Rev World Econ (2015) 151:197–229
DOI 10.1007/s10290-014-0208-3

ORIGINAL PAPER

Services trade, goods trade and productivity growth: evidence from a population of private sector firms

Nikolaj Malchow-Møller · Jakob R. Munch · Jan Rose Skaksen

Published online: 14 January 2015

Abstract In this paper, the authors analyze and compare the role of international trade for productivity growth within the service and the manufacturing sector. They distinguish between trade in goods and trade in services within both sectors, and between exports and imports. At the firm level, they find that firms that start to export or import goods experience significant increases in productivity and size. The effects of services trade are typically smaller, confined to exports and vary across sectors. At the sector level, they find that international trade plays a potentially larger role for the productivity development within the service sector than within the manufacturing sector, but it is trade in goods not trade in services that matters most. This suggests that trade intermediaries play an important role for productivity growth in the economy.

Keywords Growth · Productivity · Services trade · Goods trade · Exports · Imports

JEL Classification O47 · F14

N. Malchow-Møller
Centre for Economic and Business Research (CEBR), Copenhagen Business School, Frederiksberg, Denmark

N. Malchow-Møller
Department of Business and Economics, University of Southern Denmark, Odense, Denmark

J. R. Munch (✉)
Department of Economics, University of Copenhagen, Copenhagen, Denmark
e-mail: Jakob.Roland.Munch@econ.ku.dk

J. R. Skaksen
Danish Institute for Local and Regional Government Research (KORA), Copenhagen, Denmark

1 Introduction

The empirical literature on international trade and firm productivity has grown rapidly since Bernard and Jensen (1995) documented important within-industry differences between manufacturing exporters and non-exporters; see, e.g., Bernard et al. (2012) for a recent review.

The focus on manufacturing exporters in this literature is, however, too narrow if we wish to fully understand the potential importance of international trade for productivity and productivity growth. First, in most—if not in all—developed countries, the service sector has overtaken the manufacturing sector as the most important sector of the economy whether measured in terms of output, value added or employment. Crozet and Milet (2014) thus report that the share of the manufacturing sector in value added has dropped by 10 percentage points in most OECD countries since 1970, and it now constitutes on average less than 20 %. Second, the exporting activities of the service sector have also gained in importance and are becoming increasingly important (e.g., Lipsey 2009; Francois and Hoekman 2010; Haller et al. 2014; Lodefalk 2014). Trade in services constitute a large (roughly 20 %) and growing share of world trade, but trade in goods by service-sector firms also play an important role (e.g., Bernard et al. 2010), and the contribution to productivity growth by these firms has so far remained undocumented. Third, exports constitute only one side of the coin. Imports of goods and services at the firm level are likely to be equally important for productivity, but have—due to data limitations—often been ignored in the empirical literature (Bernard et al. 2007).[1]

In this paper, we therefore analyze and compare the role of international trade for both firm productivity and aggregate productivity growth within the service and the manufacturing sector. Furthermore, within both sectors, we distinguish between trade in services and trade in goods, and between exports and imports. This provides the most comprehensive treatment to date of the relationship between international trade and firm productivity.

As mentioned above, there exists a voluminous empirical literature about manufacturing firms that export. It is now well established that these firms are more productive than other firms (e.g., Bernard and Jensen 1995, 1999). Most research ascribe this to selection into exporting by more productive manufacturers, but some studies (e.g., Van Biesebroeck 2005; De Loecker 2007, 2013; Manjon et al. 2013) also find a causal learning effect on performance from exporting.

A related line of research has shown that the productivity advantage of exporting manufacturers also matters significantly for aggregate productivity growth both through higher within-firm productivity growth of exporting firms and through reallocations of resources from less productive non-exporting firms to more productive exporting firms. Bernard and Jensen (2004) find that up to 65 % of aggregate total factor productivity (TFP) growth in US manufacturing between 1983 and 1992 can be attributed to foreign shipments. On a more causal note, Bernard

[1] For recent exceptions, see Aristei et al. (2013), Bas and Strauss-Kahn (2014) and Foster-McGregor et al. (2014).

et al. (2006) find relatively high gains in productivity at the industry level for US industries experiencing large reductions in tariff rates between 1977 and 2001. See also Bernard et al. (2012) for other studies documenting positive aggregate productivity effects.

An obvious question to ask is therefore whether the observed relationship between export activity and firm productivity and between export activity and aggregate productivity growth within manufacturing can be "transferred" to (a) the service sector, (b) exports of services, and (c) import activities.

While a recent literature surveyed by Wagner (2012) has shown that manufacturing firms that import enjoy a productivity advantage similar to (or even greater than) that of manufacturing firms that export, we still know very little about the productivity advantages of exporters and importers in the service sector and even less about their potential aggregate effects. The few existing studies at the firm level seem to indicate that the picture resembles that in manufacturing. Thus, Breinlich and Criscuolo (2011) using data on British firms find that the relationship between productivity and exports of producer services is very similar to the relationship between productivity and goods exports. Temouri et al. (2013) focus on business services firms using enterprise data from the United Kingdom, France and Germany, and find that firms that export are more productive (measured as value added per employee) and pay higher (average) wages than non-exporting firms.[2]

To understand the relationship between trade and productivity, we need to consider not just exports of producer services or business services firms, but the full spectrum of firms and trading activities. Furthermore, we shall argue that, it is important and empirically relevant to distinguish between both the type of trade (goods or services), the direction of trade (exports or imports), and the type of firm (manufacturing or service). Thus, goods traders in the service sector (e.g., wholesale firms) are likely to be different from goods traders in the manufacturing sector (e.g., pharmaceutical firms) and services traders in the service sector (e.g., consultancy firms), and there is no a priori reason to expect that the trade productivity premium is the same for these types of firms. Both the production process and the costs and gains of engaging in international trade are likely to differ across such firms.

The purpose of the present analysis is two-fold. First, using Danish register data for the period 2002–2008, we provide a comprehensive analysis at the firm level of the relationship between international trade and firm productivity. We estimate models of the relationship between within-firm changes in productivity and a range of trade variables akin to specifications employed in the early literature on firm heterogeneity and exporting (e.g. Bernard and Jensen 1999). As we control for changes in factor use, we are implicitly focusing on the pure learning effects of trade.

[2] Jensen (2008) focuses on trade in high-tech services and finds that the results are similar to the results found when using data for manufacturing firms. Exporters are larger than non-exporters, they pay higher wages, and their labor productivity is higher. It should also be mentioned that Breinlich and Criscuolo (2011) only include producer services, and they do not distinguish between different types of firms in their analysis. Temouri et al. (2013) focus exclusively on a part of the service sector and cannot in their data distinguish between exports of goods and exports of services.

Compared with previous studies, we cover almost the entire private sector, and we distinguish between manufacturing firms and service firms, between trade in goods and trade in services, and between exports and imports. In that sense, it is the most comprehensive treatment of this issue to date. Still, the nature of our analysis is descriptive, as the relationship between firm productivity and trade is inherently endogenous. Firms that for unobserved reasons become more productive may also start to trade more. Therefore, we do not attach a causal interpretation to our results. Instead, our advantage is that we can assess the relative importance of the full range of trade activities across firms and across private sector industries. This approach is also dictated by the scarcity of exogenous variation in the data explaining trade in services (Francois and Hoekman 2010).[3] In contrast, several studies have documented causal effects of goods-trade liberalizations using observed tariff cuts as a source of exogenous change (e.g., Pavcnik 2002; Bernard et al. 2006; Trefler 2004), but such data are unavailable for services-trade liberalizations.[4]

Second, we ask whether any firm-level differences in productivity carry over to the aggregate level, and thus whether the various types of international trade play a different role for aggregate productivity growth within the service sector than within manufacturing. In order to quantify the potential importance of exports and imports for productivity growth, we apply a recent decomposition technique developed by Melitz and Polanec (2012). This method allows us to decompose aggregate productivity growth into contributions from within-firm productivity growth and from reallocations. Using our firm-level estimates, we then do a counterfactual exercise to determine how much of the aggregate productivity growth that can be attributed to international trade. This approach allows us to identify the trade activities (goods trade, services trade, importing, exporting) by firm type (manufacturing or service) that play the potentially most important roles for productivity growth.

At the firm level, we find that in particular firms that start to export or import goods enjoy increases in productivity and size. The effects are sizeable and surprisingly similar across sectors. The picture is different when it comes to trade in services. Here we also find positive productivity and size effects of starting to export, but the effects are smaller, and size effects are confined to the service sector. Productivity and size effects of services imports, on the other hand, are largely absent.

At the aggregate level, we find that international trade plays a potentially larger role for the productivity development within the service sector than within the manufacturing sector, but it is trade in goods not trade in services that matters most for the productivity development within this sector. More specifically, productivity growth seems largely to have been driven by the wholesale and the retail industries.

[3] An important exception is Cristea et al. (2012) who find substantial welfare gains from services trade liberalization in the passenger aviation industry.

[4] Some studies use matching techniques to estimate effects of exporting (see, e.g., De Loecker 2007). However, this approach is very data demanding since in principle everything that matters for selection (exporting or not) and the outcome of interest (e.g. productivity) must be observed for the estimated effects to be given a causal interpretation.

This finding is related to an emerging literature examining various aspects of intermediaries in international trade (Ahn et al. 2011; Akerman 2012; Bernard et al. 2010, 2011). This line of research uses firm-level data from a number of countries to provide evidence for the importance of wholesalers and retailers in trade flows and to determine the factors that give rise to trade by intermediaries. In contrast to this literature we are the first to show the role played by wholesalers and retailers in aggregate productivity growth.

The rest of the paper is structured as follows. In Sect. 2, we discuss the data. In Sect. 3, we consider the firm-level evidence, while Sect. 4 considers the potential effects on aggregate productivity growth. Finally, Sect. 5 concludes.

2 Data and descriptive statistics

We have access to a very rich matched worker-firm longitudinal data set covering the total Danish population of firms and their workers for the years 1995–2008. We draw on several administrative registers within which each firm is associated with the same unique identifier. The reporting level in the data is the firm, and each firm may possibly encompass several plants or subdivisions. Each individual is also associated with a unique identifier, and all employed individuals are linked with a firm identifier at the end of each year. These data contain detailed information about individual socio-economic characteristics and firm characteristics on an annual basis. To this data set we merge information on firm-level exports and imports of goods and services. We restrict attention to firms with at least one employee, i.e., we leave out self-employed without employees.

When comparing the performance of trading and non-trading service producers, a number of new issues arise relative to the case where only manufacturing firms are considered. Manufactured goods are tangible, visible and storable, while services are often intangible, invisible and perishable, requiring simultaneous production and consumption (e.g., Copeland and Mattoo 2008).[5] One implication is that it is more difficult to measure trade in services than trade in goods. This is also reflected in the framework of the General Agreement on Trade in Services (GATS), which distinguishes between four modes of international trade in services. Mode 1 constitutes services that are being shipped across borders (often electronically), such as computer software, call-center services, etc. This is the type of services trade that resembles trade in goods most closely. Mode 2, on the other hand, constitutes services where the consumer has to move (temporarily) to the country of the supplier to enjoy the service, as in the case of, e.g., tourism and education. Mode 3 covers trade in services through a commercial presence of the supplier in the country of the customer, i.e., where the supplier sells its services through a local subsidiary of the company. Finally, mode 4 constitutes services, which require that residents of the exporting country move temporarily to the country of the consumer to deliver the service—either on behalf of their employer in the exporting country or

[5] There are exceptions from this. As an example, the production of software is a service activity, despite the fact that software may be stored on, e.g., hard disks and CD's.

on their own account as temporary workers. Many consultancy services are thus covered by this mode. In our analysis, we restrict attention to mode 1 and that part of mode 4, which is on behalf of a firm in the exporting country, as these are the types of international trade in services that are measured at the firm level in our data.

Our firm-level measure of services exports is derived as the difference between the firm's total exports (including both goods and services) and the firm's exports of goods only.[6] Total exports at the firm level is recorded in the VAT register in Statistics Denmark, while the exports of goods are based on information from the Danish External Trade Statistics register at Statistics Denmark and the VAT register. In a similar way we construct firm-level measures for imports of goods and services.

Some additional remarks about the construction of the service trade measures are in order. First, the External Trade Statistics are compiled in two systems: Intrastat (trade with EU countries) and Extrastat (trade with non-EU countries). The level of detail in these registers is very high as trade flows are recorded by destination/origin country and eight-digit product code. Trade flows in Extrastat are recorded by the customs authorities, and the coverage rate is therefore close to complete. In contrast, the coverage rate in Intrastat is lower (around 90 %), because some, predominantly small, firms appear not to report data to the system. Also, data on intra-EU trade is censored in a way such that only firms exporting goods with a total annual value exceeding a certain threshold are recorded in the files. Fortunately, the VAT register records the total goods exports to EU countries from 2002 and onwards, and the coverage rate here is higher. This allows us to compute total goods export at the firm level quite accurately.

Second, the measure of total exports of goods and services also stem from the VAT register. It is a measure of total VAT-exempted exports, and thus includes the total export of goods as well as exported services when these are not liable for value added taxation in Denmark. The precise requirements for this are set forth by the Danish VAT regulations, and it seems to be the case that the export of the most important types of services are exempted from Danish VAT and hence included in the measure.[7] We therefore believe that we can calculate the exports of services at the firm level fairly accurately for the years 2002 through 2008. It should be noted, however, that the measure of total exports at the firm level also may include certain

[6] Note that we cannot distinguish between within-firm trade and trade at arm's length.

[7] The Danish VAT regulation from 2005 defines which services can be exported (and when) without adding Danish VAT. This list of services include royalties and license fees, advertising services, consultancy services, engineering services, legal services, accounting services, management services, data processing services, banking services, financial services, insurance services, delivery of labor services, leasing services, transmission and distribution of gas and electricity, telecommunication services, broadcasting services (radio and tv), electronically delivered services including software, databases, music, movies, betting, cultural events and scientific events, transportation services and services in connection with real estate. As a rule of thumb, these services are not subject to Danish VAT when they are used outside Denmark and sold either to a firm/person outside the EU or to a firm within the EU but outside Denmark. For more details see https://www.retsinformation.dk/Forms/R0710.aspx?id=17030. Services that are subject to value added taxation in Denmark are not included in the measure.

goods and services exempted from value added taxation in Denmark but sold domestically.[8]

Third, the measure of total firm-level imports in the VAT register is restricted to only include services (and goods) that are liable for value added taxation in Denmark. Again, this seems to be the case for the most important types of services, so the measurement bias from this restriction is likely to be small.[9]

Fourth, it should also be emphasized that we only have data on the total firm-level trade of services, and so we are not able to distinguish between different types of services. To compensate for this, it is important to distinguish between different types of industries in the analysis. In the main part of our analysis, we thus choose to distinguish between 8 different manufacturing industries and 20 different service industries based on the NACE industry classification (see Table 8 in the "Appendix" for the list of industries).[10]

Finally, the construction sector has been left out for two reasons. First, production in the construction sector is neither "pure" service nor "pure" manufacturing, and one of our purposes is to compare the implications of services trade to those of goods trade. Second, in the years 2002–2008, the development in the construction sector was heavily influenced by the business cycle with "overheating" in the middle part of the period, and a sharp decline at the end of the period. In total, the excluded firms account for 10 % of sales, 15 % of value added and 7 % of employment in the total numbers for the manufacturing and service sector in 2008.[11]

In Fig. 1, we show the development in the imports and exports of goods and services for firms in the manufacturing and service sector, respectively. In the manufacturing sector the share of goods exports in total sales clearly dominates with close to 50 % throughout the period 2002–2008. The goods-imports share has been mildly rising but it stays below 20 % in all years. The goods-imports share is similar in the service sector, but here it is roughly twice as high as the goods-exports share. Services-exports and services-imports shares are smaller in both sectors, but, as expected, the services-exports share is somewhat higher in the service sector.

Table 1 displays the extent of different types of trading firms in the data for 2008. Out of the 10,330 manufacturing firms in the data, 45 % are exporting firms of which 20 % export services and 42 % export goods, while 17 % do both. For comparison, Mayer and Ottaviano (2007) report that 39 % of all manufacturing firms in Norway export.[12] Even though less than half of the manufacturing firms export goods they account for the bulk of employment, sales and value added in this

[8] This includes, e.g., newspapers and rental of larger ships, but also some transportation services when these are sold in connection with exports out of the EU.

[9] The list of services captured is identical to the services listed in footnote 7.

[10] In the NACE classification firms are classified according to their main economic activity (i.e., value added not sales).

[11] We have also excluded financial intermediation and transportation of people, as we were afraid that some of their services sold domestically would be registered among total exports, which would introduce noise into our export measures, cf. footnote 8.

[12] They report higher proportions of exporters in France, Germany and Italy, but this is likely due to biases of these samples towards relatively large firms.

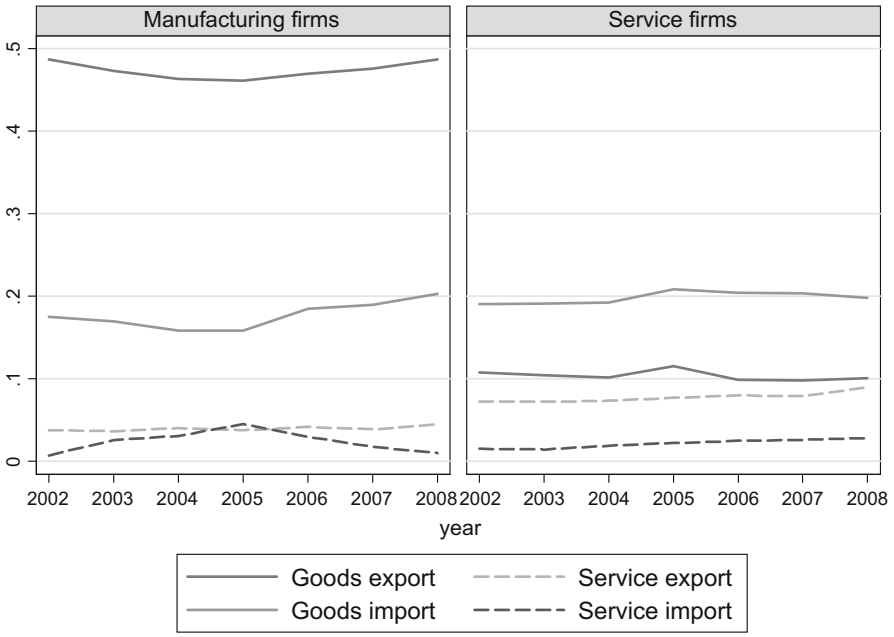

Fig. 1 Trade shares in the manufacturing and service sectors. *Data source*: register data provided by Statistics Denmark (see text for more information)

Table 1 Exporting and importing firms in the manufacturing and service sectors, 2008

	Firms exporting			Firms importing		
	Services	Goods	Goods and services	Services	Goods	Goods and services
Manufacturing sector						
Share of firms	0.20	0.42	0.17	0.07	0.48	0.06
Share of employment	0.34	0.81	0.32	0.24	0.86	0.24
Share of sales	0.34	0.89	0.33	0.25	0.92	0.25
Share of value added	0.34	0.84	0.32	0.28	0.89	0.28
Service sector						
Share of firms	0.13	0.14	0.07	0.04	0.27	0.04
Share of employment	0.36	0.42	0.26	0.22	0.56	0.21
Share of sales	0.47	0.64	0.38	0.27	0.74	0.26
Share of value added	0.39	0.47	0.28	0.23	0.63	0.22

The upper (lower) part of the table shows the relative importance of exporting and importing firms in the Danish manufacturing (service) sector in 2008 as measured by their share in the number of firms, total employment, total sales and total value added. Note that firms which, e.g., export both goods and services will be included in the first, second and third column, and therefore the sum of a row across columns 1–3 (and across columns 4–6) may exceed 1. The number of observations (firms) are 10,330 in the manufacturing sector and 52,433 in the service sector. *Data source*: register data provided by Statistics Denmark (see text for more information)

sector. There are 52,433 firms in the service sector of which a lower proportion export services (13 %), but they account for a larger share of economic activity than in the manufacturing sector. It is also noteworthy that only 14 % of service firms export goods, but they account for almost two-thirds of the sales in this sector. Similar patterns are observed when we consider imports of goods and services.

Table 2 compares the characteristics of the different types of trading firms by using regressions of the characteristic in the leftmost column on dummy variables for the trading status of the firm. The reference category is non-traders. The regressions also control for industry fixed effects and the number of employees in the firm (except in the case of the first characteristic, the log of employment). Consistent with the previous literature we find that within the manufacturing sector goods exporters are on average larger, have higher sales, are more productive and pay higher wages. For example, goods exporters are on average 89 % larger in terms of employment than non-traders, and even larger if they also export services. Table 2 shows that the same patterns hold within the service sector. Turning to goods imports it is also evident that many of the same performance differences exist in both the manufacturing sector and in the service sector. In addition, services exports in the service sector and services imports in both sectors are associated with performance premia in much the same way as goods trade. However, the picture for services exports is different in the manufacturing sector. Services exporters in the manufacturing sector are somewhat larger but they exhibit lower sales, value added per worker and capital per worker (only the latter difference is significant though). However, as is evident from Table 1 the vast majority of services exporters in the manufacturing sector are also goods exporters, so these firms also enjoy the goods-exporting premium.

As productivity measures in Table 2 we use both TFP and value added per worker. In Sect. 4 we use a method to decompose aggregate productivity growth suggested by Melitz and Polanec (2012). Following their approach, we rely on ordinary least squares (OLS) estimates of TFP using value added as the dependent variable and capital and labor as inputs.[13] It is well known that this estimator may be biased, and we could alternatively use, e.g., the Levinsohn and Petrin (2003) routine.[14] However, the estimates obtained using this approach implied (substantial) decreasing returns to scale in the production functions. This seems unlikely to be the case in reality and would tend to increase TFP estimates for larger firms. As a

[13] The estimated coefficients of labor and capital in the TFP regression are 0.74 and 0.21, respectively, and log of firm TFP is calculated as the residual in the following way: log(value added) − 0.74 × log(labor) − 0.21 × log(capital). Following Melitz and Polanec (2012), we assume similar coefficients of labor and capital across industries, but the TFP regression includes industry-specific effects. This is done in order to obtain consistent estimates of log of TFP across all industries and hence to avoid productivity effects in the subsequent decomposition analysis that stems from reallocations from, e.g., an industry with large coefficients of capital and labor to an industry with small coefficients and hence a relatively larger TFP component. We get very similar results in our TFP regressions (Table 3) if instead we allow for different coefficients in the manufacturing and service sectors or across the 28 sub-industries.

[14] Simultaneity bias may arise if positive shocks to productivity induce firms to buy more inputs. Levinsohn and Petrin (2003) introduce an estimator, which uses intermediate inputs as proxies for unobserved shocks to productivity.

Table 2 Trading premia, 2008

	Service export premia	Goods export premia	Service import premia	Goods import premia
Manufacturing sector				
Log (employment)	0.141***	0.889***	0.437***	0.744***
Log (sales)	−0.019	0.350***	0.196***	0.299***
Log (value added per worker)	−0.020	0.160***	0.061**	0.141***
Log (capital per worker)	−0.110***	0.247***	0.132**	0.094***
Log (TFP)	0.003	0.108***	0.033	0.121***
Log (wage bill per worker)	−0.019*	0.029**	−0.009	−0.013
Service sector				
Log (employment)	0.499***	0.509***	0.372***	0.408***
Log (sales)	0.258***	0.402***	0.148***	0.267***
Log (value added per worker)	0.103***	0.191***	0.058***	0.189***
Log (capital per worker)	0.003	0.166***	0.079**	−0.098***
Log (TFP)	0.102***	0.156***	0.041***	0.209***
Log (wage bill per worker)	0.050***	0.044***	−0.000	0.029***

The numbers reported in a row are the estimated coefficients from a regressions of the firm characteristic mentioned in the first column on four dummy variables: *exporting services*, *exporting goods*, *importing services* and *importing goods*. Total factor productivity is calculated from OLS regressions of value added on capital and labor. All regressions include industry fixed effects and log employment as controls, except for the regression with *log*(*employment*) as the dependent variable, where employment is omitted as a control variable. The number of observations (firms) are 10,330 in the manufacturing sector and 52,433 in the service sector. *** Significance at the 1 % level, ** at the 5 % level, and * at the 10 % level. *Data source*: register data provided by Statistics Denmark (see text for more information)

consequence reallocations between firms of different sizes could then affect aggregate productivity. Further, as argued by Van Biesebroeck (2004) the differences in the estimated TFP when using different methods are unlikely to be of first order.

Productivity estimation is particularly challenging in the service sector because output is intrinsically hard to measure here. For example, the price deflators may not fully reflect quality improvements, which would lead to an understatement of real output. We deflate value added by industry-specific price deflators (and capital by a capital-price deflator) taken from the national accounts (117 industries), but it should be kept in mind that measurement error in the price data may to some extent bias our TFP estimates.

3 Trade, productivity and growth

Trade may impact on aggregate productivity through both within-firm productivity growth and through reallocations from less to more productive firms. In Sect. 4, we use a decomposition analysis to assess the relative importance of these two channels and to determine how much of the aggregate productivity growth that can be attributed to international trade. In this section, we first look at the firm-level

Table 3 Changes in trading status and productivity growth, 2002–2008

	A: Manufacturing sector				B: Service sector			
	Δ log(TFP)	Δ log(TFP)	Δ log(VA/L)	Δ log(VA/L)	Δ log(TFP)	Δ log(TFP)	Δ log(VA/L)	Δ log(VA/L)
Goods exports								
Starting	0.1130***	0.1197***	0.1172***	0.1128***	0.1094***	0.1106***	0.0933***	0.1007***
	(3.56)	(3.82)	(3.54)	(3.56)	(4.74)	(4.92)	(3.91)	(4.41)
Stopping	−0.0269	−0.0243	−0.0148	−0.0173	0.0205	0.0185	0.0346	0.0279
	(−0.75)	(−0.69)	(−0.39)	(−0.48)	(0.87)	(0.80)	(1.42)	(1.19)
Continuing	0.0590**	0.0611***	0.0732***	0.0629***	0.0155	0.0211	0.0337*	0.0206
	(2.53)	(2.66)	(3.01)	(2.70)	(0.90)	(1.25)	(1.88)	(1.20)
Δ intensity	0.1247**	0.1386***	0.1436**	0.1254**	0.1256***	0.1244***	0.1241***	0.1179***
	(2.34)	(2.63)	(2.58)	(2.35)	(2.72)	(2.77)	(2.60)	(2.59)
Services exports								
Starting	−0.0199	−0.0193	−0.0199	−0.0221	0.0503**	0.0435**	0.0263	0.0399**
	(−0.77)	(−0.75)	(−0.73)	(−0.85)	(2.57)	(2.28)	(1.30)	(2.06)
Stopping	−0.0479*	−0.0498*	−0.0498*	−0.0467*	0.0106	0.0213	0.0372*	0.0259
	(−1.70)	(−1.79)	(−1.69)	(−1.66)	(0.55)	(1.13)	(1.87)	(1.36)
Continuing	−0.0719***	−0.0706***	−0.0751***	−0.0709***	−0.0016	−0.0031	−0.0143	−0.0045
	(−3.00)	(−2.97)	(−2.99)	(−2.96)	(−0.11)	(−0.22)	(−0.98)	(−0.32)
Δ intensity	0.3284***	0.3048***	0.3419***	0.3183***	0.1210***	0.1339***	0.1686***	0.1349***
	(3.50)	(3.29)	(3.49)	(3.40)	(2.83)	(3.22)	(3.82)	(3.20)
Goods imports								
Starting	0.0729**	0.0783***	0.0722**	0.0683**	0.0808***	0.0850***	0.0809***	0.0780***
	(2.47)	(2.69)	(2.34)	(2.32)	(4.64)	(5.01)	(4.50)	(4.53)
Stopping	0.0057	0.0057	0.0093	0.0197	−0.0130	−0.0010	0.0213	0.0091
	(0.15)	(0.15)	(0.23)	(0.50)	(−0.56)	(−0.05)	(0.89)	(0.40)

Table 3 continued

	A: Manufacturing sector				B: Service sector			
	Δ log(TFP)	Δ log(TFP)	Δ log(VA/L)	Δ log(VA/L)	Δ log(TFP)	Δ log(TFP)	Δ log(VA/L)	Δ log(VA/L)
Continuing	−0.0051	−0.0038	−0.0067	−0.0054	0.0625***	0.0535***	0.0390***	0.0526***
	(−0.22)	(−0.16)	(−0.28)	(−0.23)	(4.40)	(3.87)	(2.66)	(3.75)
Δ intensity	0.0175	0.0157	0.0354	0.0223	−0.0680*	−0.0649*	−0.0447	−0.0652*
	(0.25)	(0.23)	(0.49)	(0.32)	(−1.78)	(−1.75)	(−1.13)	(−1.73)
Services imports								
Starting	−0.0350	−0.0268	−0.0047	−0.0306	0.0057	0.0090	0.0191	0.0058
	(−1.06)	(−0.82)	(−0.14)	(−0.93)	(0.25)	(0.40)	(0.81)	(0.25)
Stopping	0.0367	0.0436	0.0711**	0.0477	−0.0355	−0.0346	−0.0242	−0.0320
	(1.11)	(1.34)	(2.06)	(1.45)	(−1.56)	(−1.56)	(−1.03)	(−1.42)
Continuing	−0.1027**	−0.1049**	−0.0817*	−0.1046**	−0.0311	−0.0359	−0.0373	−0.0345
	(−2.17)	(−2.24)	(−1.65)	(−2.21)	(−1.08)	(−1.28)	(−1.25)	(−1.21)
Δ intensity	−0.3225	−0.3200	−0.2528	−0.3175	0.0586	0.0825	0.1402*	0.0897
	(−1.41)	(−1.42)	(−1.06)	(−1.39)	(0.72)	(1.04)	(1.67)	(1.11)
Additional controls								
Δ Skilled share		0.1804***		0.2133***		0.2455***		0.2627***
		(3.15)		(3.68)		(9.83)		(10.35)
Δ Vocational share		0.2519***		0.2751***		0.2658***		0.2841***
		(6.77)		(7.31)		(16.12)		(16.97)
Δlog(capital per worker)		−0.0693***		0.1462***		−0.0938***		0.1216***
		(−11.27)		(23.53)		(−34.30)		(43.78)
Observations	6,547	6,547	6,547	6,547	24,968	24,968	24,968	24,968
R-squared	0.0324	0.0562	0.0283	0.1146	0.1982	0.2409	0.1800	0.2499

Note: Regressions are performed on a panel of firms for the period 2002–2008, where the dependent variable is the change in log productivity (either TFP or VA/L) between 2002 and 2008. All regressions include industry dummies in addition to the controls mentioned. *t*-statistics in parentheses. *** Significance at the 1 % level, ** at the 5 % level, and * at the 10 % level. Data source: Register data provided by Statistics Denmark (see text for more information)

evidence and analyze how the growth in productivity and size of a firm depends on its trading status using the standard regression approach implemented in the literature. The results from these regressions will then be used in the next section to assess the implications of trade at the firm level for aggregate productivity growth.

The results in Table 2 indicated that exporters and importers of goods are more productive than non-exporters and non-importers in both the manufacturing and service sector. A similar result was found for services exporters in the service sector. One explanation behind these patterns may be that firms learn from trading and become more productive. However, the differences between different types of firms may be partly explained by other differences than export and import status such as the educational level of the employees, the capital per worker or even unobservable differences between the firms. Thus, they might reflect that the most productive firms self-select into being exporters or importers. To control for this selection, we estimate within firm changes in productivity, where we also control for changes in factor use. Specifically, we estimate the following equation:

$$\Delta \log(productivity_i) = \beta_0 + \beta_1 \Delta type_i + \beta_2 \Delta intensity_i + \gamma \Delta Z_i + \varepsilon_i \qquad (1)$$

where $\Delta \log(productivity_i)$ is the log change in productivity of firm i between 2002 and 2008, where productivity is measured by either TFP or labor productivity (value added per worker). $\Delta type_i$ is a vector of dummy variables capturing the different types of firms. More precisely, we use 12 different indicators, reflecting whether a firm starts, stops or continues to export goods, import goods, export services or import services, respectively, between 2002 and 2008. The reference category is thus a firm that is not classified as an exporter or importer (of goods or services) by the beginning and the end of the sample window.[15] $\Delta intensity_i$ is similarly a vector of four variables containing the changes in the export and import intensities of goods and services, respectively, between 2002 and 2008, where intensities are measured relative to total sales. Z_i is a vector of other controls, including the educational level of the employees, the capital-worker ratio, and the size of the firm (number of employees). These control variables may also be affected by trade. For example, firms that increase their importing activities may change the composition of the workforce (e.g., Hummels et al. 2014), and firms may prepare for exporting by hiring certain types of workers (e.g., Molina and Muendler 2013). Thus, by including these controls, we are implicitly considering the pure effects of learning-by-exporting/importing.

The model is estimated in first differences to eliminate the effects of permanent unobserved firm differences on productivity, i.e., we control for the effects of self-selection of the most productive firms into exporting and importing activities. Furthermore, we use long differences (i.e., the difference between 2008 and 2002) to diminish any short-run stochastic impacts on the variables. In the next section, we use the results to decompose the long-run productivity growth from 2002 to 2008,

[15] To be precise, a firm is defined as a goods exporter in the beginning of the period if it exports goods in both 2002 and 2003. Likewise a firm must export goods in both 2007 and 2008 to be classified as a goods exporter by the end of the sample window. Similar definitions are applied for goods importers and service exporters and importers. We use this definition to avoid the influence of frequent switching in and out of exporting and importing.

and so using long differences is consistent with this decomposition exercise. However, it is important to emphasize that we do not control for the possibility of a firm-specific temporary shock, which simultaneously affects trading behavior and productivity. For this reason, the estimated parameters do not necessarily reflect causal effects of importing and exporting activities.

In Table 3, we report the outcomes of the regressions. The results for the manufacturing sector are reported in panel A, and the results for the service sector in panel B.

Consider first the variables for goods exports. Starting to export goods implies a productivity gain of 9–12 % in both sectors, whether measured by TFP or labor productivity, and this finding is robust to the inclusion of firm controls in the regressions. There is no effect of stopping to export goods, while firms that continue to export throughout the period enjoy larger productivity growth in the amount of 6–7 %, but only in the manufacturing sector. The positive effects of starting to export goods are supplemented by a positive effect of the goods-exports intensity, which again is surprisingly similar across the two sectors.

The effects of services exports are somewhat different. Firms that start to export services enjoy a productivity gain, but only around 3–5 % and only in the service sector. Firms that stop to export services similarly experience a loss of 5 %, but only in the manufacturing sector where there is also a negative effect of being a services exporter throughout the period. These differences between the sectors are partly reversed by the fact that the coefficient of the intensity variable for services exports is much larger within manufacturing. This quickly compensates for the absence of a start-up effect and the negative effect of exporting services throughout in the manufacturing sector.[16] Still, goods exports seem to be associated with the largest effects in both sectors.

Consider then the import measures. The effect of starting to import goods is positive in the amount of 7–8 % in both sectors, while those firms that import goods throughout also enjoy an advantage in the service sector. Importing services throughout, on the other hand, is associated with a sizeable negative effect in the manufacturing sector, while there seem to be no effects of starting or stopping to import services. Similarly, the intensity variables for imports are largely insignificant.

In sum, the largest effects are associated with starting to export or import goods, and these effects are remarkably similar across the two sectors. However, there is also a positive, although smaller, productivity effect of starting to export services in both sectors. Moreover, the estimated productivity effects are quite robust to the inclusion of additional controls for changes in the composition of production factors. Hence, the main productivity effects of international trade on the

[16] As explained in the previous section, the measure of services exports is constructed as the residual between total exports and goods exports. Since these two variables stem from two different sources, there is a risk that some noise is introduced into the resulting measure of services exports. This is most likely to be a problem in the presence of goods exports, i.e., in the manufacturing sector. In this case, there is a risk of recording a small positive amount of services exports—even in the absence of any services exports. This may introduce an attenuation bias in the coefficient of the variable indicating that a firm starts to export services, while the effects instead will be picked up by the services-exports intensity variable, which is more robust towards this type of noise.

productivity of firms seem to be independent of changes in the composition of production factors.

Bernard and Jensen (1999) have previously estimated similar models for TFP and value added per worker on a sample of US manufacturing firms for the period 1984–1992. However, they considered only the effects of starting, stopping or continuing to export goods within a 4-year period and found an additional annual growth rate in VA/L of 1–2 % for firms that started to export goods, while there was a similar negative effect both on VA/L and TFP growth for firms that stopped exporting goods. They found no statistical differences between non-exporters and firms that exported throughout the period, and they did not consider the effects of services trade and/or goods imports. For comparison, using a somewhat different specification the International Study Group on Exports and Productivity (ISGEP) (2008) finds an average labor-productivity premium of goods exporters of 7 % across 14 countries.[17]

The vast majority of studies in the literature have been unable to include service-trade measures (see, e.g., Mayer and Ottaviano 2007 for evidence on goods exporting from several European countries). Using our approach, we can actually assess whether the exclusion of services trade in the literature is likely to bias the results, which may happen if services trade and goods trade are correlated. In Table 9 in the "Appendix" we report results from estimating the model in Eq. (1) without the services-trade variables included. The most pronounced difference compared to Table 3 is that the coefficients of the goods-exports intensities become smaller and less significant. In quantitative terms, they decrease from around 0.12–0.14 to around 0.08–0.10. In other words, leaving out the services-trade variables weakens the observed relationship between an increase in the intensity of goods exports and productivity growth.

To analyze the importance of exporting and importing for the growth in the size of the firm, we estimate the following equation:

$$\Delta \log(activity_i) = \beta_0 + \beta_1 \Delta type_i + \beta_2 \Delta intensity_i + \gamma \Delta Z_i + \varepsilon_i \qquad (2)$$

where $activity_i$ is measured either by real value added or employment. We focus on these size measures because they are relevant in the subsequent decomposition of aggregate productivity growth. The results of estimating (2) are reported in Table 4.

Again, we start by considering the variables for goods exports. Sizeable positive effects on both value added and employment are found for firms that start to export goods, and negative effects of almost the same size are found for firms that stop exporting goods. This goes for both sectors. The coefficients of the intensity variable for goods exports are also large and significant.

There are also positive (but smaller) size effects associated with starting to export services, but mostly in the service sector, while the negative effects of stopping to export services pertain to both sectors. The effects of a larger services-export intensity are unclear.

[17] ISGEP (2008) regresses log labor productivity on a goods exporter dummy, firm controls, time, industry and firm fixed effects.

Table 4 Changes in trading status and growth in firm size, 2002–2008

	A: Manufacturing sector				B: Service sector			
	Δ log(VA)	Δ log(VA)	Δ log(L)	Δ log(L)	Δ log(VA)	Δ log(VA)	Δ log(L)	Δ log(L)
Goods exports								
Starting	0.2511***	0.2467***	0.1339***	0.1339***	0.2907***	0.2906***	0.1973***	0.1899***
	(6.37)	(6.30)	(4.13)	(4.26)	(10.77)	(10.80)	(8.29)	(8.22)
Stopping	−0.1490***	−0.1527***	−0.1342***	−0.1355***	−0.1533***	−0.1530***	−0.1879***	−0.1808***
	(−3.34)	(−3.45)	(−3.66)	(−3.81)	(−5.56)	(−5.56)	(−7.72)	(−7.65)
Continuing	0.0298	0.0299	−0.0434*	−0.0330	0.0335*	0.0312	−0.0002	0.0106
	(1.03)	(1.04)	(−1.82)	(−1.43)	(1.66)	(1.55)	(−0.01)	(0.61)
Δ intensity	0.3994***	0.3792***	0.2558***	0.2538***	0.2426***	0.2427***	0.1185**	0.1248***
	(6.03)	(5.75)	(4.69)	(4.80)	(4.50)	(4.51)	(2.49)	(2.70)
Services exports								
Starting	0.0367	0.0330	0.0565**	0.0551**	0.1067***	0.1094***	0.0803***	0.0695***
	(1.14)	(1.03)	(2.13)	(2.14)	(4.66)	(4.79)	(3.97)	(3.54)
Stopping	−0.1054***	−0.1065***	−0.0556*	−0.0598**	−0.0589***	−0.0626***	−0.0961***	−0.0885***
	(−3.01)	(−3.06)	(−1.93)	(−2.14)	(−2.61)	(−2.78)	(−4.83)	(−4.58)
Continuing	−0.0618**	−0.0641**	0.0133	0.0069	0.0216	0.0225	0.0359**	0.0270*
	(−2.07)	(−2.16)	(0.54)	(0.29)	(1.31)	(1.36)	(2.46)	(1.90)
Δ intensity	0.0249	0.0584	−0.3170***	−0.2599***	0.1202**	0.1148**	−0.0483	−0.0201
	(0.21)	(0.50)	(−3.31)	(−2.80)	(2.41)	(2.31)	(−1.10)	(−0.47)
Goods imports								
Starting	0.2640***	0.2599***	0.1917***	0.1916***	0.2147***	0.2133***	0.1338***	0.1353***
	(7.20)	(7.14)	(6.36)	(6.56)	(10.55)	(10.50)	(7.45)	(7.76)
Stopping	−0.2547***	−0.2502***	−0.2640***	−0.2699***	−0.1823***	−0.1864***	−0.2036***	−0.1956***
	(−5.24)	(−5.17)	(−6.59)	(−6.95)	(−6.70)	(−6.87)	(−8.49)	(−8.40)
Continuing	0.0246	0.0257	0.0313	0.0311	0.0669***	0.0703***	0.0279*	0.0177
	(0.85)	(0.89)	(1.31)	(1.35)	(4.03)	(4.25)	(1.91)	(1.25)

Table 4 continued

	A: Manufacturing sector				B: Service sector			
	Δ log(VA)	Δ log(VA)	Δ log(L)	Δ log(L)	Δ log(VA)	Δ log(VA)	Δ log(L)	Δ log(L)
Δ intensity	−0.1169	−0.1047	−0.1524**	−0.1270*	−0.0589	−0.0606	−0.0143	0.0045
	(−1.35)	(−1.22)	(−2.14)	(−1.84)	(−1.32)	(−1.36)	(−0.36)	(0.12)
Services imports								
Starting	0.0478	0.0429	0.0525	0.0736**	0.0693***	0.0676**	0.0501**	0.0618***
	(1.16)	(1.05)	(1.55)	(2.24)	(2.59)	(2.53)	(2.12)	(2.69)
Stopping	−0.0254	−0.0305	−0.0965***	−0.0781**	−0.0819***	−0.0825***	−0.0577**	−0.0505**
	(−0.62)	(−0.75)	(−2.86)	(−2.39)	(−3.08)	(−3.11)	(−2.46)	(−2.21)
Continuing	−0.1129*	−0.1087*	−0.0312	−0.0041	−0.0634*	−0.0617*	−0.0261	−0.0273
	(−1.92)	(−1.86)	(−0.64)	(−0.09)	(−1.88)	(−1.84)	(−0.88)	(−0.95)
Δ intensity	−0.3811	−0.3653	−0.1283	−0.0478	−0.0381	−0.0475	−0.1782**	−0.1372*
	(−1.34)	(−1.30)	(−0.55)	(−0.21)	(−0.40)	(−0.50)	(−2.12)	(−1.68)
Additional controls								
Δ Skilled share		−0.4196***		−0.6329***		−0.0672**		−0.3299***
		(−5.86)		(−11.01)		(−2.25)		(−12.84)
Δ Vocational share		−0.1715***		−0.4466***		−0.0679***		−0.3520***
		(−3.68)		(−11.95)		(−3.44)		(−20.76)
Δlog(capital per worker)		0.0576***		−0.0886***		0.0342***		−0.0874***
		(7.50)		(−14.36)		(10.44)		(−31.06)
Observations	6,547	6,547	6,547	6,547	24,968	24,968	24,968	24,968
R-squared	0.0556	0.0682	0.0469	0.1064	0.1660	0.1700	0.0319	0.0874

Regressions are performed on a panel of firms for the period 2002–2008, where the dependent variable is the change in log of value added (VA) or employment (L) between 2002 and 2008. All regressions include industry dummies in addition to the controls mentioned. *t*-statistics in parentheses. *** Significance at the 1 % level, ** at the 5 % level, and * at the 10 % level. Data source: register data provided by Statistics Denmark (see text for more information)

Turning to the import measures, the effects associated with goods imports are very similar to those associated with goods exports, with the exception that the intensity variable is now insignificant. The effects of services imports also resemble those of services exports. Negative effects of stopping are found in both sectors, while positive effects from starting to import services seem to be concentrated in the service sector.

To sum up, we find that in particular firms that start to export or import goods enjoy increases in productivity and size. The effects are sizeable and surprisingly similar across sectors. Starting to export services is also associated with increases in productivity and size, but the effects are smaller, and size effects are confined to the service sector. We also note that inclusion of firm controls in the regressions does not alter the results in important ways, so effects of trade on, e.g., firm size and capital intensity do not seem to play a major role for the productivity growth of firms.

4 The contribution of trade to productivity growth

The aggregate productivity development within a sector depends on the productivity development of individual firms as well as the reallocation of resources between firms with different productivity levels. In this section, we therefore decompose the development in the aggregate productivity over the period 2002–2008 for the service and the manufacturing sector, respectively, into contributions arising from the change in productivity within firms and contributions arising from the reallocation of resources between firms. For this purpose, we use a recent decomposition method developed by Melitz and Polanec (2012), which is an extension of the method suggested by Olley and Pakes (1996). The advantage of this method compared to other methods of decomposing productivity growth such as Griliches and Regev (1995) and Foster et al. (2001) is that it yields unbiased contributions of surviving, entering and exiting firms. As illustrated by Melitz and Polanec (2012), the biases inherent in the other methods are due to ill-suited reference productivity values for entering and exiting firms and the use of fixed weights when dividing contributions of surviving firms between productivity improvements and reallocations. See Melitz and Polanec (2012) for a thorough discussion of this.

The point of departure is a productivity index at the firm level, φ_{it}, which may be an index of labor productivity (real value added per labor unit) or TFP. The aggregate productivity at time t is calculated as a weighted average of the firm-level productivity indices, φ_{it}, of the n_t firms, where the weights, s_{it}, are the market shares of the firms:

$$\Phi_t = \sum_{i=1}^{n_t} s_{it}\varphi_{it} \tag{3}$$

In the case where TFP is used as the productivity measure, we use the firm's share of total value added as a measure of its market share, and in the case where labor

productivity is used as the productivity measure, we use the firm's share of total employment as its market share. The decomposition method splits the aggregate productivity index, Φ_t, into the following two components:

$$\Phi_t = \bar{\varphi}_t + \sum_{i=1}^{n_t}(s_{it} - \bar{s}_t)(\varphi_{it} - \bar{\varphi}_t) = \bar{\varphi}_t + cov(s_{it}, \varphi_{it}) \tag{4}$$

where $\bar{\varphi}_t = \frac{1}{n_t}\sum_{i=1}^{n_t} \varphi_{it}$ is the unweighted average of the firm productivity indices, and $cov(s_{it}, \varphi_{it})$ is the (estimated) covariance between the market share and the productivity of a firm.[18] If bigger firms tend to be more productive, this covariance will be positive. The change in the aggregate productivity between two periods is then given by:

$$\Delta\Phi = \Phi_2 - \Phi_1 = \Delta\bar{\varphi} + \Delta cov \tag{5}$$

The aggregate productivity index thus increases between period 1 and period 2 if there is an increase in the unweighted productivity average and/or if there has been an increase in the covariance between market shares and productivities of firms.

The aggregate productivity index in period t, Φ_t, can also be written as a weighted average of the aggregate productivities of different subgroups of firms. In particular, if we distinguish between surviving, entering and exiting firms, the average productivities in two subsequent periods can be written as:

$$\Phi_1 = s_{S1}\Phi_{S1} + s_{X1}\Phi_{X1} \tag{6}$$

$$\Phi_2 = s_{S2}\Phi_{S2} + s_{E2}\Phi_{E2} \tag{7}$$

where Φ_{St} and s_{St} are the aggregate productivity and aggregate market share, respectively, of surviving firms in period t ($t = 1, 2$). Φ_{X1} and s_{X1} are the aggregate productivity and aggregate market share, respectively, of exiting firms in period 1 (these firms exit before period 2), and Φ_{E2} and s_{E2} are the aggregate productivity and aggregate market share, respectively, of entering firms in period 2. The change in aggregate productivity can then be written as:

$$\Delta\Phi = \Delta\bar{\varphi}_S + \Delta cov_S + s_{E2}(\Phi_{E2} - \Phi_{S2}) + s_{X1}(\Phi_{S1} - \Phi_{X1}) \tag{8}$$

The first term reflects the average increase in productivity of surviving firms (i.e., within-firm productivity changes). The second term reflects productivity effects of reallocations among surviving firms. If more productive firms get a bigger market share, or if the productivity increases more in firms with a higher market share, this term tends to be positive. The third term is the productivity effect of entering firms. If these firms have a higher productivity than surviving firms in period 2, this term becomes positive. Finally, the last term is the effect of exiting firms. If these firms are less productive than surviving firms in period 1, this term also becomes positive.

The decomposition in (8) can be applied to the private sector as a whole or to any subsector. The change in the aggregate productivity for the private sector as a whole

[18] To be precise, $cov(s_{it}, \varphi_{it})$ is n_t times the estimated covariance.

can also be decomposed into contributions from the manufacturing sector and the service sector, respectively, as well as contributions from inter-sectoral reallocations (see Melitz and Polanec 2012 for details). In the following, we decompose the productivity growth in the manufacturing sector and the service sector separately using (8), but we also compute the contributions of these two sectors to the aggregate productivity development of the private sector as a whole.

The results of this exercise are provided in Table 5. The numbers in italics are weighted contributions of a certain category to the aggregate productivity development in the private sector, and in a given column these numbers add up to the *intra-sector contribution*. We get the *total contribution* to the private sector by adding the *inter-sector contribution*.

We observe that the aggregate increase in private sector TFP has been 23.7 %, and the increase in labor productivity (value added per worker) has been 13.0 %. Only a small part of this is due to reallocations between the service sector and the manufacturing sector. We also observe that the increase in productivity has been much higher in the manufacturing sector than in the service sector. Aggregate TFP in the manufacturing sector has thus increased by 34.2 %, while it has increased by a more modest 15.5 % in the service sector. Similarly, labor productivity has increased by 28.0 % in the manufacturing sector, while it has increased by only 7.0 % in the service sector.

We can also see that the relative importance of within-firm productivity changes and reallocations differ between the two sectors. The main source of productivity increases in the manufacturing sector is thus within-firm productivity changes, while the main source in the service sector is reallocations. Firms entering have a negative contribution to aggregate productivity growth both in the service sector and in the manufacturing sector, while the contribution from exiting firms is positive. These results reflect that both new firms and exiting firms are less productive than surviving firms. Melitz and Polanec (2012) observe similar results using a sample of Slovenian manufacturing firms.

In order to investigate the industry differences in more detail, Table 6 presents the results when we distinguish between 8 different manufacturing industries and 20 different service industries.[19] Not surprisingly, the inter-industry effect is much higher than the inter-sector effect from Table 5. It now accounts for close to 50 % of the productivity growth whether measured by TFP or value added per worker. Besides that, the within-firm productivity effect still seems to dominate within most manufacturing industries, although a few of them have a larger contribution from reallocations. Within the service sector, the picture is more blurred with some industries, such as *Computer and related activities*, exhibiting large and dominating within-firm productivity effects, while other industries, such as *Hotels and Restaurants*, to a much larger extent rely on reallocation effects.

As a robustness check, we also estimated the decomposition from Table 5 with 2007 instead of 2008 as the final year. Results are reported in Table 10 in the "Appendix". Using 2007 as the last year increases both TFP and labor productivity growth in the service sector, while it reduces both of these in the manufacturing

[19] A small number of firms (<2 %) switch industry between 2002 and 2008 in our sample. We assign the firm's modal industry during 2002–2008 to these firms.

Table 5 Decomposition of productivity growth, 2002–2008

	TFP					Value added per worker				
	Within-firm effect	Reallocation effect	Entry effect	Exit effect	Total effect	Within-firm effect	Reallocation effect	Entry effect	Exit effect	Total effect
Manufacturing sector										
Unweighted contribution	0.182	0.146	−0.011	0.025	0.342	0.240	0.035	−0.035	0.040	0.280
Weighted contribution	*0.038*	*0.030*	*−0.005*	*0.010*	*0.073*	*0.050*	*0.007*	*−0.012*	*0.015*	*0.060*
Service sector										
Unweighted contribution	−0.024	0.210	−0.045	0.013	0.155	0.014	0.115	−0.111	0.052	0.070
Weighted contribution	*−0.019*	*0.167*	*−0.025*	*0.008*	*0.131*	*0.011*	*0.091*	*−0.073*	*0.032*	*0.061*
Intra-sector contribution	*0.019*	*0.197*	*−0.030*	*0.018*	*0.204*	*0.061*	*0.098*	*−0.085*	*0.048*	*0.122*
Inter-sector contribution		*0.039*	*−0.007*	*0.001*	*0.033*		*0.018*	*−0.022*	*0.012*	*0.008*
Total contribution	*0.019*	*0.236*	*−0.036*	*0.019*	*0.237*	*0.061*	*0.117*	*−0.108*	*0.059*	*0.130*

The table contains the results of a decomposition of the growth in productivity (TFP or VA/L) in the Danish private sector between 2002 and 2008 using the technique from Melitz and Polanec (2012). Value added shares are used as weights in TFP decompositions and employment shares are used as weights in VA/L decompositions. See the text for further details. The numbers in italics are weighted contributions to the aggregate productivity development in the private sector. In a column the weighted contributions add up to the intra-sector contribution. The total contribution to the private sector is obtained by adding the inter-sector contribution. *Data source*: register data provided by Statistics Denmark (see text for more information)

Table 6 Decomposition of productivity growth at the industry level, 2002–2008

	TFP					Value added per worker				
	Within-firm effect	Reallocation effect	Entry effect	Exit effect	Total effect	Within-firm effect	Reallocation effect	Entry effect	Exit effect	Total effect
Manufacturing sector										
Food, beverages and tobacco	−0.042	0.021	−0.028	0.042	−0.007	0.022	0.079	−0.056	0.059	0.104
Textiles, apparel, leather and footwear	0.190	0.000	−0.020	0.039	0.210	0.249	−0.021	−0.051	0.059	0.236
Wood, paper, pulp and printing	0.198	0.245	−0.057	0.028	0.414	0.265	0.084	−0.036	0.054	0.367
Chemicals, plastic and rubber	0.235	0.119	−0.021	0.032	0.364	0.301	0.118	−0.038	0.061	0.441
Glass, ceramic and cement	0.049	0.048	−0.011	0.033	0.119	0.171	0.044	−0.023	0.021	0.213
Iron and metal	0.218	0.069	0.029	0.001	0.316	0.276	−0.053	0.003	0.008	0.234
Machinery and electronics	0.227	0.161	0.028	−0.021	0.395	0.264	0.017	−0.016	0.001	0.266
Furniture	0.241	0.301	−0.032	0.034	0.544	0.307	0.081	−0.038	0.071	0.421
Service sector										
Sale, maintenance, repair of motor vehicles and retail sale of fuel	−0.123	0.188	−0.026	0.033	0.072	−0.055	0.103	−0.101	0.036	−0.018
Wholesale trade except motor vehicles	0.087	0.040	−0.021	−0.003	0.103	0.113	0.014	−0.026	0.034	0.135
Retail trade except motor vehicles	0.092	0.011	0.027	−0.011	0.119	0.121	−0.066	−0.034	0.019	0.039
Hotels and restaurants	−0.108	0.287	−0.142	−0.018	0.019	−0.036	0.089	−0.142	0.064	-0.024
Land transport	−0.341	0.093	−0.022	−0.008	−0.278	−0.242	0.030	−0.048	0.011	-0.249
Supporting and auxiliary transport activities	0.285	0.070	0.040	−0.062	0.333	0.162	0.058	−0.016	0.003	0.208
Real estate activities	−2.152	0.754	0.367	0.177	−0.854	−2.102	0.240	−0.109	0.027	−1.944
Renting of machinery and equipment	0.339	−0.001	0.103	−0.408	0.034	0.519	0.199	0.080	−0.172	0.626
Computer and related activities	0.399	−0.073	−0.069	0.019	0.276	0.348	−0.027	−0.073	0.058	0.307
Research and development	0.084	−0.200	−0.103	0.022	−0.196	0.037	−0.187	−0.171	0.089	-0.232
Legal, accounting, book-keeping, management consultancy etc.	−0.160	0.216	−0.048	−0.060	−0.051	−0.047	0.104	−0.092	−0.026	-0.061

Table 6 continued

	TFP					Value added per worker				
	Within-firm effect	Reallocation effect	Entry effect	Exit effect	Total effect	Within-firm effect	Reallocation effect	Entry effect	Exit effect	Total effect
Architectural and engineering activities	−0.200	0.079	−0.023	0.023	−0.121	−0.268	0.199	−0.072	0.002	-0.140
Technical testing and analysis	0.088	−0.192	−0.088	−0.005	−0.197	−0.037	−0.010	−0.101	0.007	-0.141
Advertising	0.093	0.139	0.012	0.070	0.314	0.075	0.429	−0.152	0.344	0.695
Labour recruitment and provision of personnel	0.886	1.090	−0.339	−0.029	1.607	1.138	0.745	−0.549	0.005	1.338
Investigation and security activities	0.085	0.538	−0.240	−0.072	0.311	−0.066	−0.159	0.041	−0.022	-0.206
Industrial cleaning	0.248	0.577	−0.175	0.037	0.687	0.246	0.218	−0.148	0.008	0.324
Miscellaneous business activities n.e.c	−0.143	0.207	−0.038	0.060	0.087	−0.112	0.098	−0.076	0.034	-0.056
Intra-industry contribution	0.019	0.124	−0.021	0.003	0.124	0.061	0.045	−0.054	0.032	0.084
Inter-industry contribution		0.112	−0.015	0.016	0.113		0.072	−0.054	0.027	0.045
Total contribution	0.019	0.236	−0.036	0.019	0.237	0.061	0.117	−0.108	0.059	0.129

The table contains the results of a decomposition of the growth in productivity (TFP or VA/L) in the Danish private sector between 2002 and 2008 using the technique from Melitz and Polanec (2012). See the text for details. The numbers reported for each industry are unweighted contributions to the aggregate productivity development in the private sector. The intra-industry contribution is obtained as the sum of the weighted industry contributions (not shown). Value added shares are used as weights in TFP decompositions and employment shares are used as weights in VA/L decompositions. The total contribution to the private sector is obtained as the sum of the intra-industry contribution and the inter-industry contribution. Data source: register data provided by Statistics Denmark (see text for more information)

sector, so 2008 appears to have been a relatively bad year for the service sector. Still, productivity growth was higher in manufacturing, and otherwise results are very similar to those presented in Table 5.

The question we ultimately want to answer is: how much of the productivity change in Table 5 can potentially be attributed to exporting and importing of goods and services? To analyze this, we use the estimated coefficients of the exporting and importing variables reported in Tables 3 and 4 to construct "counterfactual" values of TFP, labor productivity, employment and value added for each firm in our dataset in the final year (2008). As a consequence, we focus only on continuing firms, i.e., firms present in both periods (2002 and 2008) in this analysis. The counterfactual scenarios are then decomposed in the same way as the actual scenario from Table 5.

Some caveats apply when interpreting such calculations. First, as mentioned in the previous section, the estimated coefficients in Tables 3 and 4 are not necessarily representing causal effects as shocks affecting both trade and productivity may bias the results. Second, general equilibrium effects feeding through, e.g., wages, capital investments and education are not captured by this analysis. The results must be interpreted as the effects of international trade for a given composition of production factors. In addition to these effects, there may be effects due to changes in the incentives for investment and education. However, the estimates in Table 4 show that the composition of the production factors in firms only play a minor role in explaining productivity changes.

We first consider the manufacturing sector. The first row of Table 7 reproduces the decomposition from Table 5 where the population of firms has been restricted to continuing firms only. Thus, while the within-firm and reallocation effects are as in Table 5, the total effects are slightly different, as there are no contributions from entering and exiting firms.

The second row presents the result of a decomposition where we have neutralized all contributions from trade to aggregate productivity growth. Hence, if a firm starts to export goods between 2002 and 2008, we have used the coefficients of the dummy for "start exporting goods" in Table 3 (from the regression with firm controls included) to remove the effect of this from its growth in TFP and VA/L. We have also removed the positive effect of starting to export goods on its size (employment and VA) using the corresponding coefficients from Table 4. In a similar way, we neutralize the effects of stopping to export goods or continuing to export goods using the coefficients from Tables 3 and 4, and we also neutralize the effects of any changes in the goods-exports intensity. Finally, we have used the same approach to remove the effects of goods imports as well as export and import of services.

The decomposition for this counterfactual scenario is presented in the second row of Table 7. It shows that total productivity growth in the manufacturing sector would only have been slightly lower without the trade activities, whether measured by TFP or VA/L. More precisely, as reported in the following row, TFP growth would have been 0.4 percentage points lower (corresponding to 1.3 % of the actual TFP growth), while VA/L growth would have been 1.1 percentage points lower (corresponding to 3.9 % of actual VA/L growth). The reason is that the within-firm productivity effects become somewhat smaller without the effects from trade, while the reallocation effects increase by almost the same amount.

Table 7 Decompositions of productivity growth, actual and counterfactual scenarios, 2002–2008

	TFP			Value added per worker		
	Within-firm effect	Reallocation effect	Total effect	Within-firm effect	Reallocation effect	Total effect
Manufacturing sector						
Actual scenario	0.182	0.146	0.328	0.240	0.035	0.275
Counterfactual scenario: All trade effects neutralized	0.158	0.166	0.324	0.216	0.048	0.264
Changes compared to actual scenario from						
Neutralizing all trade effects	−0.024	0.020	−0.004	−0.024	0.013	−0.011
Neutralizing effects from services exports	0.016	0.009	0.025	0.016	0.009	0.024
Neutralizing effects from goods exports	−0.036	−0.014	−0.049	−0.036	−0.014	−0.050
Neutralizing effects from services imports	0.002	0.019	0.021	0.002	0.013	0.015
Neutralizing effects from goods imports	−0.005	0.007	0.001	−0.004	0.005	0.001
Service sector						
Actual scenario	−0.024	0.210	0.186	0.014	0.115	0.129
Counterfactual scenario: All trade effects neutralized	−0.056	0.181	0.125	−0.017	0.095	0.077
Changes compared to actual scenario from						
Neutralizing all trade effects	−0.032	−0.030	−0.062	−0.031	−0.020	−0.052
Neutralizing effects from services exports	−0.004	−0.004	−0.007	−0.004	−0.002	−0.006
Neutralizing effects from goods exports	−0.009	−0.007	−0.016	−0.009	−0.006	−0.015
Neutralizing effects from services imports	0.002	0.002	0.004	0.002	0.002	0.004
Neutralizing effects from goods imports	−0.021	−0.022	−0.044	−0.021	−0.017	−0.038

The table contains the results of a decomposition of actual and counterfactual growth in productivity (TFP and VA/L) in the Danish private sector between 2002 and 2008 using the technique from Melitz and Polanec (2012). Counterfactual growth scenarios are constructed using the estimates from Tables 3 and 4. Value added shares are used as weights in TFP decompositions and employment shares are used as weights in VA/L decompositions. See the text for further details. Data source: register data provided by Statistics Denmark (see text for more information)

To investigate the sources of these differences, the following rows of Table 7 present decompositions where we in turn have neutralized the effects of services exports, goods exports, services imports and goods imports. As can be seen, neutralizing the effects of goods exports have the largest negative consequences for aggregate productivity growth: around 5 percentage points corresponding to 15 % of actual TFP growth and 18 % of actual VA/L growth. More than two-thirds of this

comes from changes in within-firm productivity. On the other hand, neutralizing the effects of service trade in the manufacturing sector actually increases aggregate productivity growth, and thus counteracts the positive effects from goods exports. This result may possibly be explained by the existence of complementarities between delivery of goods and accompanying (costly) producer services for services exporters in the manufacturing sector. Finally, there are positive within-firm effects of goods imports (consistent with, e.g., Amiti and Konings 2007), but they are counteracted by negative reallocation effects of goods imports.

Turning to the service sector (the lower part of Table 7), the results are different. The counterfactual scenario now results in substantially lower growth. TFP growth thus drops by 6.2 percentage points (corresponding to 1/3 of actual TFP growth), while growth in VA/L is reduced by 5.2 percentage points (corresponding to 40 % of actual VA/L growth). The following rows show that the main source of this is the imports of goods. Thus, without the positive effects of importing goods (and starting to import goods), TFP growth would be 4.4 percentage points lower (corresponding to more than 23 % of actual growth), and VA/L growth 3.8 % lower (corresponding to close to 30 % of actual growth). There is also a significant contribution from the exports of goods in the service sector, but still less than half of the effect from goods imports. Exports and imports of services, on the other hand, do not seem to matter much for aggregate productivity growth in the service sector.

To sum up, we find that international trade plays a potentially larger role for the productivity development within the service sector than within the manufacturing sector. We find that it is trade in goods not trade in services that seem to matter most for the productivity development within this sector. In particular, we find that large positive productivity effects are associated with goods imports, and smaller positive effects with goods exports. The wholesale and retail industries account for 84 % of total goods imports and 82 % of the total goods exports in the service sector, so this suggests that these two industries have played an important role for aggregate productivity growth in the service sector. This finding fits well with the recent literature that investigates the importance of intermediaries in international trade (Ahn et al. 2011; Akerman 2012; Bernard et al. 2010, 2011). These studies have used firm-level data from different countries to provide evidence of the importance of wholesalers and retailers in trade flows and to determine the factors that give rise to trade by intermediaries. Our findings show that wholesalers and retailers also play an important role for aggregate productivity development.

In line with, e.g., Bernard and Jensen (2004) and Bernard et al. (2006), we also find a potentially important role of goods exports in the manufacturing sector, which, however, seems to be nullified by negative effects of trade in services. Goods imports seem to matter less in this sector.

5 Conclusion

The aim of this paper has been to provide evidence for the relationship between exports and imports of goods and services and productivity growth for a population of private sector firms. By using a very rich Danish dataset for the years 2002–2008,

we explicitly distinguish between firms in the manufacturing sector and firms in the service sector, between goods trade and services trade, and between exporting and importing. This makes it possible to discover some important differences between the service sector and the manufacturing sector, and between the different types of trading activities. Thus, we can identify trading activities and sub-sectors with important contributions to aggregate productivity growth.

At the firm level we rely on the approach taken in the early literature on firm heterogeneity and trade and relate within-firm changes in trade variables to changes in productivity. This means that due to the lack of exogenous variation in service trade, we do not estimate effects of trade on productivity in a strictly causal sense. Instead our results should be seen as a first attempt to assess the relative importance of goods trade and services trade for productivity growth among both manufacturing and service sector firms. In particular, we find that firms that start to export or import goods become both more productive and bigger. These effects are sizeable and surprisingly similar across sectors. Starting to export services is also associated with increases in productivity and size, but the effects are smaller, and size effects are confined to the service sector.

To quantify how much these micro-level correlations amount to in terms of aggregate productivity growth, we use a recently developed decomposition technique from Melitz and Polanec (2012) to decompose aggregate productivity growth into contributions from within-firm productivity growth and from reallocations. Using our firm-level estimates, we are then able to determine how much of the aggregate productivity growth that can be attributed to international trade. We find that international trade is likely to play a larger role for the productivity development within the service sector than within the manufacturing sector. Furthermore, within the service sector, it is trade in goods (especially imports) rather than trade in services that matters most for the productivity development. Thus, imports of goods can explain between 23 and 30 % of the actual productivity growth over the period 2002–2008 within the service sector.

Recently, productivity has been high on the policy agenda in a number of European countries. One reason for this is that there has been a productivity slowdown in Europe relative to the USA since the mid 1990s (e.g., van Ark et al. 2008). Furthermore, this productivity gap has mainly developed in the service sector. Our results show that further international trade may play an important role for increasing productivity in the service sector, but mainly in the part of the service sector trading with goods. The bulk of goods trade in the service sector is accounted for by trade intermediaries, so this suggests that wholesalers and retailers play an important role for productivity growth in the economy.

Our results also open up a possible direction for future research. Because trade intermediaries primarily trade in goods, it is possible to exploit exogenous variation in goods trade to estimate causal effects on productivity for these firms. Several papers use tariff liberalization episodes to explain firm-level trade and productivity (e.g., Amiti and Konings 2007; Bernard et al. 2006; Pavcnik 2002; Trefler 2004). Hummels et al. (2014) construct a firm-product level world export supply instrument for goods imports to estimate the effects of goods trade on wages in Danish manufacturing firms. Similar identification strategies may be employed for trade intermediaries.

Acknowledgments We would like to thank participants at ETSG Leuven 2012 for helpful suggestions and comments. We also thank Søren Jensen at the Danish Tax Authorities and Jane Duedal Lundsgaard at Deloitte for clarifying the contents of the VAT register. Any remaining errors are our own responsibility. Financial support from the Economic Policy Research Network (EPRN) is gratefully acknowledged.

Appendix

See Tables 8, 9 and 10.

Table 8 List of industries in the sample

Industries	Two-digit NACE codes
Manufacturing sector	
Food, beverages and tobacco	15 and 16
Textiles, apparel, leather and footwear	17, 18 and 19
Wood, paper, pulp and printing	20, 21 and 22
Chemicals, plastic and rubber	23, 24 and 25
Glass, ceramic and cement	26
Iron and metal	27 and 28
Machinery and electronics	29, 30, 31, 32, 33, 34 and 35
Furniture	36
Service sector	
Sale, maintenance, repair of motor vehicles and retail sale of fuel	50
Wholesale trade except motor vehicles	51
Retail trade except motor vehicles	52
Hotels and restaurants	55
Land transport	60 (except 60.10, 60.21, 60.22, 60.23)
Water transport	61 (except 61.10, 61.20)
Air transport	62 (except 62.10, 62.20, 62.30)
Supporting and auxiliary transport activities	63 (except 63.11, 63.12, 63.21, 63.22, 63.23, 63.30)
Real estate activities	70 (except 70.20, 70.3210, 70.3220)
Renting of machinery and equipment	71
Computer and related activities	72
Research and development	73
Legal, accounting, book-keeping, management consultancy etc.	74.1 (except 74.15)
Architectural and engineering activities	74.2
Technical testing and analysis	74.3
Advertising	74.4
Labour recruitment and provision of personnel	74.5 (except 74.5010)
Investigation and security activities	74.6
Industrial cleaning	74.7
Miscellaneous business activities n.e.c	74.8

Table 9 Changes in trading status and productivity growth, 2002–2008

	A: Manufacturing sector				B: Service sector			
	Δ log(TFP)	Δ log(TFP)	Δ log(VA/L)	Δ log(VA/L)	Δ log(TFP)	Δ log(TFP)	Δ log(VA/L)	Δ log(VA/L)
Goods exports								
Starting	0.1166***	0.1231***	0.1220***	0.1159***	0.1202***	0.1209***	0.1019***	0.1104***
	(3.70)	(3.95)	(3.70)	(3.68)	(5.27)	(5.44)	(4.32)	(4.89)
Stopping	−0.0348	−0.0320	−0.0227	−0.0250	0.0211	0.0206	0.0383	0.0306
	(−0.97)	(−0.90)	(−0.61)	(−0.70)	(0.91)	(0.91)	(1.59)	(1.33)
Continuing	0.0381*	0.0405*	0.0535**	0.0421*	0.0192	0.0247	0.0354**	0.0239
	(1.71)	(1.84)	(2.29)	(1.89)	(1.16)	(1.54)	(2.08)	(1.47)
Δ intensity	0.0860	0.1022**	0.1011*	0.0884*	0.0876*	0.0851*	0.0803*	0.0796*
	(1.64)	(1.97)	(1.85)	(1.69)	(1.95)	(1.94)	(1.73)	(1.79)
Goods imports								
Starting	0.0726**	0.0784***	0.0743**	0.0683**	0.0848***	0.0891***	0.0856***	0.0818***
	(2.46)	(2.69)	(2.41)	(2.32)	(4.89)	(5.28)	(4.77)	(4.78)
Stopping	0.0057	0.0060	0.0117	0.0205	−0.0157	−0.0028	0.0221	0.0079
	(0.15)	(0.15)	(0.29)	(0.52)	(−0.68)	(−0.13)	(0.92)	(0.35)
Continuing	−0.0119	−0.0095	−0.0078	−0.0111	0.0609***	0.0519***	0.0382***	0.0510***
	(−0.52)	(−0.42)	(−0.33)	(−0.49)	(4.37)	(3.83)	(2.66)	(3.71)
Δ intensity	0.0023	0.0010	0.0226	0.0080	−0.0890**	−0.0878**	−0.0717*	−0.0877**
	(0.03)	(0.01)	(0.31)	(0.11)	(−2.36)	(−2.39)	(−1.84)	(−2.35)
Additional controls								
Δ Skilled share		0.1874***		0.2205***		0.2468***		0.2640***
		(3.27)		(3.81)		(9.88)		(10.41)
Δ Vocational share		0.2551***		0.2784***		0.2661***		0.2844***
		(6.84)		(7.39)		(16.14)		(16.99)

Table 9 continued

	A: Manufacturing sector				B: Service sector			
	Δ log(TFP)	Δ log(TFP)	Δ log(VA/L)	Δ log(VA/L)	Δ log(TFP)	Δ log(TFP)	Δ log(VA/L)	Δ log(VA/L)
Δlog(capital per worker)		−0.0694***		0.1461***		−0.0937***		0.1217***
		(−11.28)		(23.48)		(−34.26)		(43.84)
Observations	6,547	6,547	6,547	6,547	24,968	24,968	24,968	24,968
R-squared	0.0271	0.0511	0.0231	0.1098	0.1975	0.2402	0.1790	0.2492

Regressions are performed on a panel of firms for the period 2002–2008, where the dependent variable is the change in log productivity (either TFP or VA/L) between 2002 and 2008. All regressions include industry dummies in addition to the controls mentioned. *t*-statistics in parentheses. *** Significance at the 1 % level, ** at the 5 % level, and * at the 10 % level. *Data source*: register data provided by Statistics Denmark (see text for more information)

Table 10 Decomposition of productivity growth, 2002–2007

	TFP					Value added per worker				
	Within-firm effect	Reallocation effect	Entry effect	Exit effect	Total effect	Within-firm effect	Reallocation effect	Entry effect	Exit effect	Total effect
Manufacturing sector										
Unweighted contribution	0.160	0.059	−0.005	0.026	0.241	0.196	0.009	−0.023	0.038	0.221
Weighted contribution	*0.033*	*0.012*	*−0.002*	*0.011*	*0.054*	*0.040*	*0.002*	*−0.008*	*0.015*	*0.049*
Service sector										
Unweighted contribution	−0.009	0.241	−0.039	0.011	0.204	0.020	0.131	−0.111	0.050	0.090
Weighted contribution	*−0.007*	*0.192*	*−0.022*	*0.006*	*0.169*	*0.016*	*0.104*	*−0.072*	*0.031*	*0.079*
Intra-sector contribution	*0.025*	*0.204*	*−0.024*	*0.017*	*0.222*	*0.056*	*0.106*	*−0.080*	*0.046*	*0.128*
Inter-sector contribution		*−0.003*	*0.000*	*0.001*	*−0.002*		*0.006*	*−0.017*	*0.011*	*0.000*
Total contribution	*0.025*	*0.201*	*−0.025*	*0.018*	*0.219*	*0.056*	*0.112*	*−0.097*	*0.057*	*0.128*

The table contains the results of a decomposition of the growth in productivity (TFP or VA/L) in the Danish private sector between 2002 and 2007 using the technique from Melitz and Polanec (2012). Value added shares are used as weights in TFP decompositions and employment shares are used as weights in VA/L decompositions. See the text for further details. The numbers in italics are weighted contributions to the aggregate productivity development in the private sector. In a column the weighted contributions add up to the intra-sector contribution. The total contribution to the private sector is obtained by adding the inter-sector contribution. *Data source*: register data provided by Statistics Denmark (see text for more information)

References

Ahn, J., Khandelwal, A., & Wei, S. (2011). The role of intermediaries in facilitating trade. *Journal of International Economics, 84*(1), 73–85.

Akerman, A. (2012). *Wholesalers and economies of scope in international trade*. Mimeo: Stockholm University.

Amiti, M., & Konings, J. (2007). Trade liberalization, intermediate inputs, and productivity: Evidence from Indonesia. *American Economic Review, 97*(5), 1611–1638.

Aristei, D., Castellani, D., & Franco, C. (2013). Firms' exporting and importing activities: Is there a two-way relationship? *Review of World Economics/Weltwirtschaftliches Archiv, 149*(1), 55–84.

Bas, M., & Strauss-Kahn, V. (2014). Does importing more inputs raise exports? Firm-level evidence from France. *Review or World Economics/Weltwirtschaftliches Archiv, 150*(2), 241–276.

Bernard, A., Grazzi, M., & Tomasi, C. (2011). *Intermediaries in international trade: Direct versus indirect modes of export*. Dartmouth: Mimeo.

Bernard, A., & Jensen, J. B. (1995). Exporters, jobs, and wages in U.S. manufacturing: 1976–1987. *Brookings Papers on Economic Activity Microeconomics, 1995*, 67–119.

Bernard, A., & Jensen, J. B. (1999). Exceptional exporter performance: Cause effect or both? *Journal of International Economics, 47*(1), 1–25.

Bernard, A., & Jensen, J. B. (2004). Exporting and productivity in the USA. *Oxford Review of Economic Policy, 20*(3), 343–357.

Bernard, A., Jensen, B., Redding, S., & Schott, P. (2007). Firms in international trade. *Journal of Economic Perspectives, 21*(3), 105–130.

Bernard, A., Jensen, B., Redding, S., & Schott, P. (2010). Wholesalers and retailers in US trade. *American Economic Review Papers and Proceedings, 100*, 408–413.

Bernard, A., Jensen, B., Redding, S., & Schott, P. (2012). The empirics of firm heterogeneity and international trade. *Annual Review of Economics, 4*, 283–313.

Bernard, A., Jensen, B., & Schott, P. (2006). Trade costs, firms and productivity. *Journal of Monetary Economics, 53*(5), 917–937.

Breinlich, H., & Criscuolo, C. (2011). International trade in services: A portrait of importers and exporters. *Journal of International Economics, 84*(2), 188–206.

Copeland, B., & Mattoo, A. (2008). The basic economics of services trade. In A. Mattoo, R. M. Stern, & G. Zanini (Eds.), *A handbook of international trade in services* (pp. 84–129). Oxford: Oxford University Press.

Cristea, A., Hummels, D., & Roberson, B. (2012). *Estimating the gains from liberalizing services trade: The case of passenger aviation*. Mimeo: University of Oregon.

Crozet, M., & Milet, E. (2014). *The servitization of French manufacturing firms* (CEPII Discussion Paper 2014-10). Paris: Centré d'É tudes Prospectives et d'Informations Internationales.

De Loecker, J. (2007). Do exports generate higher productivity? Evidence from Slovenia. *Journal of International Economics, 73*(1), 69–98.

De Loecker, J. (2013). Detecting learning by exporting. *American Economic Journal: Microeconomics, 5*(3), 1–21.

Foster, L., Haltiwanger, J. C., & Krizan, C. J. (2001). Aggregate productivity growth: Lessons from microeconomic evidence. In C. R. Hulten, E. R. Dean, & M. J. Harper (Eds.), *New developments in productivity analysis* (pp. 303–372). Chicago: University of Chicago Press.

Foster-McGregor, N., Isaakson, A., & Kaulich, F. (2014). Importing, exporting and performance in sub-Saharan African manufacturing firms. *Review of World Economics/Weltwirtschaftliches Archiv, 150*(2), 309–336.

Francois, J., & Hoekman, B. (2010). Services trade and policy. *Journal of Economic Literature, 48*(3), 642–692.

Griliches, Z., & Regev, H. (1995). Firm productivity in Israeli industry: 1979–1988. *Journal of Econometrics, 65*(1), 175–203.

Haller, S., Damijan, J., Kaitila, V., Kostevc, C., Malirinta, M., Milet, E., et al. (2014). Trading firms in the services sectors: comparable evidence from four EU countries. *Review of World Economics/ Weltwirtschaftliches Archiv, 150*(3), 471–506.

Hummels, D., Jørgensen, R., Munch, J., & Xiang, C. (2014). The wage effects of offshoring: Evidence from Danish matched worker-firm data. *American Economic Review, 104*(6), 1597–1629.

International Study Group on Exports and Productivity (ISGEP) (2008). Understanding cross-country differences in export premia—Comparable evidence for 14 countries. *Review of World Economics/ Weltwirtschaftliches Archiv, 144*(3), 596–635.

Jensen, J. B. (2008). Trade in high-tech services. *Journal of Industry, Competition and trade, 8*(3–4), 181–197.

Levinsohn, J., & Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *Review of Economic Studies, 70*(2), 317–342.

Lipsey, R. E. (2009). Measuring international trade in services. In M. Reinsdorf & M. J. Slaughter (Eds.), *International trade in services and intangibles in the era of globalization* (pp. 27–70). Chicago: Chicago University Press.

Lodefalk, M. (2014). The role of services for manufacturing firm exports. *Review of World Economics/ Weltwirtschaftliches Archiv, 150*(1), 59–82.

Manjon, M., Manez, J. A., Rochina-Barrachina, M. E., & Sanchis-Llopis, J. A. (2013). Reconsidering learning by exporting. *Review of World Economics/Weltwirtschaftliches Archiv, 149*(1), 5–22.

Mayer, T., & Ottaviano, G. (2007). *The happy few: The internationalisation of European firms*. New facts based on firm-level evidence, Bruegel–CEPR EFIM Rep., Bruegel Blueprint Ser., Brussels.

Melitz, M. J., & Polanec, S. (2012). *Dynamic Olley-Pakes productivity decomposition with entry and exit* (NBER Working Paper 18182). Cambridge, MA: National Bureau of Economic Research.

Molina, D., & Muendler, M.-A. (2013). *Preparing to export* (NBER Working Paper 18962). Cambridge, MA: National Bureau of Economic Research.

Olley, S., & Pakes, A. (1996). The dynamics of productivity in the telecommunications industry. *Econometrica, 64*(6), 1263–1298.

Pavcnik, N. (2002). Trade liberalization, exit, and productivity improvement: Evidence from Chilean plants. *Review of Economic Studies, 69*(1), 245–276.

Temouri, Y., Vogel, A., & Wagner, J. (2013). Self-selection into export markets by business services firms—Evidence from France, Germany and the United Kingdom. *Structural Change and Economic Dynamics, 25*, 146–158.

Trefler, D. (2004). The long and short of the Canada–US free trade agreement. *American Economic Review, 94*(4), 870–895.

Van Ark, B., O'Mahony, M., & Timmer, M. P. (2008). The productivity gap between Europe and the United States: Trends and causes. *Journal of Economic Perspectives, 22*(1), 25–44.

Van Biesebroeck, J. (2004). *Robustness of productivity estimates* (NBER Working Paper 10303). Cambridge, MA: National Bureau of Economic Research.

Van Biesebroeck, J. (2005). Exporting raises productivity in sub-Saharan African manufacturing firms. *Journal of International Economics, 67*(2), 373–391.

Wagner, J. (2012). International trade and firm performance: A survey of empirical studies since 2006. *Review of World Economics/Weltwirtschaftliches Archiv, 148*(2), 235–267.