Business Dynamics and Productivity

Chapter 8

Employment dynamics and labour productivity growth in the Norwegian economy: Evidence from firm-level data

by
Arvid Raknerud *and* Diana-Cristina Iancu
Statistics Norway

This chapter proposes a new decomposition of employment and labour productivity growth. The decomposition is an extension of a standard method that is frequently used, for example, by the OECD. It identifies three main sources of productivity growth: within-firm productivity growth, between-firm reallocation effects and entry/exit dynamics. The contributions from different industries are quantified; from SMEs versus large firms; and non-exporting versus exporting firms. The analyses reveal that the strong employment growth in labour-intensive service industries during the last decade – partly driven by labour immigration – mainly affected productivity growth through the channel of entry/exit dynamics. In particular, net entry of employees into new firms in some service industries in the period 2002-07 is associated with an annual one percentage point reduction in productivity growth. However, these developments by no means explain the strong downward trend in productivity growth during the last decade.

Introduction

The government appointed productivity commission[1] reports that productivity growth in the Norwegian mainland business sector declined after 2005 compared to 1996-2005. The commission cites official statistics showing that average annual labour productivity growth was 0.8% during 2006-14, down from 3% during 1996-2005 (see Figure 1.1 in NOU [2016]). This productivity slowdown is assumed to reflect strong employment growth in labour-intensive industries such as construction, transportation, retail trade and other service industries, which became particularly strong in the wake of the European Union (EU) expansion in 2004. As is noted in the report, the downward trend in labour productivity during the last ten years or so is by no means a Norwegian peculiarity. For all the OECD countries combined, the trend growth in annual labour productivity declined steadily from 1.8% in 2000 to 0.4% in 2014.

The data reported by the commission – and in other official productivity statistics – come from the National Accounts (NA). The purpose of this chapter is to analyse productivity growth patterns and employment flows using firm-level registry data for the total population of Norwegian incorporated firms over the period 1996-2014.

An important benefit of firm-level data is the possibility to decompose employment and output growth – and hence also aggregate growth in labour productivity – additively according to different types of sources, such as contributions from entry and exit, within-firm reallocations, exporting versus non-exporting firms, and so on. This chapter proposes and explore a new decomposition, which is an extension of the decomposition outlined in OECD (2001, p. 145). This study's decomposition identifies three main sources or channels of productivity growth: i) within-firm productivity growth; ii) between-firm reallocation effects; and iii) firm turnover effects (entry/exit dynamics). The decomposition into parts i) and ii) is somewhat abstract, as it attempts to separate between the (counterfactual) productivity growth that would have occurred without any reallocation of labour between existing firms on the one hand and the effect of such labour reallocations on the other. The chapter also quantifies the contributions from the different industries; from small and medium-sized enterprises (SMEs) versus large firms; and non-exporting versus exporting firms.

This analysis' findings with regard to employment and labour productivity growth in Norway in the period 1996-2014 correspond well with the findings of the productivity commission cited above. For example, calculations show that growth in labour productivity (real value-added per employee) during 2005-14 was 1.3% annually in the mainland Norwegian economy, compared to 3.2% during 1996-2004. Hence this study also finds a strong productivity slowdown during the last decade. It is the purpose of the rest of this chapter to look further into the sources of this slowdown.

Productivity growth decompositions

The seminal paper of Foster, Haltiwanger and Krizan (2001) outlines a framework for decomposing productivity growth based on weighted average productivity levels to identify the contribution of firm turnover, e.g. entry/exit dynamics, to aggregate productivity growth.

It has been used by many – e.g. Foster, Haltiwanger and Syverson (2008) – to quantify the impact of different sources of productivity growth, for example the contributions from reallocation of labour inputs among existing firms versus turnover (exit and entry). Possible drawbacks of their decomposition method have been pointed out by several authors, for example Katayama, Lu and Tybout (2003), who point out that productivity indices based on nominal variables may have little to do with actual productivity levels. Alternative aggregation methods exist in the literature. A recent proposal is von Brasch (2015) who outlines a decomposition that identifies the contribution of entering and exiting firms to aggregate productivity growth using a Constant Elasticity of Subsitution (CES) framework. In contrast to the method in Foster, Haltiwanger and Syverson (2008), which is based on the assumptions that inputs and outputs are homogenous across firms, the framework in Brasch (2015) allows for both heterogeneous outputs and heterogeneous inputs. The contribution of entering and exiting firms to aggregate productivity growth is in this framework shown to be based on the profitability of entering and exiting firms relative to the profitability of continuing firms.

This chapter extends a well-known framework (see OECD [2001, p. 145]) for decomposing aggregate productivity growth rates at the sectoral level into between-industry reallocation effects and within-industry productivity growth. It does so by incorporating firm-level dynamics. The method is different from Foster, Haltiwanger and Krizan (2001) who decompose productivity growth levels rather than productivity growth rates. This study's extension incorporates the effects from entering and exiting firms in a similar way to von Brasch (2015), but is algebraically much simpler (requiring no reliance on, or understanding of, complicated index theory). However, like Foster, Haltiwanger and Syverson (2008), it assumes homogeneous output and input.

It starts its analysis by introducing some definitions and notation. First, let Q_{it} and L_{it} be output (e.g. value-added in real prices) and labour input (e.g. number of employees) of firm *i* in period *t*, respectively. For simplicity, capital input is not taken into account. Aggregate output and input in *t* and *t-1* can be decomposed as:

$$Q_t = \sum_{i \in C(t)} Q_{it} + \sum_{i \in E(t)} Q_{it}, \quad L_t = \sum_{i \in C(t)} L_{it} + \sum_{i \in E(t)} L_{it},$$

and

$$Q_{t-1} = \sum_{i \in C(t)} Q_{i,t-1} + \sum_{i \in X(t)} Q_{i,t-1}, \quad L_{t-1} = \sum_{i \in C(t)} L_{i,t-1} + \sum_{i \in X(t)} L_{i,t-1},$$

where *C(t)* is the set of continuing firms (firms that exist in both *t-1* and *t*), *X(t)* is the set of exiting firms (existing in *t-1* but not *t*) and *E(t)* the set of entering firms (existing in *t* but not *t-1*). Output and input weights of continuing and exiting firms are also defined as follows:

$$s^Q_{C(t)} = \frac{\sum_{i \in C(t)} Q_{i,t-1}}{Q_{t-1}}, \quad s^Q_{X(t)} = \frac{\sum_{i \in X(t)} Q_{i,t-1}}{Q_{t-1}},$$

$$s^L_{C(t)} = \frac{\sum_{i \in C(t)} L_{i,t-1}}{L_{t-1}}, \quad s^L_{X(t)} = \frac{\sum_{i \in X(t)} L_{i,t-1}}{L_{t-1}}.$$

Let Δ be the backward difference operator, for example, $\Delta Q_t = Q_t - Q_{t-1}$. Relative output and input growth is then given by:

$$\frac{\Delta Q_t}{Q_{t-1}} = \frac{1}{Q_{t-1}}\left[\sum_{i\in C(t)} \Delta Q_{it} + \sum_{i\in E(t)} Q_{it} - \sum_{i\in X(t)} Q_{i,t-1}\right]$$
$$= s^Q_{C(t)} \frac{\sum_{i\in C(t)} \Delta Q_{it}}{\sum_{i\in C(t)} Q_{i,t-1}} + s^Q_{X(t)} \frac{\left(\sum_{i\in E(t)} Q_{it} - \sum_{i\in X(t)} Q_{i,t-1}\right)}{\sum_{i\in X(t)} Q_{i,t-1}}, \quad (1)$$

and

$$\frac{\Delta L_t}{L_{t-1}} = \frac{1}{L_{t-1}}\left[\sum_{i\in C(t)} \Delta L_{it} + \sum_{i\in E(t)} L_{it} - \sum_{i\in X(t)} L_{i,t-1}\right]$$
$$= s^L_{C(t)} \frac{\sum_{i\in C(t)} \Delta L_{it}}{\sum_{i\in C(t)} L_{i,t-1}} + s^L_{X(t)} \frac{\left(\sum_{i\in E(t)} L_{it} - \sum_{i\in X(t)} L_{i,t-1}\right)}{\sum_{i\in X(t)} L_{i,t-1}}, \quad (2)$$

Labour productivity growth (at the aggregate level) is defined as:

$$\frac{d\ln\left(Q(t)/L(t)\right)}{dt} = \frac{\Delta Q_t}{Q_{t-1}} - \frac{\Delta L_t}{L_{t-1}},$$

where

$$\frac{\Delta Q_t}{Q_{t-1}} - \frac{\Delta L_t}{L_{t-1}} = s^Q_{C(t)}\left(\frac{\sum_{i\in C(t)} \Delta Q_{it}}{\sum_{i\in C(t)} Q_{i,t-1}} - \frac{\sum_{i\in C(t)} \Delta L_{it}}{\sum_{i\in C(t)} L_{i,t-1}}\right)$$
$$+(s^Q_{C(t)} - s^L_{C(t)}) \frac{\sum_{i\in C(t)} \Delta L_{it}}{\sum_{i\in C(t)} L_{i,t-1}} + \psi_t, \quad (3)$$

with ψ_t representing the net contribution from the entering and exiting firms, that is, the firms in the set $E(t)$ and $X(t)$, respectively. An expression for ψ_t is given below.

Next, firms are classified directly into different industries $J \in \{1,\ldots,M\}$ and let $J(i)$ denote the industry of firm i. The following weights need to be defined:

$$s^Q_{it} = \frac{Q_{i,t-1}}{\sum_{k\in J(i)\cap C(t)} Q_{k,t-1}}, \quad \alpha^Q_{J|C(t)} = \frac{\sum_{i\in J\cap C(t)} Q_{i,t-1}}{\sum_{i\in C(t)} Q_{i,t-1}}, \quad \alpha^L_{J|X(t)} = \frac{\sum_{i\in J\cap X(t)} L_{i,t-1}}{\sum_{i\in X(t)} L_{i,t-1}}$$

$$\alpha^Q_{J|X(t)} = \frac{\sum_{i\in J\cap X(t)} Q_{i,t-1}}{\sum_{i\in X(t)} Q_{i,t-1}}, \quad s^L_{it} = \frac{L_{i,t-1}}{\sum_{k\in J(i)\cap C(t)} L_{k,t-1}}, \quad \alpha^L_{J|C(t)} = \frac{\sum_{i\in J\cap C(t)} L_{i,t-1}}{\sum_{i\in C(t)} L_{i,t-1}}.$$

In practice, the second term in (3) will be small in absolute value (less than 0.001 in this analysis' data) and contributes negligibly to aggregate productivity growth. Ignoring this term, Annex 8.A1 shows that an approximate decomposition can be made as follows:

$$\frac{\Delta Q_t}{Q_{t-1}} - \frac{\Delta L_t}{L_{t-1}}$$
$$= \sum_J s^Q_{C(t)} \alpha^Q_{J|C(t)} \sum_{i\in J\cap C(t)} s^Q_{it}\left(\frac{\Delta Q_{it}}{Q_{i,t-1}} - \frac{\Delta L_{it}}{L_{i,t-1}}\right)$$
$$+\sum_J\left[s^Q_{C(t)}\left(\alpha^Q_{J|C(t)} - \alpha^L_{J|C(t)}\right)\frac{\sum_{i\in J\cap C(t)} \Delta L_{it}}{\sum_{i\in J\cap C(t)} L_{i,t-1}} + \sum_{i\in J\cap C(t)} s^Q_{C(t)} \alpha^Q_{J|C(t)}\left(s^Q_{it} - s^L_{it}\right)\frac{\Delta L_{it}}{L_{i,t-1}}\right] + \sum_J \psi_{Jt}, \quad (4)$$

where

$$\psi_{Jt} = -\left(s^Q_{X(t)}\alpha^Q_{J|X(t)} - s^L_{X(t)}\alpha^L_{J|X(t)}\right) + \left(\frac{\sum_{i\in E(t)\cap J} Q_{it}}{Q_{t-1}} - \frac{\sum_{i\in E(t)\cap J} L_{it}}{L_{t-1}}\right). \quad (5)$$

The terms in the first summation in (4) reflect the within-firm productivity growth among continuing firms, summed over all the industries, J. The different terms within the squared bracket (in the second summation) reflect the combined reallocation effects among the continuing firms. These are decomposed into two parts: i) reallocation between continuing firms across industries (inter-industry reallocation); and ii) reallocation between firms in the same industry (intra-industry reallocation). Finally, the term Ψ_{Jt} represents the net contribution to productivity growth from firm turnover (entry/exit dynamics) in industry *J*.

The turnover effect, Ψ_{Jt}, can furthermore be decomposed into two parts: The first part is the negative of the expression in the first parenthesis in Equation (5), which is the contribution to productivity growth from exiting firms. This contribution is positive if the initial output share of the exiting firms is *smaller* than their initial input share. Since the terms $s_D^Q \alpha_{J|D}^Q - s_D^L \alpha_{J|D}^L$ sum to zero overall $D \in \{C(t), X(t)\}$ and $J \in \{1,...,M\}$, this is tantamount to saying that the contribution is positive if the initial productivity level of the exiting firms is lower than the aggregate productivity level over all firms. The second part is the contribution to productivity growth from entering firms. For a given industry, *J*, this contribution is positive if the productivity level of the entering firms is higher than the initial aggregate productivity level of the whole industry.

A problem with the interpretation of the turnover effect Ψ_{Jt} (and the corresponding entry and exit contributions), is related to the definition of an entering firm. An entering firm is a new legal entity (the corporation), but it may still (partially or fully) be a continuation of an old firm, for example through a merger or demerger. Obviously, this has potentially wide impacts on the interpretation of productivity decompositions, especially the importance of new versus old firms.

To take one step towards separating genuine start-ups from firms that are just new legal units, this study uses the possibility it has in its data to match firms to establishments, i.e. production units (e.g. plants) with own identification numbers in the statistics. It defines an entering firm as a fake entry if it consists of at least one establishment that previously belonged to another firm. All other entering firms (at *t*) belong to the set $E^{gen}(t)$ of genuine entering firms – a subset of *E(t)*. Summing the entry-effects in Equation (5) only over firms in $E^{gen}(t)$, this analysis defines the (genuine) entry-effect as follows:

$$\text{Entry-effect}_{Jt} = \frac{\sum_{i \in E^{gen}(t) \cap J} Q_{it}}{Q_{t-1}} - \frac{\sum_{i \in E^{gen}(t) \cap J} L_{it}}{L_{t-1}}.$$

Next, it defines the net exit-effect as the residual term:

$$\text{Exit-effect}_{Jt} = \Psi_{Jt} - \text{Entry-effect}_{Jt},$$

where Ψ_{Jt} is defined as before (in Equation (5)). Thus, the turnover effect (entry plus exit-effect) is unchanged, so Equation (4) is still valid. Note that in the (likely) case that a fake entry has a counterpart in the form of a "fake exit" (i.e. the legal unit is liquidated, but the activity continues under a new firm), the contributions from the two firms automatically cancel out in the turnover effect, Ψ_{Jt}. However, not eliminating the fake entries before calculating the entry-effect would mean that in absolute value both the entry- and exit-effect will be overstated (but their sum is unchanged).

The decomposition in Equation (4) and the decomposition of Ψ_{Jt} into a (genuine) entry-effect and a (net) exit-effect are the basis for all this study's empirical analyses in the third section. Note that both output, Q, and the industry-specific weights $\alpha_{J|C(t)}^Q$ are based on deflated current values and hence depend on the method of deflation.[2]

Data

This study's population is limited to the incorporated firms (including public-owned firms) in the mainland economy.[3] This population accounts for about 80% of employment in the market-based industries in Norway. This study defines (labour) productivity as value-added per employee in real prices. Value-added is defined as the gross value of production minus the value of intermediate inputs. Intermediate input is not a variable in the accounts statistics, but is calculated residually as total operating costs minus the sum of labour costs and capital costs (such as depreciation). Value-added can be interpreted as the contribution of labour and capital inputs to operating income (before taxes) during the year. This chapter's data source regarding employment is Statistics Norway's employer-employee register, which is a matched employer-employee data set. Registry data for total number of employees may differ slightly from the National Accounts (NA) figures, which include employed foreigners on short-term contracts that are not residents of Norway. The latter information is obtained through surveys.

This analysis deflates value-added in current prices using (implicit) industry-specific price indices of value-added from NA. That is:

$$\text{price index} \times \text{value-added in real prices} = \text{value-added in current prices.}$$

When value-added is measured in real prices, the aggregation from the individual industries to the mainland economy is based on real weights (share of real value-added and share of employees) as mentioned in the second section of this chapter.

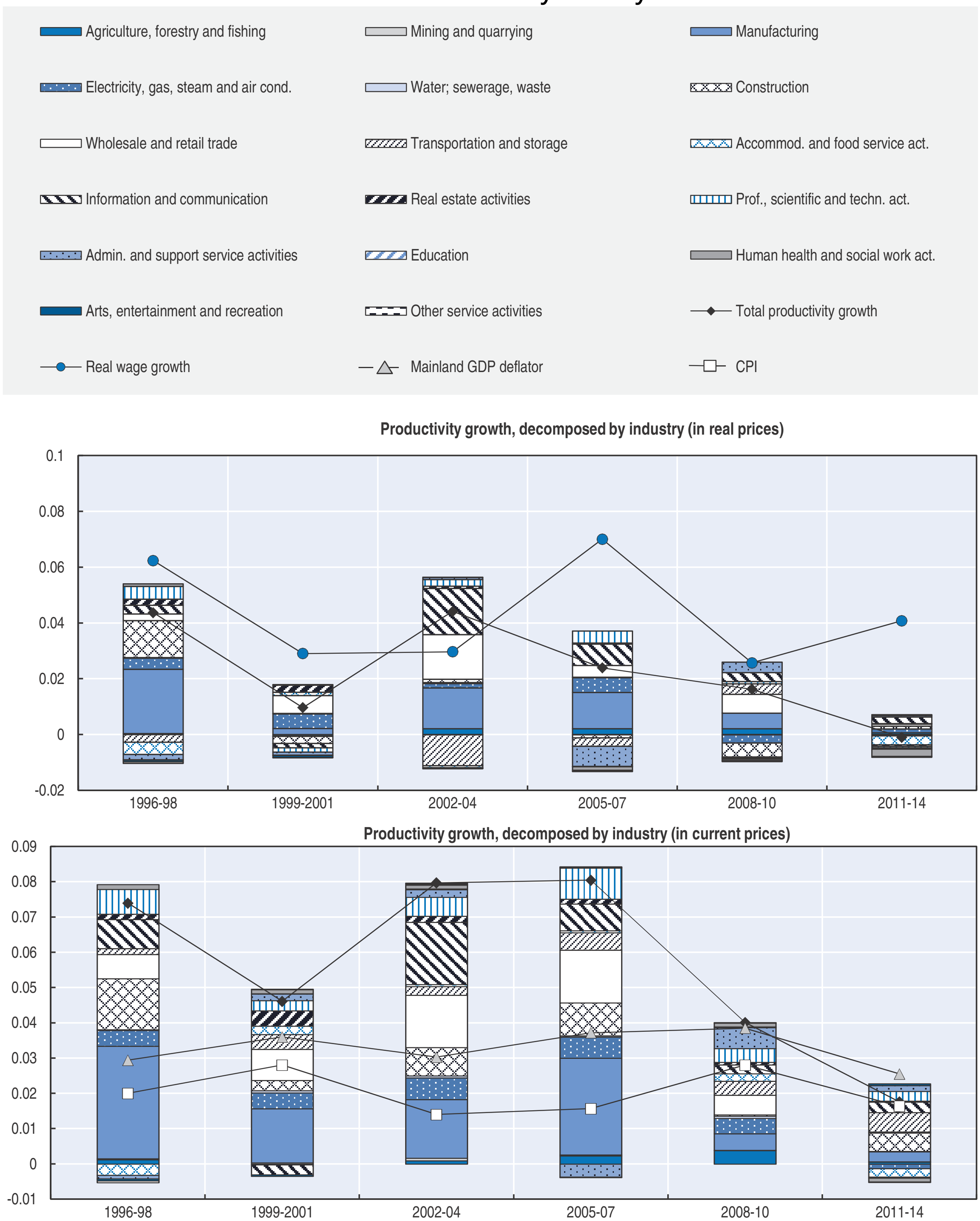
There are many sources of potential discrepancies between this study's micro-based productivity calculations and official statistics from NA. One is that NA, in accordance with international standards, uses the method of double deflation of gross product and intermediate inputs at a detailed product level (see OECD [2001]) to obtain value-added in real (constant) prices. On the other hand, output growth calculated from firm-level data must rely on simple deflation, as there is no data with regard to the composition of gross product or intermediate input in the business accounts. This chapter uses the ratio of value-added in current and real prices as published by NA at the industry level as the price index of value-added. Then, if NA were to use simple deflation of value-added instead of double deflation, value-added in real prices would be the same with both methods of deflation. The method of deflation should then in principle not be a source of discrepancy between this chapter's approach and NA with regard to productivity measurement.

Productivity growth in the Norwegian mainland economy 1996-2014

The upper chart of Figure 8.1 shows average annual productivity growth rates for the period 1996-2014. The period has been split into intervals covering three years each, except the interval 2011-14. Thus, with reference to this study's formal framework, $t = 1$ corresponds to 1995 (the first base year used in the calculations), $t = 2$ corresponds to 1998, $t = 3$ to 2001, etc.[4] The indicators on the solid orange curve show the average annual growth rate in the corresponding time interval. A (grey) curve indicating average annual real wage growth in mainland Norway (obtained from official statistics) has also been included.

First, the marked downward trend in productivity growth over the period 2005-14 can be noted, compared to 1996-2004. Next, the divergent pattern of real wage and real productivity growth during the last ten-year period can be noted. To understand this development, it is useful to observe the growth rates of the aggregate mainland GDP deflator and the CPI deflator in the same period, depicted as the pink and green curves in

Figure 8.1. **Annual productivity growth in mainland economy decomposed into contributions by industry**



Note: Transportation and storage does not include transport via pipeline, passenger ocean transport and freight ocean transport.
Source: Authors' calculations and Statistics Norway.

the lower chart of Figure 8.1. On average, producer prices (represented by the GDP deflator) have annually increased about 1.5 percentage points more than consumer prices (the CPI deflator). This gap accounts for the difference between productivity growth and real wage growth in the first two three-year intervals, 1996-98 and 1999-2001.

The period 2005-07 coincides with the peak of the oil-fuelled boom-period that lasted from 2001 until the financial crisis of 2008 (when oil prices surged from USD 20 to more than USD 100 per barrel). The extraordinary real wage growth rate of 7% annually (compared to 2% productivity growth) was much debated in Norway at the time. It can be attributed to several factors. First, it reflects a "catching-up" effect from the low real wage growth during 2002-04, when productivity growth was 4.5% annually and real wage growth 3%. Second, the gap between annual producer price growth and inflation was almost 2 percentage points during 2005-07.

While the difference between real wage and productivity growth in the next three-year period, 2008-10, can be explained fully by the difference between the (mainland) gross domestic product (GDP)-deflator and inflation, the last time interval, 2011-14, stands out as truly extraordinary. In this interval productivity growth was virtually zero, while real wages grew by 4% annually in real terms. This discrepancy could not be sustained. It is not surprising that the steep fall in oil prices from above USD 100 in August 2014 to USD 30 in January 2016, not only affected the oil industry, but also spurred a halt in real wage growth in mainland Norway (which is expected to be close to zero in 2016). The prospect of very low productivity growth, permanently low oil prices and an ageing population is arguably the biggest challenge for the Norwegian economy in the years to come.

Reallocation effects and entry/exit dynamics

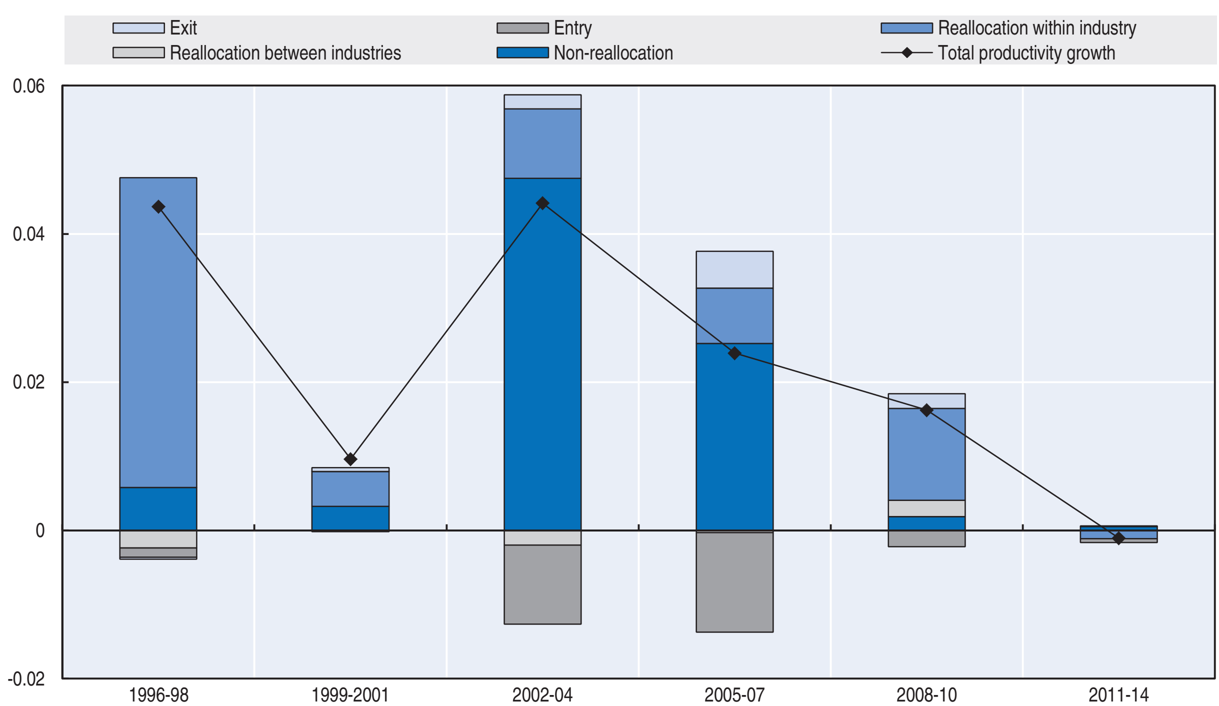
The bar graphs of Figure 8.1 show an (additive) decomposition of total productivity growth into contributions from the different industries. The sum of the positive contributions (the bars above the horizontal axis) and the negative contributions (the bars below the axis) equals total productivity growth (the orange curve). The contribution from each industry depends on the productivity growth in that industry and the weight it carries in the mainland economy (see Equation (4)). The most striking development over time is with regard to manufacturing. From 1996-2007, manufacturing was the main driver of productivity growth in the mainland economy. Since 2007 its contribution has dropped gradually to virtually zero in 2011-14.

Another important contributor is the wholesale and retail trade, especially since 1999, but also in this industry productivity growth fizzled out in the last interval. A third important industry is information and communication. After the collapse of the dot-com bubble in 2000-01, the industry went through a period of sustained productivity growth. Information and communication accounted for the highest contribution (0.24 percentage points) to productivity growth in 2011-14, when total productivity growth in mainland Norway was -0.11%.

The productivity growth figures of the different industries (not shown here) reveal that during 1996-2014, manufacturing, the wholesale and retail trade, and information and communication had average annual productivity growth rates of respectively 4%, 4% and 5%. These were the highest average growth rates among all the industries, except agriculture, forestry and fishing (8%) and electricity supply[5] (5%). The latter two industries make up only 2% of employment and 6% of value-added in 2014. In comparison, manufacturing, wholesale and the retail trade and information and communication account for respectively 16%, 24% and 6% of the employees (see Figure 8.A1.1) and 19%, 18% and 9% of value-added (see Figure 8.A1.2).

The contribution to growth in real value-added per employee also includes reallocation effects, as discussed in the second section. Reallocation effects are due to employees switching between continuing firms with different productivity levels, as measured by $s_{it}^{Q} - s_{it}^{L}$. Switching in this sense does not necessarily refer to individual workers changing jobs, but changes in employment shares of firms. When employees "move" in this sense, there may be a productivity effect even if each firm's productivity level remains unchanged. For example, if employees move from a firm *i* with low initial productivity level (say $s_{it}^{Q} < s_{it}^{L}$) to a firm *j* in the same industry with high initial productivity level ($s_{it}^{Q} > s_{it}^{L}$), the contribution to aggregate productivity will be positive. Reallocations may occur both within industries and across industries. In general, the total within-industry reallocation effect is determined by the covariance between $\left(s_{it}^{Q} - s_{it}^{L}\right)$ and $\Delta L_{it} / L_{i,t-1}$. The between-industry reallocation effect is determined by the covariance between $\left(\alpha_{J|C(t)}^{Q} - \alpha_{J|C(t)}^{L}\right)$ and $\sum_{i \in J \cap C(t)} \Delta L_{it} / \sum_{i \in J \cap C(t)} L_{i,t-1}$. The total between-industry reallocation effect is positive if industries (*J*), with high (low) initial productivity, $\alpha_{J|C(t)}^{Q} - \alpha_{J|C(t)}^{L}$, experience high (low) relative labour input growth (see Equation (4) and the following discussion).

Figure 8.2. **Decomposition of productivity growth into five sources: within- and between-industry reallocation; entry- and exit-effects; and non-reallocation**



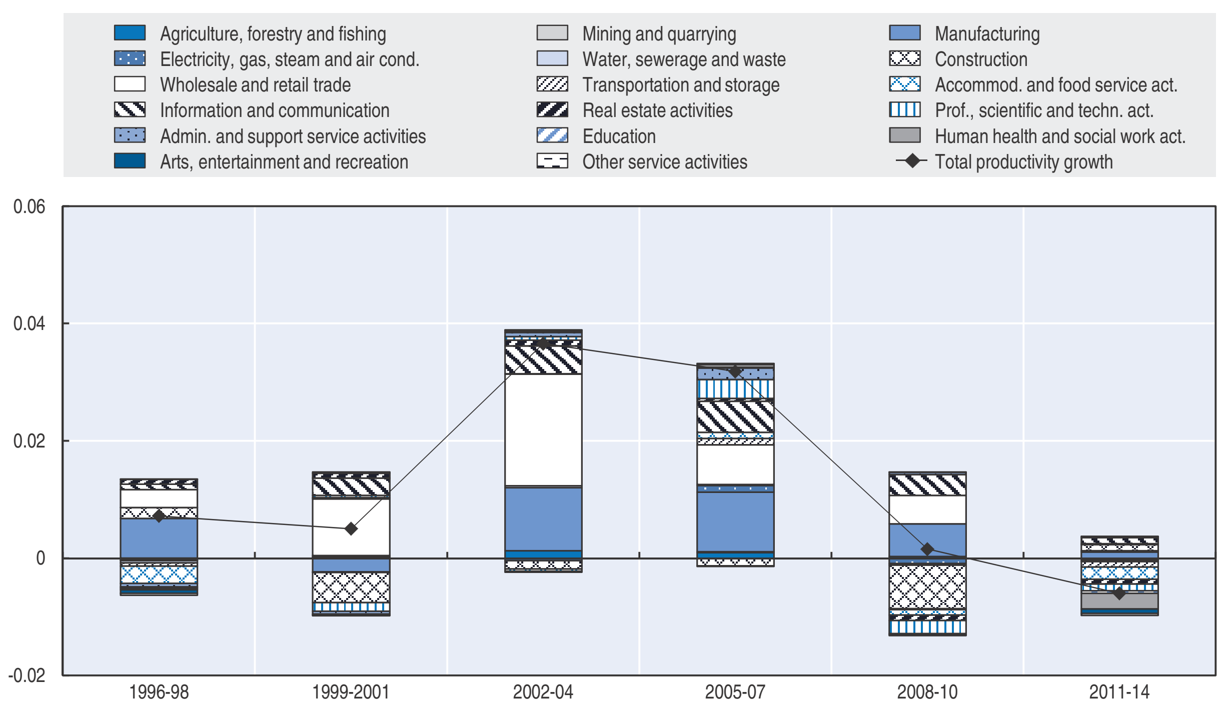
Source: Authors' calculations.

Figure 8.2 depicts the results of the decomposition of productivity growth into five sources: reallocation between firms in the same industries (intra-industry reallocation), reallocation between firms in different industries (inter-industry reallocation), entry-effect, exit-effect and non-reallocation; i.e. within-firm productivity growth. Note that there are two types of reallocation effects. The two effects correspond to the two terms inside the squared bracket in Equation (4) (which are summed over the industries, *J*). In general, within-industry reallocation is much more important than between-industry reallocation. With regard to the relative importance of the different sources of productivity growth, the picture is mixed. During 1996-2010, between-firm reallocation dominated but during 2002-07 within-firm productivity growth (non-reallocation) was the main source of aggregate productivity growth in mainland Norway.

Regarding the impact of firm turnover, Figure 8.2 shows that the contribution from (genuine) entry to productivity growth is substantial and negative during 2002-07. This may seem counter intuitive as the conventional wisdom is that firm turnover contributes to "creative destruction" whereby inefficient, old firms are replaced by new and more efficient firms. While Figure 8.2 confirms part of this story: the productivity level of the exiting firms in an industry is lower than the aggregate productivity level of the industry, it raises questions about the reason for the large negative contribution to productivity growth from firm entry during 2002-07. This issue will be addressed in more detail below.

Figure 8.3 depicts the decomposition of the non-reallocation effects by industry. The main drivers of non-reallocation effects are the same as for total productivity growth; manufacturing, wholesale and retail trade, and information and communication. The notable negative contribution from construction in two time-intervals, 1999-2001 and 2008-10, are most likely due to the collapse of the dot-com bubble and the financial crisis, respectively, with a marked negative impact on profitability (and value-added) in this strongly pro-cyclical industry.

Figure 8.3. **The contribution from non-reallocation to productivity growth, by industry**

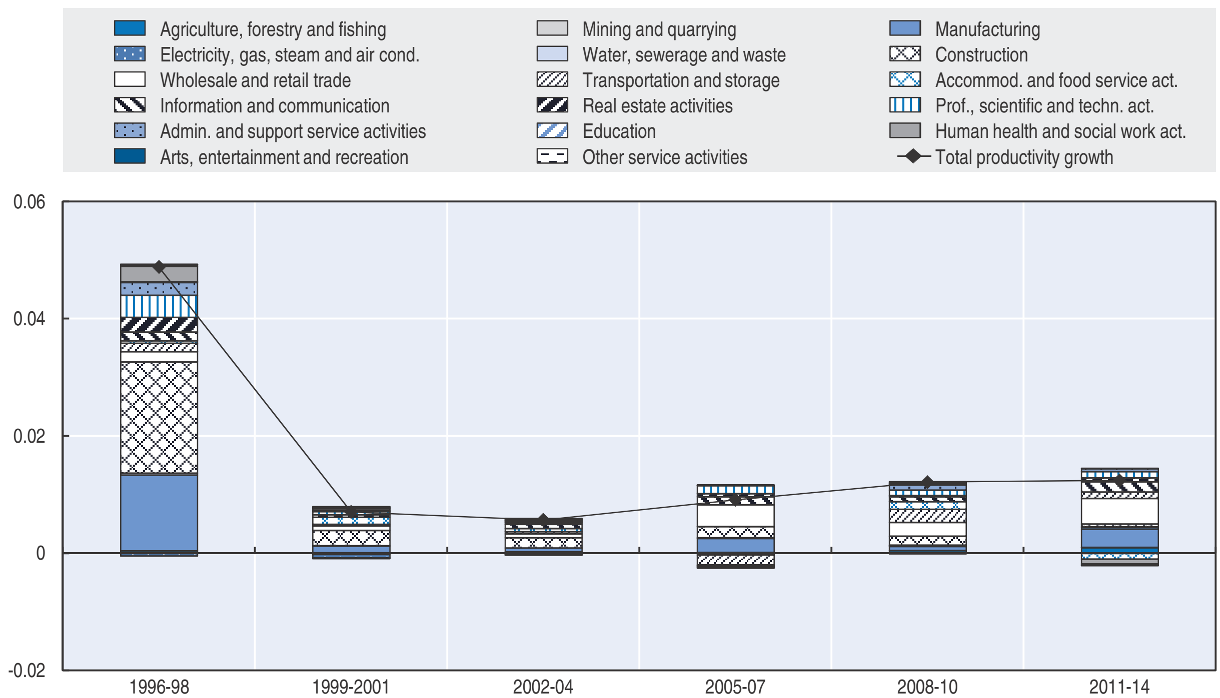


Note: Transportation and storage does not include transport via pipeline, passenger ocean transport and freight ocean transport.
Source: Authors' calculations.

Figure 8.4 depicts a decomposition of the (total) between-firm reallocation effects by industry. It shows that manufacturing and construction were the main contributors to the extraordinarily strong reallocation effects during 1996-98. To examine this further,

Figure 8.A1.1 (in Annex 8.A1) first shows that manufacturing – and to a lesser degree construction – went through a stark reduction in employment share during this period. At the same time, both industries increased their productivity level dramatically, as seen from Figure 8.A1.2. An explanation of the productivity-enhancing reallocation effect for these two industries during 1996-98 is the following: the industries' reduced employment shares did not come to pass as a proportional decrease in labour input across all firms. Instead, the most productive firms (within each industry) increased their relative employment within the industry. The least productive firms were probably not even able to pay the increased wage costs (real wages increased by 6% annually during this period) and closed down (see also Figure 8.5 below).

Figure 8.4. **The contribution from between-firm reallocation to productivity growth, by industry**

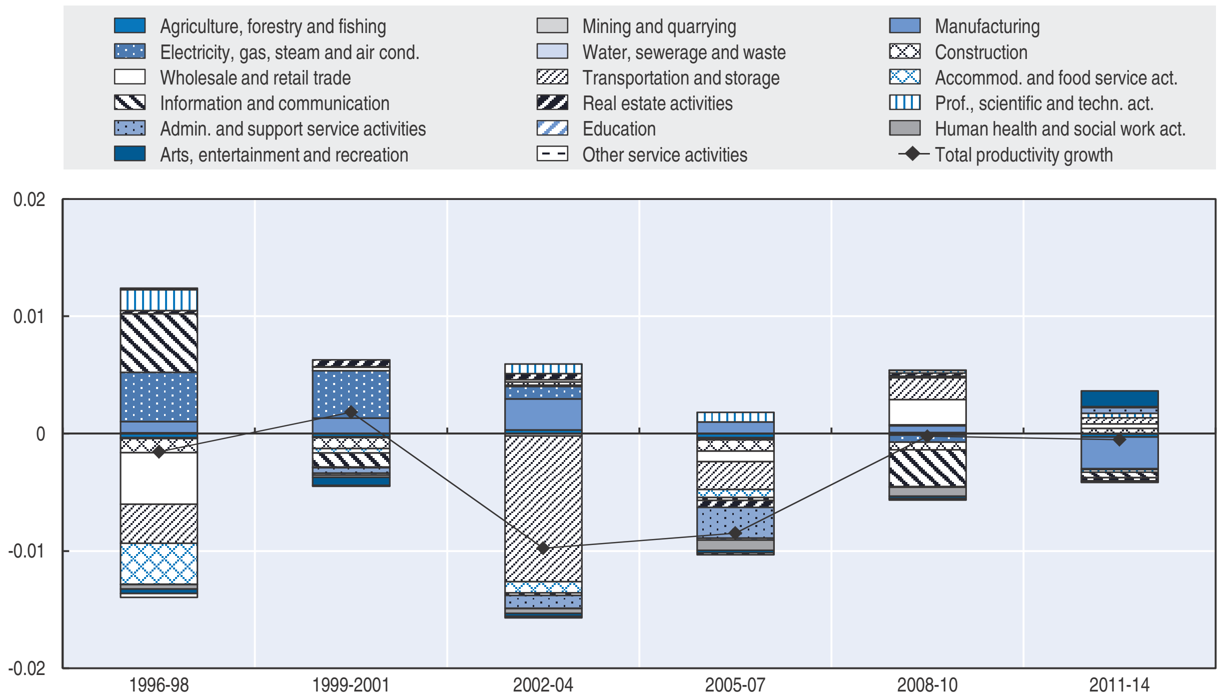


Note: Transportation and storage does not include transport via pipeline, passenger ocean transport and freight ocean transport.
Source: Authors' calculations.

The contributions to firm turnover (entry/exit dynamics) from the different industries are depicted in Figure 8.5. The net contribution from firm turnover is small, except over the period 2002-07, when it was about -1 percentage point annually. During 2002-04, the negative net contribution stems mostly from transportation and storage and during 2005-07 also from administrative and support services. Figure 8.6 shows that during 2002-07, these two industries also contributed most positively to aggregate employment growth.

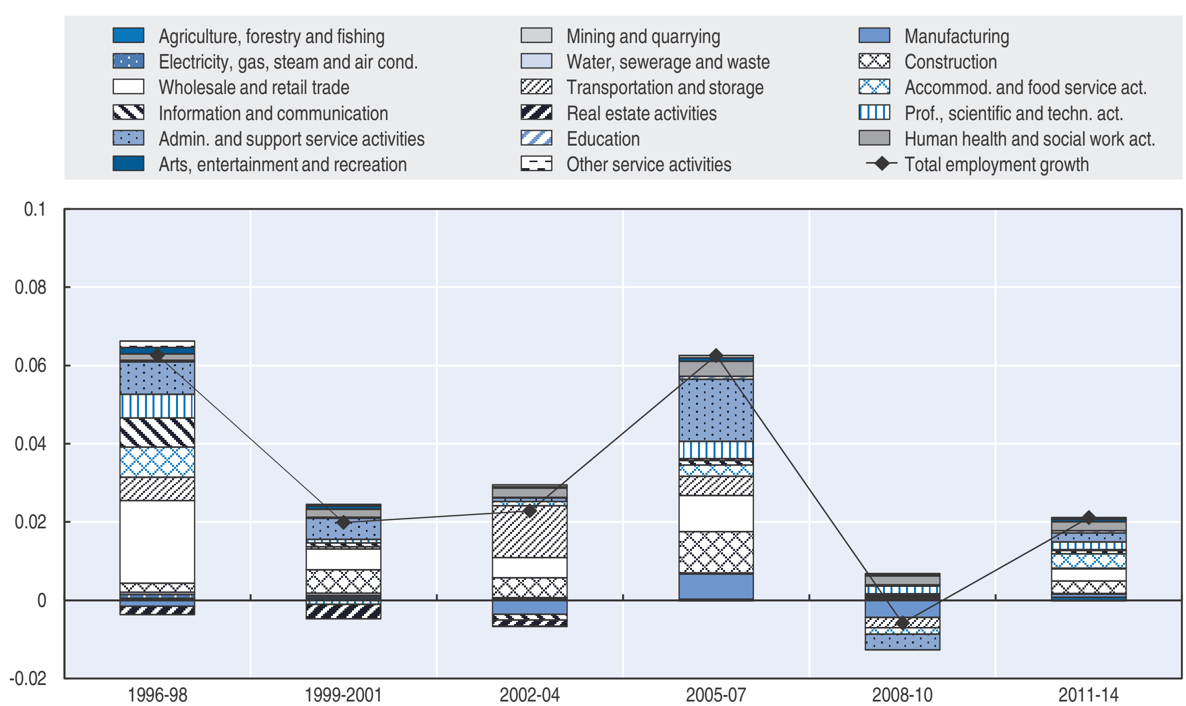
Comparing Figure 8.5 to the decomposition of the total firm turnover effect into a separate entry- and exit-effect in Figure 8.2 indicates that net entry of employees into new firms in transportation and storage and administrative and support services reduced aggregate productivity growth during 2002-07. This hypothesis is confirmed when one looks at the industry-decomposition of the entry-effect in Figure 8.A1.3 (in Annex 8.A1). On the other hand, productivity growth in existing firms (see Figure 8.3) or reallocation effects (see Figure 8.4), did not affect productivity growth adversely in these industries.

Figure 8.5. **The contribution from entry/exit dynamics to productivity growth, by industry**



Note: Transportation and storage does not include transport via pipeline, passenger ocean transport and freight ocean transport.
Source: Authors' calculations.

Figure 8.6. **Decomposition of employment flows, by industry**



Note: Transportation and storage does not include transport via pipeline, passenger ocean transport and freight ocean transport.
Source: Authors' calculations.

During 2005-07, administrative and support service activities contributed most of all industries to aggregate employment growth (almost 2 percentage points). The industry also increased its share of employees from 6% to 9% over the period 2004-07, whereas its share of value-added increased from 4% to 6%. This implies a considerable increase in employment share in an industry with a low initial productivity level (see Figure 8.A1.2). When one looks closer at the data, one learns that this development occurred mainly because of labour hire companies, which to a large extent employ labour immigrants either from other Scandinavian countries or the new EU member states after the 2004 expansion. Many of these employees actually work in construction, accommodation and food services, the retail trade and other service industries, but are employed in labour supply firms within the industry administrative and support services.[6]

Taken together, this analysis' evidence shows that the strong employment growth in labour-intensive service industries during the last ten years – partly driven by labour immigration – is associated with lower productivity growth in the Norwegian mainland economy through the channel of entry dynamics. However, this effect is restricted to a few service industries in the period 2002-07, reducing productivity growth by one percentage point annually. This temporary effect by no means explains the strong downward trend in productivity growth in mainland Norway during 2005-14.

The contribution of small versus large and exporting versus non-exporting firms to productivity and employment growth

Figure 8.A1.4 (in Annex 8.A1) shows that large continuing firms (>50 employees) are the main contributors to productivity growth. However, when it comes to employment growth (see Figure 8.A1.5), large firms contribute little, and in some periods even negatively. New jobs seem to be created mainly by entering firms and SMEs. Figures 8.A1.6 and 8.A1.7 show the corresponding decompositions with regard to exporting and non-exporting firms. Exporting firms are the dominating contributors to productivity growth in all periods, with non-exporting firms contributing with a gradually decreasing amount (see Figure 8.A1.6). However, with regard to job creation, non-exporting firms are more important than exporting firms (see Figure 8.A1.7). This pattern is, of course, related to the role of manufacturing in the economy, as the largest exporters are found there.

Conclusions

This chapter has explored a new decomposition of labour productivity growth that extends a standard method to incorporate the effects of firm-level dynamics. The analyses have quantified three main sources of productivity growth: within-firm productivity growth, between-firm reallocation effects and entry/exit dynamics. Those of Norwegian firm-level data covering all incorporated firms in the Norwegian mainland economy from 1996-2014 revealed a strong downward trend in labour productivity during the last decade: they found that growth in real value-added per employee during 2005-14 was 1.3% annually, compared to 3.2% during 1996-2004. Moreover, they found that the strong employment growth in labour-intensive service industries in the period 2002-07, partly driven by labour immigration, mainly affected productivity growth through net entry of employees into some service industries. This process temporarily reduced productivity growth in mainland Norway by one percentage point annually, but by no means explains the strong downward trend in productivity growth during the last decade. This chapter's results suggest that the productivity slowdown is related to the diminishing role of manufacturing, wholesale and retail trade and information and communication as drivers of productivity growth in the mainland economy.

Notes

1. See Official Norwegian Reports NOU (2015) and NOU (2016).
2. The within-industry weights, S_{it}^{Q}, are not affected by deflating, since the same deflator applies to all firms in the same industry.
3. The non-mainland industries, which are excluded, comprise extraction of crude petroleum and natural gas; support activities for petroleum and natural gas extraction; transport via pipeline; passenger ocean transport and freight ocean transport. These industries account for, on average, 20 % of annual GDP in the period analysed.
4. Firms that enter and exit within the same interval are excluded from the analysis.
5. This industry consists to a large degree of publicly owned enterprises.
6. See *www.ssb.no/en/varehandel-og-tjenesteyting/statistikker/ftot/aar/2016-05-30* for an article (in English) about labour supply services. Labour recruitment and provision of personnel (NACE 78) is a part of administrative and support service activities. Supply of personnel within construction had the largest turnover, covering almost 23% of the industry's total turnover in Norway in 2014.

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ANNEX 8.A1

Proofs and supplementary figures

Proof of the decomposition of Equation (4)

From (1), (2) and (3), it follows that:

$$\begin{aligned}
\psi_t &= s^Q_{X(t)} \frac{\left(\sum_{i\in E(t)} Q_{it} - \sum_{i\in X(t)} Q_{i,t-1}\right)}{\sum_{i\in X(t)} Q_{i,t-1}} - s^L_{X(t)} \frac{\left(\sum_{i\in E(t)} L_{it} - \sum_{i\in X(t)} L_{i,t-1}\right)}{\sum_{i\in X(t)} L_{i,t-1}} \\
&= \sum_J \left[-\left(s^Q_{X(t)} \alpha^Q_{J|X(t)} - s^L_{X(t)} \alpha^L_{J|X(t)} \right) + s^Q_{X(t)} \alpha^Q_{J|X(t)} \frac{\sum_{i\in E(t)\cap J} Q_{it}}{\sum_{i\in X(t)\cap J} Q_{i,t-1}} - s^L_{X(t)} \alpha^L_{J|X(t)} \frac{\sum_{i\in E(t)\cap J} L_{it}}{\sum_{i\in X(t)\cap J} L_{i,t-1}} \right] \\
&= \sum_J \left[-\left(s^Q_{X(t)} \alpha^Q_{J|X(t)} - s^L_{X(t)} \alpha^L_{J|X(t)} \right) + \frac{\sum_{i\in E(t)\cap J} Q_{it}}{Q_{t-1}} - \frac{\sum_{i\in E(t)\cap J} L_{it}}{L_{t-1}} \right] \\
&\equiv \sum_J \psi_{Jt}.
\end{aligned}$$

Assuming $\left(s^Q_{C(t)} - s^L_{C(t)}\right)\left(\sum_{i\in C(t)} \Delta L_{it} / \sum_{i\in C(t)} L_{i,t-1}\right) = 0$ (which holds in practice to a high degree of accuracy):

$$\begin{aligned}
\frac{\Delta Q_t}{Q_{t-1}} - \frac{\Delta L_t}{L_{t-1}} &= s^Q_{C(t)} \left(\frac{\sum_{i\in C(t)} \Delta Q_{it}}{\sum_{i\in C(t)} Q_{i,t-1}} - \frac{\sum_{i\in C(t)} \Delta L_{it}}{\sum_{i\in C(t)} L_{i,t-1}} \right) + \sum_J \psi_{Jt} \\
&= s^Q_{C(t)} \left(\sum_J \alpha^Q_{J|C(t)} \frac{\sum_{i\in C(t)\cap J} \Delta Q_{it}}{\sum_{i\in C(t)\cap J} Q_{i,t-1}} - \sum_J \alpha^L_{J|C(t)} \frac{\sum_{i\in C(t)} \Delta L_{it}}{\sum_{i\in C(t)} L_{i,t-1}} \right) + \sum_J \psi_{Jt},
\end{aligned}$$

where

$$\alpha^Q_{J|C(t)} = \frac{\sum_{i\in J\cap C(t)} Q_{i,t-1}}{\sum_{i\in C(t)} Q_{i,t-1}}, \quad \alpha^L_{J|C(t)} = \frac{\sum_{J\cap i\in C(t)} L_{i,t-1}}{\sum_{i\in C(t)} L_{i,t-1}}.$$

The focus is now on the contribution from continuing firms to $\frac{\Delta Q_t}{Q_{t-1}} - \frac{\Delta L_t}{L_{t-1}}$. For all $i \in C(t)$:

$$\begin{aligned}
&\frac{\sum_{i\in C(t)} \Delta Q_{it}}{\sum_{i\in C(t)} Q_{i,t-1}} - \frac{\sum_{i\in C(t)} \Delta L_{it}}{\sum_{i\in C(t)} L_{i,t-1}} \\
&= \sum_J \alpha^Q_{J|C(t)} \frac{\sum_{i\in J\cap C(t)} \Delta Q_{it}}{\sum_{i\in J\cap C(t)} Q_{i,t-1}} - \sum_J \alpha^L_{J|C(t)} \frac{\sum_{i\in J\cap C(t)} \Delta L_{it}}{\sum_{i\in J\cap C(t)} L_{i,t-1}} \\
&= \sum_{i\in C(t)} \alpha^Q_{it} \left(\frac{\Delta Q_{it}}{Q_{i,t-1}} - \frac{\Delta L_{it}}{L_{i,t-1}} \right) + \sum_{i\in C(t)} \left(\alpha^Q_{it} - \alpha^L_{it} \right) \frac{\Delta L_{it}}{L_{i,t-1}},
\end{aligned}$$

where

$$\alpha^Q_{it} = \frac{Q_{i,t-1}}{\sum_{i\in C(t)} Q_{i,t-1}} = \alpha^Q_{J(i)|C(t)} s^Q_{it}$$

$$\alpha_{it}^{L} = \frac{L_{i,t-1}}{\sum_{i \in C(t)} L_{i,t-1}} = \alpha_{J(i)|C(t)}^{L} s_{it}^{L},$$

With *J(i)* being the industry of *i* and:

$$s_{it}^{Q} = \frac{Q_{i,t-1}}{\sum_{k \in J(i) \cap C(t)} Q_{k,t-1}}, \quad \alpha_{J(i)|C(t)}^{Q} = \frac{\sum_{k \in J(i) \cap C(t)} Q_{k,t-1}}{\sum_{k \in C(t)} Q_{k,t-1}}$$

$$s_{it}^{L} = \frac{L_{i,t-1}}{\sum_{k \in J(i) \cap C(t)} L_{k,t-1}}, \quad \alpha_{J(i)|C(t)}^{L} = \frac{\sum_{k \in J(i) \cap C(t)} L_{k,t-1}}{\sum_{k \in C(t)} L_{k,t-1}}.$$

First, the term $\sum_{i \in C(t)} \left(\alpha_{it}^{Q} - \alpha_{it}^{L}\right) \frac{\Delta L_{it}}{L_{i,t-1}}$ is investigated:

$$\sum_{i \in C(t)} \alpha_{it}^{L} \frac{\Delta L_{it}}{L_{i,t-1}} = \sum_{i \in C(t)} \alpha_{J(i)|C(t)}^{L} s_{it}^{L} \frac{\Delta L_{it}}{L_{i,t-1}} = \sum_{J} \alpha_{J|C(t)}^{L} \sum_{i \in J \cap C(t)} s_{it}^{L} \frac{\Delta L_{it}}{L_{i,t-1}}$$
$$= \sum_{J} \alpha_{J|C(t)}^{L} \frac{\sum_{i \in J \cap C(t)} \Delta L_{it}}{\sum_{i \in J \cap C(t)} L_{i,t-1}}.$$

Next:

$$\sum_{i \in C(t)} \alpha_{it}^{Q} \frac{\Delta L_{it}}{L_{i,t-1}}$$
$$= \sum_{J} \alpha_{J|C(t)}^{Q} \sum_{i \in J \cap C(t)} s_{it}^{Q} \frac{\Delta L_{it}}{L_{i,t-1}}$$
$$= \sum_{J} \alpha_{J|C(t)}^{Q} \frac{\sum_{i \in J \cap C(t)} \Delta L_{it}}{\sum_{i \in J \cap C(t)} L_{i,t-1}} + \sum_{J} \alpha_{J|C(t)}^{Q} \sum_{i \in J \cap C(t)} s_{it}^{Q} \frac{\Delta L_{it}}{L_{i,t-1}} - \sum_{J} \alpha_{J|C(t)}^{Q} \sum_{i \in J \cap C(t)} s_{it}^{L} \frac{\Delta L_{it}}{L_{i,t-1}}$$
$$= \sum_{J} \alpha_{J|C(t)}^{Q} \frac{\sum_{i \in J \cap C(t)} \Delta L_{it}}{\sum_{i \in J \cap C(t)} L_{i,t-1}} + \sum_{J} \alpha_{J|C(t)}^{Q} \sum_{i \in J \cap C(t)} \left(s_{it}^{Q} - s_{it}^{L}\right) \frac{\Delta L_{it}}{L_{i,t-1}}.$$

Hence:

$$\sum_{i \in C(t)} \left(\alpha_{it}^{Q} - \alpha_{it}^{L}\right) \frac{\Delta L_{it}}{L_{i,t-1}}$$
$$= \sum_{J} \alpha_{J|C(t)}^{Q} \frac{\sum_{i \in J \cap C(t)} \Delta L_{it}}{\sum_{i \in J \cap C(t)} L_{i,t-1}} + \sum_{J} \alpha_{J|C(t)}^{Q} \sum_{i \in J \cap C(t)} \left(s_{it}^{Q} - s_{it}^{L}\right) \frac{\Delta L_{it}}{L_{i,t-1}} - \sum_{J} \alpha_{J|C(t)}^{L} \frac{\sum_{i \in J \cap C(t)} \Delta L_{it}}{\sum_{i \in J \cap C(t)} L_{i,t-1}}$$
$$= \sum_{J} \left(\alpha_{J|C(t)}^{Q} - \alpha_{J|C(t)}^{L}\right) \frac{\sum_{i \in J \cap C(t)} \Delta L_{it}}{\sum_{i \in J \cap C(t)} L_{i,t-1}} + \sum_{J} \alpha_{J|C(t)}^{Q} \sum_{i \in J \cap C(t)} \left(s_{it}^{Q} - s_{it}^{L}\right) \frac{\Delta L_{it}}{L_{i,t-1}}.$$

Finally:

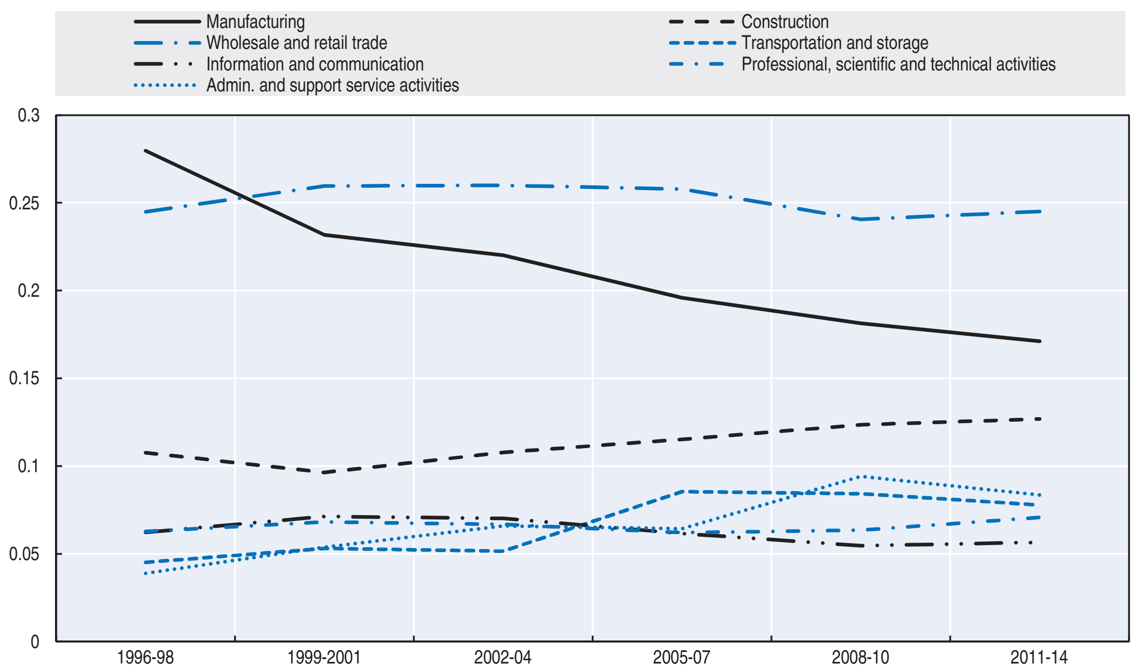
$$\frac{\sum_{i \in C(t)} \Delta Q_{it}}{\sum_{i \in C(t)} Q_{i,t-1}} - \frac{\sum_{i \in C(t)} \Delta L_{it}}{\sum_{i \in C(t)} L_{i,t-1}}$$
$$= \sum_{i \in C(t)} \alpha_{it}^{Q} \left(\frac{\Delta Q_{it}}{Q_{i,t-1}} - \frac{\Delta L_{it}}{L_{i,t-1}}\right) + \sum_{J} \left(\alpha_{J|C(t)}^{Q} - \alpha_{J|C(t)}^{L}\right) \frac{\sum_{i \in J \cap C(t)} \Delta L_{it}}{\sum_{i \in J \cap C(t)} L_{i,t-1}}$$
$$+ \sum_{J} \alpha_{J|C(t)}^{Q} \sum_{i \in J \cap C(t)} \left(s_{it}^{Q} - s_{it}^{L}\right) \frac{\Delta L_{it}}{L_{i,t-1}},$$

and

$$\begin{aligned}
&\frac{\Delta Q_{it}}{Q_{i,t-1}}-\frac{\Delta L_{it}}{L_{i,t-1}}\\
&=s^{Q}_{C(t)}\left(\frac{\sum_{i\in C(t)}\Delta Q_{it}}{\sum_{i\in C(t)}Q_{i,t-1}}-\frac{\sum_{i\in C(t)}\Delta L_{it}}{\sum_{i\in C(t)}L_{i,t-1}}\right)+\sum_{J}\psi_{Jt}\\
&=\sum_{J}s^{Q}_{C(t)}\alpha^{Q}_{J|C(t)}\sum_{i\in J\cap C(t)}s^{Q}_{it}\left(\frac{\Delta Q_{it}}{Q_{i,t-1}}-\frac{\Delta L_{it}}{L_{i,t-1}}\right)
\end{aligned}$$

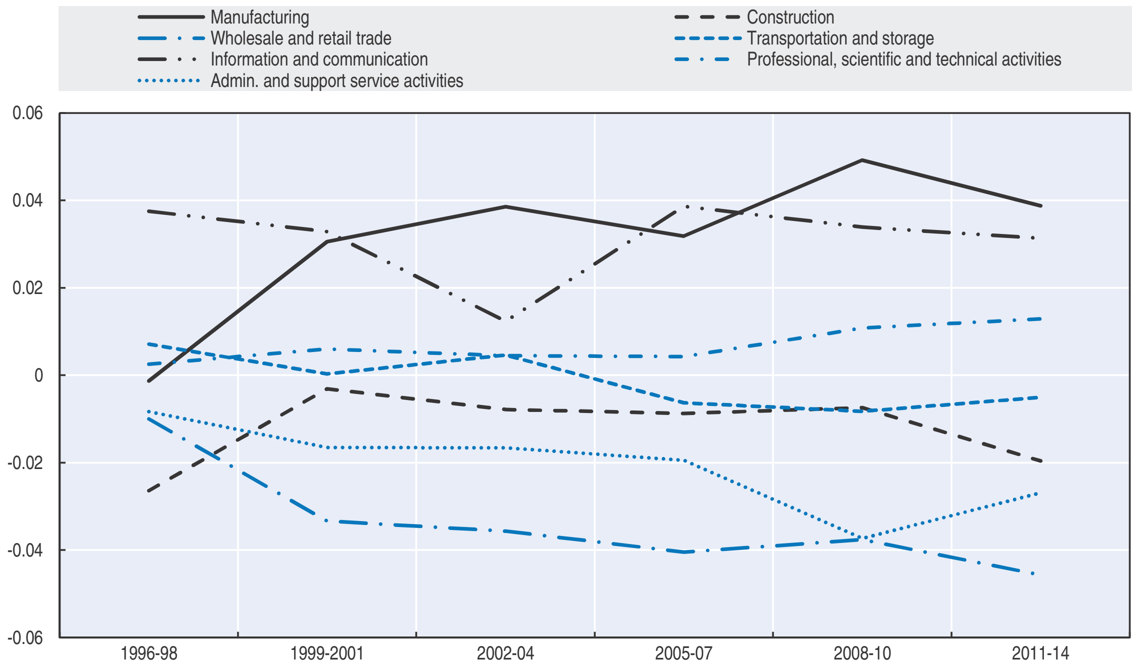
$$\begin{aligned}
&+\sum_{J}\left[s^{Q}_{C(t)}\left(\alpha^{Q}_{J|C(t)}-\alpha^{L}_{J|C(t)}\right)\frac{\sum_{i\in J\cap C(t)}\Delta L_{it}}{\sum_{i\in J\cap C(t)}L_{i,t-1}}+\sum_{i\in J\cap C(t)}s^{Q}_{C(t)}\alpha^{Q}_{J|C(t)}\left(s^{Q}_{it}-s^{L}_{it}\right)\frac{\Delta L_{it}}{L_{i,t-1}}\right]\\
&+\sum_{J}\psi_{Jt}.
\end{aligned}$$

Figure 8.A1.1. **Employment shares of selected industries**



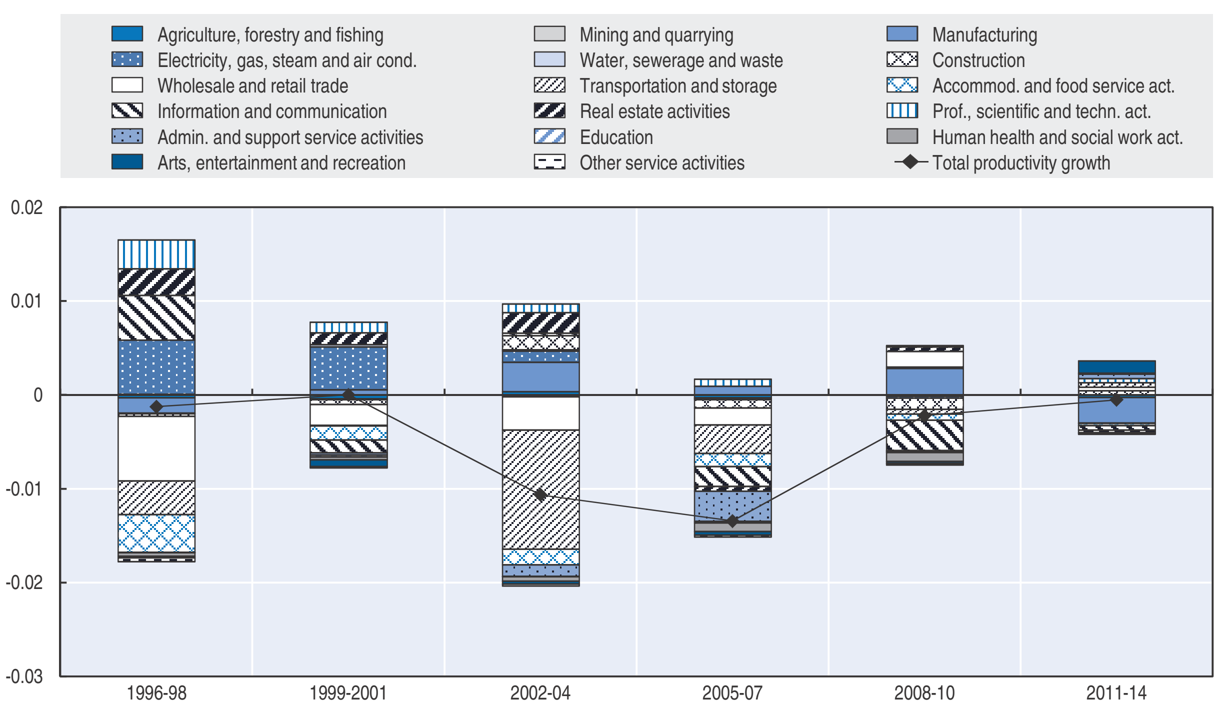
Source: Authors' calculations.

Figure 8.A1.2. **Output shares minus input shares of selected industries**



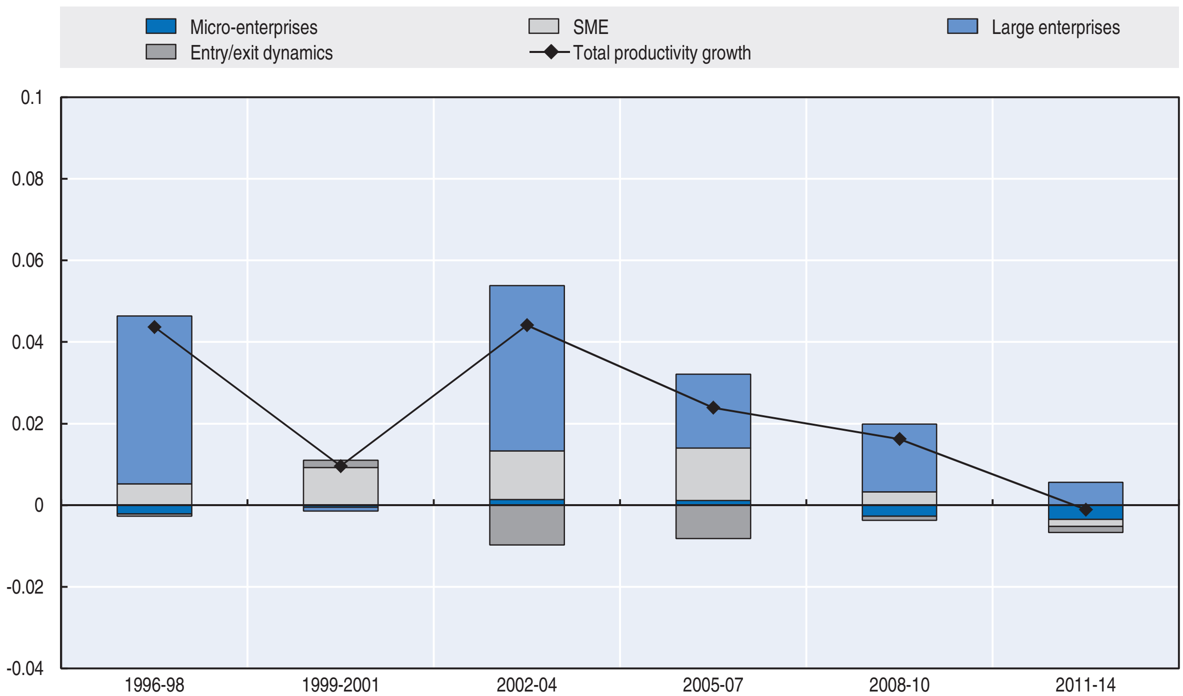
Source: Authors' calculations.

Figure 8.A1.3. **The contribution of entry-effects to productivity growth, by industry**



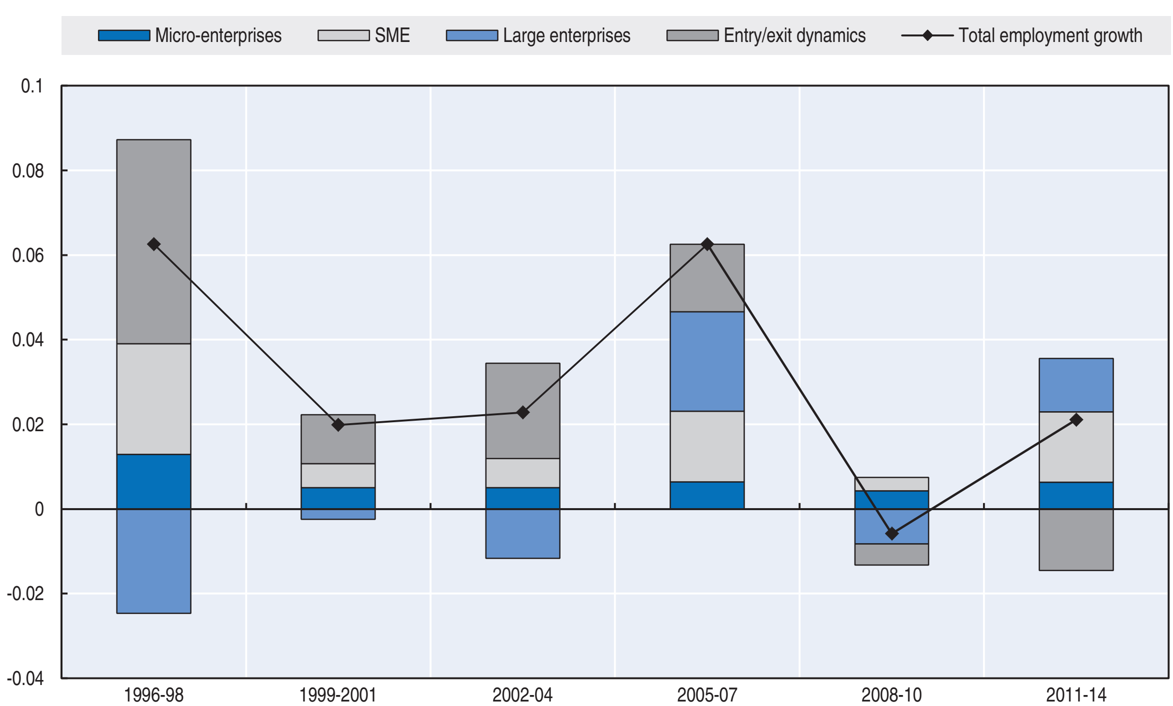
Source: Authors' calculations.

Figure 8.A1.4. **Contribution to productivity growth by firm size**



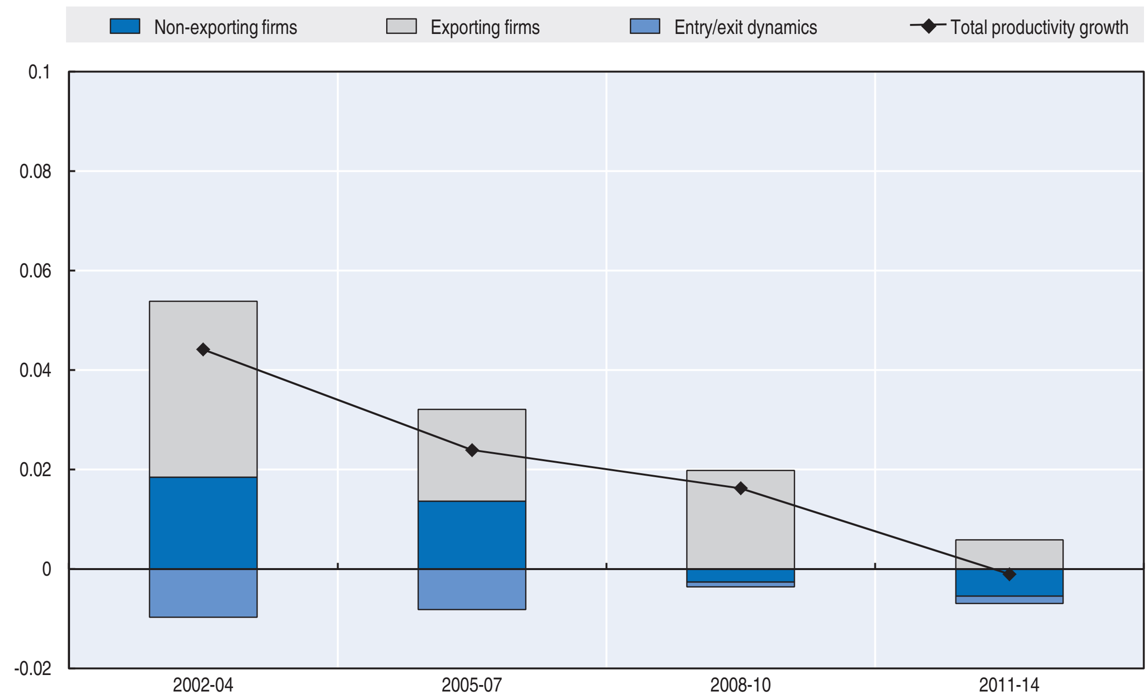
Source: Authors' calculations.

Figure 8.A1.5. **Contribution to employment growth by firm size**



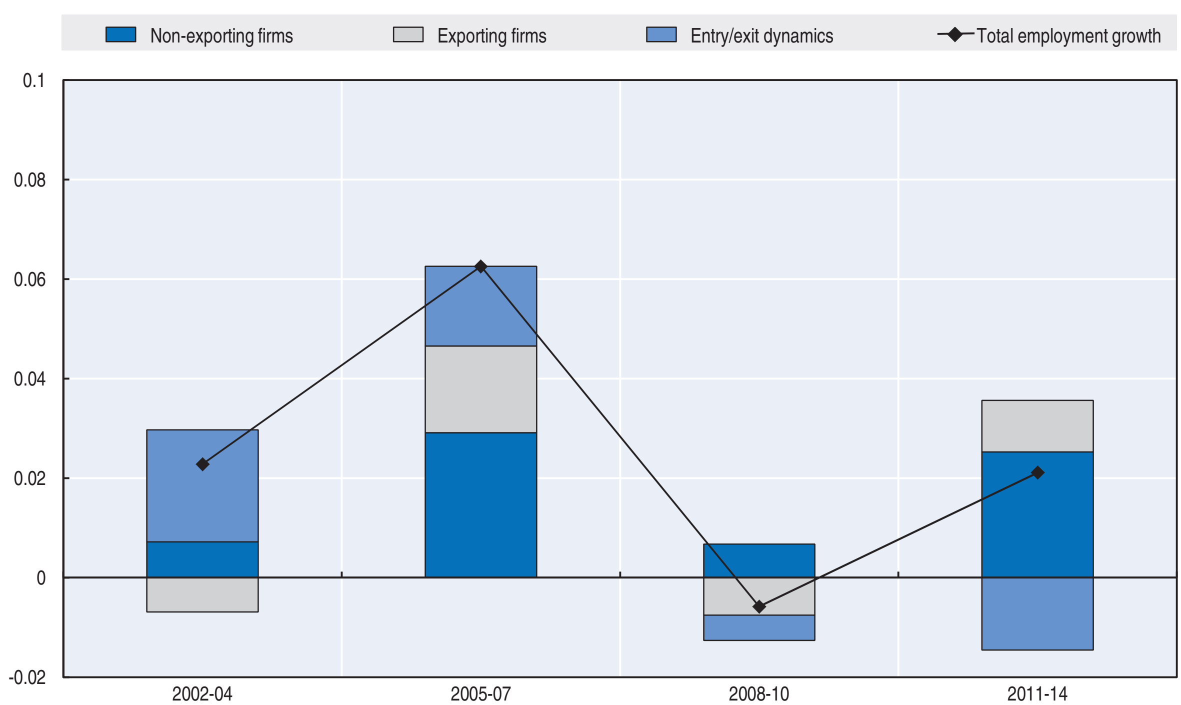
Source: Authors' calculations.

Figure 8.A1.6. **Contribution to productivity growth by exporting status**

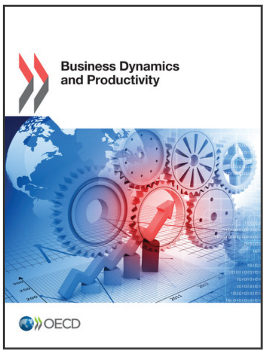


Source: Authors' calculations.

Figure 8.A1.7. **Contribution to employment growth by exporting status**



Source: Authors' calculations.



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