dummy		27-19-10 0.0100 (-0.0316)
Capital	-0.0542*** *(-5.29)*	-0.0384*** *(-3.95)*
Raw Material	0.4203*** *(8.15)*	0.3831*** *(7.72)*
External Costs	-0.0065 *(-0.53)*	-0.0106 *(-0.99)*
Energy	0.0788** *(2.03)*	0.0667* *(1.91)*
Other Costs	0.0043 *(0.52)*	-0.0008 *(-0.09)*
Returns-to-scale	-0.1437*** *(-3.26)*	-0.1538*** *(-3.35)*
R-squared	0.9960	0.5610
Hausman P > m	0.0061	0.9778
DFE	555	555

Table B7. Smoking and salting of fish (152020): 91 firms

	MODEL 3	MODEL 4
Fixed Intercept	89-87-80 1.5698 (1.5881)	
Random Intercept		1.7664*** *(5.22)*
Time	-0.0177* *(-1.79)*	
Time Dummy		22-18-8 -0.0483 (-0.0865)
Capital	0.0642*** *(5.60)*	0.0778*** *(5.73)*
Raw Material	0.5697*** *(7.67)*	0.5552*** *(8.15)*
External Costs	-0.1005* *(-1.86)*	-0.1328*** *(-2.67)*
Energy	0.1055* *(1.92)*	0.0831* *(1.73)*
Other Costs	0.0187* *(1.69)*	0.0245** *(2.29)*
Returns-to-scale	-0.0177 *(-0.43)*	-0.0116 *(-0.30)*
R-squared	0.9967	0.7166
Hausman P > m	0.0061	0.9965
DFE	347	347

Table B8. Production of bone fishmeal (152030): 16 firms

	MODEL 3	MODEL 4
Random Intercept	2.0063***	1.2408
	(3.06)	*(1.11)*
Time	-0.0258	
	(-1.07)	
Time Dummy		6-4-3
		0.1937 (0.4955)
Capital	-0.0314	-0.0434
	(-0.96)	*(-0.82)*
Raw Material	0.3413***	0.4588***
	(2.75)	*(4.02)*
External Costs	0.3046**	0.2487**
	(2.39)	*(2.48)*
Energy	0.0355	-0.0018
	(0.46)	*(-0.02)*
Other Costs	0.0125	-0.0010
	(0.89)	*(-0.10)*
Returns-to-scale	0.0153	0.0571
	(0.18)	*(0.37)*
R-squared	0.7623	0.9306
Hausman P > m	0.1474	0.4677
DFE	64	49

Table B9. Processing and preserving of potatoes (153100): 10 firms

	MODEL 3	MODEL 4
Random Intercept	3.3194***	Not computable
	(3.15)	
Time	0.0325	
	(1.48)	
Capital	0.1757*	
	(1.78)	
Raw Material	0.3532**	
	(2.35)	
External Costs	-0.2406*	
	(-1.88)	
Energy	-0.0604	
	(-0.65)	
Other Costs	0.0628	
	(1.33)	
Returns-to-scale	0.0558	
	(0.76)	
R-squared	0.1706	
Hausman P > m	0.6729	
DFE	46	

Table B10. Processing and preserving of fruit and vegetables n.e.c. (153300): 45 firms

	MODEL 3	MODEL 4
Fixed Intercept	45-45-45	
	6.2905	
Random Intercept		5.7810***
		(15.51)
Time	0.0107	
	(0.85)	
Time Dummy		10-5-3
		-0.0024 (-0.0839)
Capital	0.0230*	0.0282**
	(1.92)	*(2.35)*
Raw Material	-0.0364	0.0898
	(-0.57)	*(1.35)*
External Costs	0.0372	0.0073
	(0.69)	*(0.13)*
Energy	0.1430**	0.0530
	(2.25)	*(0.82)*
Other Costs	0.0103	0.0073
	(0.96)	*(0.67)*
Returns-to-scale	-0.4541***	-0.4746***
	(-10.32)	*(-9.43)*
R-squared	0.9971	0.5643
Hausman P > m	<.0001	0.9989
DFE	186	186

Table B11. Manufacture of margarine and similar edible fats (154300): 14 firms

	MODEL 3	MODEL 4
Random Intercept	1.1278	1.4077
	(1.64)	*(1.55)*
Time	0.0437**	
	(2.48)	
Time Dummy		4-3-1
		0.1360 (0.1102)
Capital	-0.2020***	-0.0949
	(-2.76)	*(-1.22)*
Raw Material	0.7232***	0.5739***
	(5.14)	*(3.51)*
External Costs	-0.0114	-0.2161
	(-0.08)	*(-1.28)*
Energy	-0.0135	0.2181
	(-0.10)	*(1.63)*
Other Costs	0.1507***	0.1598***
	(6.88)	*(7.27)*
Returns-to-scale	-0.0010	0.2679***
	(-0.03)	*(3.05)*
R-squared	0.6811	0.8052
Hausman P > m	Not computable	0.9978
DFE	61	48

Table B12. Operation of dairies and cheese making (155110): 83 firms

	MODEL 3	MODEL 4
Fixed Intercept	83-83-82	29-23-11
	1.8343	0.8995 (1.2854)
Time	0.0227***	
	(3.10)	
Time Dummy		13-8-6
		0.0075 (0.1130)
Capital	0.0379***	0.0112
	(4.19)	*(0.91)*
Raw Material	0.3752***	0.5365***
	(7.14)	*(8.68)*
External Costs	0.0018	-0.0052
	(0.10)	*(-0.31)*
Energy	0.2427***	0.1981***
	(7.80)	*(5.57)*
Other Costs	0.0002	-0.0043
	(0.04)	*(-0.62)*
Returns-to-scale	0.0735*	0.1331**
	(1.89)	*(2.07)*
R-squared	0.9980	0.9987
Hausman P > m	0.0247	<.0001
DFE	356	274

Table B13. Manufacture of ice cream (155200): 20 firms

	MODEL 3	MODEL 4
Random Intercept	2.0003***	0.8246
	(3.90)	*(1.33)*
Time	0.0537***	
	(3.01)	
Time Dummy		5-3-1
		-0.0174 (-0.1298)
Capital	0.2832***	0.2851***
	(10.78)	*(11.61)*
Raw Material	0.2441**	0.4816***
	(2.29)	*(3.98)*
External Costs	-0.1890	-0.1895
	(-1.58)	*(-1.41)*
Energy	0.2596**	0.0377
	(2.10)	*(0.28)*
Other Costs	0.0275*	0.0224
	(1.98)	*(1.49)*
Returns-to-scale	0.1699***	0.3015***
	(4.21)	*(3.39)*
R-squared	0.7877	0.8423
Hausman P > m	0.8448	0.8325
DFE	85	66

Table B14. Manufacture of grain mill products and industrial manufacturing and processing of seeds (156100): 26 firms

	MODEL 3	MODEL 4
Random Intercept	2.8297***	1.7837***
	(6.80)	*(3.16)*
Time	0.0204*	
	(1.67)	
Time Dummy		5-3-2
		0.0130 (0.2100)
Capital	0.0142	0.0683***
	(0.66)	*(2.65)*
Raw Material	0.2334***	0.2992***
	(2.72)	*(3.28)*
External Costs	0.1600*	0.2663***
	(1.72)	*(2.73)*
Energy	0.0919*	0.0312
	(1.70)	*(0.59)*
Other Costs	-0.0066	-0.0191
	(-0.29)	*(-0.86)*
Returns-to-scale	0.0510	-0.0216
	(1.00)	*(-0.25)*
R-squared	0.4065	0.5395
Hausman P > m	0.4598	0.9999
DFE	135	110

Table B15. Manufacture of starches and starch products (156200): 8 firms

	MODEL 3	MODEL 4
Fixed Intercept	8-8-8	
	8.2154	
Random Intercept		9.0355***
		(10.99)
Time	0.0157	
	(0.59)	
Time Dummy		3-2-1
		-0.0947 (0.0379)
Capital	0.0600**	0.0570***
	(2.53)	*(2.79)*
Raw Material	0.1025	0.0851
	(0.77)	*(0.73)*
External Costs	-0.2459*	-0.2421**
	(1.83)	*(-2.08)*
Energy	0.1381*	0.1534**
	(1.70)	*(2.12)*
Other Costs	-0.0244*	-0.0213*
	(-1.95)	*(-1.87)*
Returns-to-scale	-0.7469***	-0.9950***
	(-3.96)	*(-5.47)*
R-squared		0.6399
Hausman P > m	0.0168	0.3974
DFE	41	41

Table B16. Manufacture of prepared feeds for agriculture and fur farming (157110): 64 firms

	MODEL 3	MODEL 4
Fixed Intercept	64-64-64	
	2.9660	
Random Intercept		2.9526***
		(8.14)
Time	0.0432***	
	(4.03)	
Time Dummy		12-7-4
		0.0115 (0.0188)
Capital	0.0347***	0.0378***
	(2.65)	*(2.74)*
Raw Material	0.2478***	0.2508***
	(4.51)	*(4.73)*
External Costs	0.2045***	0.2563***
	(3.09)	*(4.04)*
Energy	-0.0413	-0.0739**
	(-1.30)	*(-2.44)*
Other Costs	-0.0054	-0.0100
	(-0.79)	*(-1.39)*
Returns-to-scale	-0.0605	-0.1474***
	(-1.08)	*(-2.63)*
R-squared	0.9973	0.5162
Hausman P > m	<.0001	0.7006
DFE	247	247

Table B17. Manufacture of prepared pet feeds (157200): 18 firms

	MODEL 3	MODEL 4
Fixed Intercept		16-16-16
		5.0575 (5.7110)
Random Intercept	3.7136***	
	(7.11)	
Time	-0.0009	
	(-0.04)	
Time Dummy		4-2-2
		-0.0307 (-0.2799)
Capital	0.0264	-0.0387
	(0.95)	*(-0.35)*
Raw Material	0.2393*	0.2436*
	(1.98)	*(1.70)*
External Costs	-0.0758	-0.1450
	(-0.67)	*(-1.11)*
Energy	0.1090	0.0248
	(1.50)	*(0.28)*
Other Costs	0.0081	-0.0242
	(0.40)	*(-1.21)*
Returns-to-scale	0.0587	-0.2442***
	(1.16)	*(-2.75)*
R-squared	0.2967	0.9986
Hausman P > m	0.1210	0.0008
DFE	78	44

Table B18. Manufacture of bread and other bakery products (158110): 56 firms

	MODEL 3	MODEL 4
Random Intercept	3.4614***	3.6221***
	(14.74)	*(14.75)*
Time	0.0113	
	(1.53)	
Time Dummy		21-12-7
		-0.0151 (-0.0391)
Capital	0.0607***	0.0559***
	(4.00)	*(3.60)*
Raw Material	0.3087***	0.2958***
	(5.72)	*(5.49)*
External Costs	-0.0474	-0.0319
	(-0.97)	*(-0.64)*
Energy	0.0202	0.0247
	(0.43)	*(0.51)*
Other Costs	-0.0022	-0.0116
	(-0.25)	*(-1.27)*
Returns-to-scale	0.0999***	0.0760***
	(5.50)	*(3.43)*
R-squared	0.3402	0.7439
Hausman P > m	0.1258	0.1190
DFE	301	246

Table B19. Baker's shops (158120): 1953 firms

	MODEL 3	MODEL 4
Fixed Intercept	1952-1951-1947	Not computable
	1.6425 (1.6439)	
Time	0.0169***	
	(14.47)	
Capital	0.0173***	
	(9.49)	
Raw Material	0.7698***	
	(65.04)	
External Costs	-0.1751***	
	(-23.41)	
Energy	0.0115*	
	(1.66)	
Other Costs	0.0137***	
	(4.76)	
Returns-to-scale	0.1121***	
	(15.73)	
R-squared	0.9985	
Hausman P > m	<.0001	
DFE	8761	

Table B20. Manufacture of rusks and biscuits, manufacture of preserved pastryn goods and cakes (158200): 38 firms

	MODEL 3	MODEL 4
Fixed Intercept	38-38-38	
	3.1507	
Random Intercept		4.6749***
		(7.73)
Time	-0.0084	
	(-0.50)	
Time Dummy		6-5-3
		-0.0260 (0.0478)
Capital	0.0279	0.0524***
	(1.29)	*(2.69)*
Raw Material	0.1637	0.0060
	(1.49)	*(0.05)*
External Costs	0.2006**	0.1462
	(2.17)	*(1.61)*
Energy	0.0585	0.0210
	(0.87)	*(0.25)*
Other Costs	0.0526	0.0221
	(1.41)	*(0.53)*
Returns-to-scale	0.0755	-0.0485
	(0.93)	*(-0.62)*
R-squared	0.9961	0.5655
Hausman P > m	0.0779	1.0000
DFE	150	150

Table B21. Manufacture of cocoa, chocolate and sugar confectionery (158400): 79 firms

	MODEL 3	MODEL 4
Fixed Intercept	65-63-55	
	1.0714 (1.2422)	
Random Intercept		1.1079***
		(4.25)
Time	0.0364***	
	(4.09)	
Time Dummy		23-16-7
		0.0431 (0.1254)
Capital	-0.0006	-0.0173
	(-0.04)	*(-1.33)*
Raw Material	0.8207***	0.7298***
	(11.58)	*(12.09)*
External Costs	-0.0804	-0.0177
	(-1.52)	*(-0.39)*
Energy	-0.0457	-0.0040
	(-1.17)	*(-0.11)*
Other Costs	0.0213***	0.0111*
	(2.81)	*(1.69)*
Returns-to-scale	-0.1176**	0.0213
	(-2.58)	*(0.52)*
R-squared	0.9979	0.8309
Hausman P > m	0.0107	1.0000
DFE	310	310

Table B22. Manufacture of condiments and seasonings (158700): 21 firms

	MODEL 3	MODEL 4
Random Intercept	0.0428	0.1901
	(0.08)	*(0.30)*
Time	-0.0073	
	(-0.47)	
Time Dummy		4-2-2
		-0.0147 (-0.0169)
Capital	0.0595	0.1250**
	(1.35)	*(2.55)*
Raw Material	0.6777***	0.5557***
	(4.44)	*(3.28)*
External Costs	0.1653	0.2204
	(1.35)	*(1.60)*
Energy	0.0329	0.0567
	(0.51)	*(0.81)*
Other Costs	0.0113	0.0108
	(0.87)	*(0.75)*
Returns-to-scale	-0.0191	-0.0283
	(-0.44)	*(-0.45)*
R-squared	0.6313	0.7898
Hausman P > m	0.7306	0.6375
DFE	117	97

Table B23. Manufacture of dietary supplements and other food products n.e.c. (158900): 74 firms

	MODEL 3	MODEL 4
Fixed Intercept	74-74-74	
	4.3724	
Random Intercept		2.9601***
		(7.40)
Time	0.0322***	
	(3.56)	
Time Dummy		11-7-3
		0.0311 (0.1478)
Capital	0.0360***	0.0276**
	(3.41)	*(2.38)*
Raw Material	0.2952***	0.3697***
	(4.89)	*(6.10)*
External Costs	0.0291	0.0509
	(0.65)	*(1.18)*
Energy	0.0012	0.0141
	(0.04)	*(0.50)*
Other Costs	-0.0041	0.0017
	(-0.52)	*(0.21)*
Returns-to-scale	-0.3534***	-0.0322
	(-5.40)	*(-0.60)*
R-squared	0.9979	0.5577
Hausman P > m	<.0001	0.9997
DFE	283	283

Table B24. Manufacture of beer (159600): 21 firms

	MODEL 3	MODEL 4
Random Intercept	2.2555***	4.8628***
	(5.47)	*(5.21)*
Time	-0.0182	
	(-1.49)	
Time Dummy		6-3-2
		-0.0148 (-0.1054)
Capital	0.1146***	0.0675**
	(3.86)	*(2.62)*
Raw Material	0.2838***	0.0754
	(3.97)	*(0.91)*
External Costs	0.0849*	-0.0205
	(1.71)	*(-0.46)*
Energy	0.1288*	0.0215
	(1.78)	*(0.28)*
Other Costs	0.0304***	0.0262**
	(3.17)	*(2.49)*
Returns-to-scale	0.1075***	-0.0097
	(4.47)	*(-0.10)*
R-squared	0.6443	0.6846
Hausman P > m	Not computable	1.0000
DFE	97	77

Table B25. Production of mineral waters and soft drinks (159800): 20 firms

	MODEL 3	MODEL 4
Random Intercept	1.4877***	3.3706***
	(3.23)	*(3.03)*
Time	-0.0489**	
	(-2.13)	
Time Dummy		3-1-1
		-0.0203 (0.0556)
Capital	0.0703	0.0532
	(1.42)	*(0.55)*
Raw Material	0.3172***	0.1856
	(3.15)	*(1.39)*
External Costs	0.3822***	0.2500*
	(3.59)	*(1.80)*
Energy	0.0142	0.0368
	(0.16)	*(0.31)*
Other Costs	0.0461	0.0849
	(0.94)	*(1.37)*
Returns-to-scale	-0.0028	-0.2346*
	(-0.10)	*(-1.89)*
R-squared	0.5657	0.4202
Hausman P > m	Not computable	0.9961
DFE	98	79

Wholesale

Table B26. Wholesale of fruits and vegetables (513100): 301 firms

	MODEL 3	MODEL 4
Fixed Intercept	242-222-184 0.9515 (1.1333)	
Random Intercept		1.3371*** *(5.64)*
Time	0.0016 *(0.17)*	
Time Dummy		40-26-13 -0.0240 (-0.1105)
Capital	0.0345*** *(4.88)*	0.0442*** *(5.99)*
Raw Material	0.5617*** *(17.85)*	0.5128*** *(16.76)*
External Costs	-0.0174 *(-0.68)*	0.0114 *(0.49)*
Energy	0.0121** *(2.02)*	0.0066 *(1.14)*
Other Costs	0.0097 *(0.92)*	0.0085 *(0.81)*
Returns-to-scale	0.1993*** *(5.60)*	0.1762*** *(4.65)*
R-squared	0.9955	0.5890
Hausman P > m	<.0001	0.9722
DFE	997	997

Table B27. Wholesale of meat and meat products (513200): 317 firms

	MODEL 3	MODEL 4
Fixed Intercept	317-317-317 4.2484	
Random Intercept		4.5251*** *(22.32)*
Time	0.0059 *(0.58)*	
Time Dummy		57-40-24 -0.0325 (-0.1833)
Capital	0.0216*** *(2.99)*	0.0231*** *(3.38)*
Raw Material	0.1648*** *(7.73)*	0.1515*** *(7.40)*
External Costs	0.0335 *(1.49)*	0.0458** *(2.27)*
Energy	0.0164** *(2.13)*	0.0159** *(2.31)*
Other Costs	0.1007*** *(6.94)*	0.0672*** *(4.88)*
Returns-to-scale	-0.1249*** *(-3.44)*	-0.1010*** *(-2.80)*
R-squared	0.9950	0.5791
Hausman P > m	<.0001	0.9997
DFE	1065	1065

Table B28. Wholesale of diary produce, eggs and edible oils and fats (513300): 153 firms

	MODEL 3	MODEL 4
Fixed Intercept	153-153-153 2.5393	
Random Intercept		3.0071*** *(8.23)*
Time	0.0130 *(0.91)*	
Time Dummy		20-15-10 -0.0128 (-0.0102)
Capital	-0.0067 *(-0.75)*	-0.0103 *(-1.15)*
Raw Material	0.5025*** *(10.69)*	0.4096*** *(9.45)*
External Costs	-0.1521 *(-4.66)*	-0.0736** *(-2.44)*
Energy	0.0345*** *(3.75)*	0.0260*** *(3.09)*
Other Costs	-0.0115 *(-0.89)*	-0.0176 *(-1.13)*
Returns-to-scale	-0.0403 *(-0.71)*	0.0371 *(0.62)*
R-squared	0.9958	0.5488
Hausman P > m	<.0001	0.9700
DFE	454	454

Table B29. Wholesale of beer and soft drinks (513410): 150 firms

	MODEL 3	MODEL 4
Fixed Intercept	56-34-13 0.5026 (0.7667)	
Random Intercept		1.1078*** *(3.37)*
Time	0.1117*** *(5.24)*	
Time Dummy		25-21-14 0.0852 (0.3029)
Capital	0.0089 *(1.53)*	0.0093 *(1.54)*
Raw Material	0.5272*** *(13.15)*	0.4327*** *(11.42)*
External Costs	0.1289*** *(3.93)*	0.1582*** *(5.21)*
Energy	0.0371*** *(3.88)*	0.0422*** *(4.86)*
Other Costs	0.0118 *(1.10)*	-0.0178* *(-1.83)*
Returns-to-scale	-0.0114 *(-0.24)*	0.0647 *(1.36)*
R-squared	0.9967	0.7374
Hausman P > m	0.0119	0.8112
DFE	471	471

Table B30. Wholesale of wine and spirits (513420): 235 firms

	MODEL 3	MODEL 4
Fixed Intercept	82-60-21	
	0.3311 (0.7573)	
Random Intercept		0.5348*
		(1.82)
Time	0.0068	
	(0.59)	
Time Dummy		27-18-8
		0.0002 (-0.0089)
Capital	0.0009	-0.0036
	(0.10)	*(-0.42)*
Raw Material	0.6559***	0.6149***
	(15.15)	*(14.91)*
External Costs	-0.0133	0.0283
	(-0.43)	*(0.99)*
Energy	0.0093	0.0085
	(1.29)	*(1.23)*
Other Costs	0.0115	0.0086
	(0.78)	*(0.56)*
Returns-to-scale	0.1076**	0.0956**
	(2.15)	*(2.03)*
R-squared	0.9941	0.5996
Hausman P > m	<.0001	0.9905
DFE	804	804

Table B31. Wholesale of fruit and vegetable juice etc. (513490): 14 firms

	MODEL 3	MODEL 4
Random Intercept	2.7475***	3.2266***
	(3.69)	*(4.09)*
Time	0.0239	
	(0.61)	
Time Dummy		3-1-0
		0.0179 (0.0250)
Capital	0.1340***	0.1261***
	(3.36)	*(2.81)*
Raw Material	0.3324***	0.2556**
	(3.21)	*(2.19)*
External Costs	-0.0633	-0.0661
	(-1.09)	*(-1.20)*
Energy	0.0145	0.0177
	(0.95)	*(1.18)*
Other Costs	-0.0219	0.0639
	(-0.24)	*(0.56)*
Returns-to-scale	0.0852	0.0504
	(1.33)	*(0.68)*
R-squared	0.4287	0.7987
Hausman P > m	0.4393	0.9910
DFE	45	32

Table B32. Wholesale of tobacco products (513500): 16 firms

	MODEL 3	MODEL 4
Random Intercept	2.7875***	3.1919***
	(3.62)	*(3.83)*
Time	0.0478**	
	(2.29)	
Time Dummy		3-2-1
		0.0739 (0.1604)
Capital	-0.0101	-0.0343
	(-0.35)	*(-1.16)*
Raw Material	0.3028***	0.2978***
	(3.41)	*(3.29)*
External Costs	0.0272	-0.0042
	(0.35)	*(-0.05)*
Energy	0.0040	0.1050
	(0.05)	*(1.07)*
Other Costs	0.0798	0.0187
	(1.12)	*(0.23)*
Returns-to-scale	0.0847	-0.0183
	(0.90)	*(-0.15)*
R-squared	0.3199	0.5303
Hausman P > m	0.1418	0.4151
DFE	67	52

Table B33. Wholesale of bread, cakes, sugar, chocolate and sugar confectionery (513600): 90 firms

	MODEL 3	MODEL 4
Fixed Intercept	90-90-90	
	4.4998	
Random Intercept		4.0518***
		(10.50)
Time	0.0236	
	(1.08)	
Time Dummy		15-8-2
		0.0339 (0.1064)
Capital	0.0127	-0.0010
	(1.09)	*(-0.08)*
Raw Material	0.0600*	0.0852**
	(1.92)	*(2.54)*
External Costs	-0.0065	0.0451
	(-0.08)	*(0.60)*
Energy	0.0737***	0.0472**
	(3.37)	*(2.16)*
Other Costs	0.1493***	0.1794***
	(3.59)	*(4.33)*
Returns-to-scale	0.0422	-0.0159
	(0.48)	*(-0.20)*
R-squared	0.9923	0.5137
Hausman P > m	0.0178	0.5542
DFE	272	272

Table B34. Wholesale of coffee, tea, cocoa and spices (513700): 81 firms

	MODEL 3	MODEL 4
Fixed Intercept	81-81-81 4.1985	
Random Intercept		3.7770*** *(7.19)*
Time	0.0373** *(2.11)*	
Time Dummy		23-17-8 0.0702 (0.0991)
Capital	0.0622*** *(3.20)*	0.0609*** *(3.69)*
Raw Material	0.2266*** *(3.40)*	0.2149*** *(3.66)*
External Costs	-0.2434*** *(-3.02)*	-0.1896** *(-2.45)*
Energy	-0.0545** *(-2.36)*	-0.0401* *(-1.84)*
Other Costs	0.2470*** *(6.85)*	0.2083*** *(5.18)*
Returns-to-scale	-0.0436 *(-0.48)*	0.0419 *(0.45)*
R-squared	0.9961	0.5672
Hausman P > m	0.0119	0.9033
DFE	265	265

Table B35. Wholesale of fish and products thereof (513810): 323 firms

	MODEL 3	MODEL 4
Fixed Intercept	314-310-304 1.6021 (1.6420)	
Random Intercept		1.6611*** *(6.53)*
Time	0.0228*** *(2.65)*	
Time Dummy		50-37-16 0.0305 (0.0410)
Capital	0.0008 *(0.14)*	-0.0050 *(-0.93)*
Raw Material	0.4636*** *(13.72)*	0.4434*** *(13.91)*
External Costs	0.0397 *(1.25)*	0.0683** *(2.27)*
Energy	0.0282*** *(3.02)*	0.0249*** *(2.71)*
Other Costs	0.0101 *(0.59)*	0.0094 *(0.59)*
Returns-to-scale	0.0613* *(1.74)*	0.0208 *(0.58)*
R-squared	0.9956	0.5395
Hausman P > m	0.0115	1.0000
DFE	1091	1091

Table B36. Wholesale of bread, cakes and biscuits (513820): 46 firms (terminated in 2002)

	MODEL 3	MODEL 4
Fixed Intercept	45-45-45 3.8485 (3.9184)	
Random Intercept		3.9299*** *(5.77)*
Time	-0.0190 *(-0.55)*	
Time Dummy		9-4-2 -0.0549 (-0.2233)
Capital	0.0439** *(2.07)*	0.0566*** *(2.83)*
Raw Material	0.2682*** *(3.21)*	0.3641*** *(4.81)*
External Costs	-0.1250 *(-1.23)*	-0.2308** *(-2.56)*
Energy	0.1534*** *(3.74)*	0.1638*** *(3.88)*
Other Costs	-0.0234 *(-0.47)*	-0.0162 *(-0.37)*
Returns-to-scale	0.2542** *(2.09)*	0.0895 *(0.78)*
R-squared	0.9941	0.6774
Hausman P > m	<.0001	0.4552
DFE	122	122

Table B37. Wholesale of health food products (513830): 71 firms

	MODEL 3	MODEL 4
Fixed Intercept	71-70-70 3.5105	
Random Intercept		3.3458*** *(5.64)*
Time	0.0155 *(0.59)*	
Time Dummy		14-10-2 -0.0092 (-0.1203)
Capital	0.0345* *(1.88)*	0.0290 *(1.54)*
Raw Material	0.2923*** *(3.27)*	0.2956*** *(3.75)*
External Costs	-0.0893 *(-1.13)*	-0.0783 *(-0.97)*
Energy	0.0038 *(0.17)*	-0.0021 *(-0.10)*
Other Costs	0.0277 *(0.66)*	0.0327 *(0.76)*
Returns-to-scale	0.0702 *(0.74)*	0.2970*** *(3.15)*
R-squared	0.9921	0.4182
Hausman P > m	0.0032	0.9991
DFE	216	216

Table B38. B38: Other specialized wholesale of food, beverages and tobacco (513890): 102 firms

	MODEL 3	MODEL 4
Fixed Intercept	102-102-97 2.8481	58-53-40 3.3092 (4.1583)
Time	0.0636** (2.58)	
Time Dummy		12-11-6 0.1553 (0.7897)
Capital	-0.0142 *(-0.87)*	-0.0113 *(-0.59)*
Raw Material	0.3362*** *(3.94)*	0.1670 *(1.62)*
External Costs	-0.1143 *(-1.43)*	-0.0804 *(-0.86)*
Energy	0.0374* *(1.94)*	0.0553** *(2.20)*
Other Costs	0.1234*** *(2.85)*	0.1630** *(2.39)*
Returns-to-scale	0.0271 *(0.28)*	-0.0435 *(-0.31)*
R-squared	0.9923	0.9955
Hausman P > m	0.0615	0.2105
DFE	287	186

Table B39. Non-specialized wholesale of food, beverages and tobacco (513900): 301 firms

	MODEL 3	MODEL 4
Fixed Intercept	288-284-272 1.6816 (1.7412)	
Random Intercept		1.7898*** *(7.32)*
Time	0.0260*** *(2.75)*	
Time Dummy		42-29-16 0.0224 (0.0529)
Capital	0.0030 *(0.53)*	0.0055 *(0.95)*
Raw Material	0.4601*** *(15.23)*	0.4357*** *(14.26)*
External Costs	-0.0125 *(-0.61)*	0.0068 *(0.33)*
Energy	0.0250*** *(2.73)*	0.0220** *(2.48)*
Other Costs	0.0550*** *(4.28)*	0.0522*** *(3.94)*
Returns-to-scale	0.0748*** *(2.61)*	0.0811*** *(2.84)*
R-squared	0.9956	0.6031
Hausman P > m	<.0001	0.9945
DFE	883	883

Retail sale

Table B40. Grocer's shops (521110): 3739 firms

	MODEL 3
Fixed Intercept	3120-2880-2422
	0.6451 (0.7403)
Time	-0.0199***
	(-12.26)
Capital	0.0284***
	(18.62)
Raw Material	0.5458***
	(51.67)
External Costs	0.0778***
	(9.13)
Energy	0.0694***
	(11.90)
Other Costs	0.0264***
	(5.34)
Returns-to-scale	0.0246**
	(2.12)
R-squared	0.9961
Hausman P > m	<.0001
DFE	13356

Table B41. All-night shops (521120): 1874 firms

	MODEL 3
Fixed Intercept	1860-1857-1846
	-1.1799 (-1.1881)
Time	-0.0155***
	(-5.47)
Capital	0.0300***
	(15.62)
Raw Material	0.8795***
	(48.42)
External Costs	-0.0307**
	(-2.33)
Energy	0.0220***
	(2.69)
Other Costs	0.0073
	(0.72)
Returns-to-scale	0.1084***
	(6.37)
R-squared	0.9968
Hausman P > m	<.0001
DFE	5058

Table B42. Supermarkets (521130): 914 firms

	MODEL 3
Fixed Intercept	914-914-914
	3.4214
Time	0.0001
	(0.02)
Capital	0.0293***
	(11.54)
Raw Material	0.2282***
	(19.32)
External Costs	0.0552***
	(6.39)
Energy	0.0214***
	(3.77)
Other Costs	-0.0013
	(-0.32)
Returns-to-scale	0.0065
	(0.53)
R-squared	0.9977
Hausman P > m	<.0001
DFE	3661

Table B43. Variety stores (521210): 35 firms

	MODEL 3
Fixed Intercept	1-0-0
	0.0187 (-1.3161)
Time	-0.0051
	(-0.57)
Capital	0.0229**
	(2.40)
Raw Material	0.8007***
	(8.51)
External Costs	-0.0847
	(-1.53)
Energy	0.0160
	(0.63)
Other Costs	-0.0008
	(-0.10)
Returns-to-scale	0.0077
	(0.12)
R-squared	0.9995
Hausman P > m	0.0013
DFE	98

Table B44. Retail sale of fruit and vegetables (522100): 1374 firms

	MODEL 3
Fixed Intercept	251-199-127
	-0.0258 (-0.0312)
Time	-0.0039
	(-1.40)
Capital	0.0289***
	(10.92)
Raw Material	0.7281***
	(35.07)
External Costs	0.0615***
	(2.87)
Energy	0.0138***
	(2.82)
Other Costs	0.0110
	(1.36)
Returns-to-scale	0.0693***
	(3.36)
R-squared	0.9964
Hausman P > m	<.0001
DFE	4031

Table B45. Retail sale of meat and meat products (522200): 1412 firms

	MODEL 3
Fixed Intercept	1127-1032-873
	0.5784 (0.6856)
Time	-0.0045**
	(-2.44)
Capital	-0.0029
	(-1.44)
Raw Material	0.7394***
	(49.71)
External Costs	-0.0361***
	(-3.21)
Energy	0.0373***
	(7.37)
Other Costs	0.0054
	(1.05)
Returns-to-scale	0.2567***
	(18.93)
R-squared	0.9974
Hausman P > m	<.0001
DFE	5755

Table B46. Retail sale of fish, game, crustaceans and molluscs (522300): 513 firms

	MODEL 3
Fixed Intercept	194-145-69
	-0.1479 (-0.2291)
Time	-0.0085***
	(-2.73)
Capital	0.0024
	(0.86)
Raw Material	0.8908***
	(34.38)
External Costs	-0.0981***
	(-3.66)
Energy	0.0411***
	(5.20)
Other Costs	0.0150
	(1.57)
Returns-to-scale	0.2043***
	(8.47)
R-squared	0.9975
Hausman P > m	0.0027
DFE	1974

Table B47. Retail sale of bread, cakes and flour confectionery (522410): 209 firms

	MODEL 3
Fixed Intercept	144-124-55
	0.6203 (0.7875)
Time	0.0164**
	(2.03)
Capital	0.0327***
	(5.55)
Raw Material	0.5690***
	(9.62)
External Costs	0.0885
	(1.38)
Energy	0.0095
	(0.54)
Other Costs	0.0710***
	(2.72)
Returns-to-scale	0.1067**
	(2.08)
R-squared	0.9965
Hausman P > m	0.0005
DFE	587

Table B48. Retail sale of chocolate and sugar confectionery (522420): 833 firms

	MODEL 3
Fixed Intercept	533-448-305
	0.5268 (0.7020)
Time	-0.0024
	(-0.64)
Capital	0.0094***
	(3.46)
Raw Material	0.6977***
	(24.01)
External Costs	-0.0222
	(-0.77)
Energy	0.0303***
	(4.59)
Other Costs	0.0273**
	(2.48)
Returns-to-scale	0.2057***
	(7.17)
R-squared	0.9958
Hausman P > m	<.0001
DFE	2683

Table B49. Retail sale of alcoholic and other beverages (522500): 388 firms

	MODEL 3
Fixed Intercept	354-325-272
	0.9311 (0.9909)
Time	-0.0012
	(-0.20)
Capital	0.0269***
	(5.89)
Raw Material	0.4835***
	(11.10)
External Costs	0.1734***
	(4.01)
Energy	0.0218**
	(2.29)
Other Costs	0.0071
	(0.50)
Returns-to-scale	0.0203
	(0.48)
R-squared	0.9949
Hausman P > m	<.0001
DFE	1293

Table B50. Retail sale of tobacco products (522600): 1842 firms

	MODEL 3
Fixed Intercept	1805-1794-1752
	1.2938 (1.3155)
Time	-0.0024
	(-0.95)
Capital	0.0350***
	(19.88)
Raw Material	0.5045***
	(26.78)
External Costs	0.0718***
	(3.66)
Energy	0.0352***
	(5.24)
Other Costs	0.0238**
	(1.97)
Returns-to-scale	-0.1540***
	(-7.70)
R-squared	0.9957
Hausman P > m	<.0001
DFE	6479

Table B51. Retail sale of cheese (522710): 234 firms

	MODEL 3
Fixed Intercept	48-31-11
	0.0769 (0.1781)
Time	0.0079*
	(1.74)
Capital	0.0061*
	(1.72)
Raw Material	0.7759***
	(18.55)
External Costs	-0.0401
	(-0.87)
Energy	0.0267
	(1.46)
Other Costs	0.0650***
	(2.65)
Returns-to-scale	0.0892**
	(1.98)
R-squared	0.9973
Hausman P > m	0.0407
DFE	1017

Table B52. Retail sale of health food (522730): 343 firms

	MODEL 3
Fixed Intercept	65-34-17
	-0.1482 (-0.3028)
Time	0.0092
	(1.64)
Capital	0.0161***
	(3.57)
Raw Material	0.8073***
	(18.79)
External Costs	-0.0300
	(-0.73)
Energy	0.0099
	(1.57)
Other Costs	0.0080
	(0.75)
Returns-to-scale	0.0823*
	(1.69)
R-squared	0.9963
Hausman P > m	<.0001
DFE	1022

Table B53. Other retail sale of food and beverages in specialized stores (522790): 191 firms

	MODEL 3
Fixed Intercept	39-31-22
	0.1461 (0.5910)
Time	-0.0149*
	(-1.82)
Capital	-0.0066
	(-0.96)
Raw Material	0.7800***
	(13.70)
External Costs	0.0294
	(0.50)
Energy	0.0318***
	(2.67)
Other Costs	-0.0132
	(-0.61)
Returns-to-scale	-0.0988
	(-1.59)
R-squared	0.9961
Hausman P > m	<.0001
DFE	534

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