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Abstract

This paper studies the effect of bundling products and services on the export performance of firms. Using a unique sample, we document several facts about German small and medium enterprises (SMEs). First, bundling is a relatively rare activity, which is unevenly spread across sectors. Second, SMEs that bundle products and services are more productive than those selling products and services separately. Third, these firms tend to be more internationally oriented. While most of the existing literature focuses on large firms, we contribute to the literature by uncovering a robust positive relation between product-service bundling and exporting in SMEs. Importantly, the competitiveness-enhancing effect of bundling goes beyond manufacturing, affecting non-manufacturing firms also. To mitigate endogeneity concerns, we exploit the panel structure of the data and implement several (doubly robust) propensity score matching techniques.

Key words: Bundling, innovation, export, SMEs.

JEL classification: D22, F10, F14, F23, L80.

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1 INTRODUCTION

This paper contributes to the literature on innovation and exporting by small and medium enterprises (SMEs). While this theme has been extensively researched both in international business (e.g. Cassiman and Golovko, 2011; Golovko and Valentini, 2011) and in international trade (e.g. Altomonte et al., 2013; Aghion et al., 2018), a number of issues are still understudied, including to what extent the third industrial revolution is transforming the way firms innovate and compete in international markets (e.g. Alcacer et al., 2016; Dosi et al., 2013).

One factor that characterizes this revolution is the fact that firms are increasingly adopting hybrid business models (Teece, 2018), whereby they sell bundles of products and services (Cusumano et al., 2015). Previous studies have examined conceptually (Vandermerwe and Rada, 1988) and empirically (Ariu et al., 2018) the positive relation between selling products and services abroad (i.e. bi-exporting) and a firm's export performance. However, to the best of our knowledge, this is the first paper that considers how bundling products and services in the same commercial offer, that is, *integrated solution* (Davies, 2004), affects a firm's internationalization. Unlike other papers, e.g. Ariu et al. (2018), who observe whether (manufacturing) firms have positive sales for services but cannot tell whether both goods and services are sold to the same buyer, in our case we observe the firm-level breakdown of sales generated by products, services and a combination of the products and services (bundling).

The way firms implement an integrated solution depends on their primary sector. For example, manufacturers normally servitize by offering the use rather than the ownership of their products (e.g. outcomes-based contracts) to their clients (Baines et al., 2017; Crozet and Milet, 2017; Rabetino et al., 2018), whereas (knowledge-based) service firms package their services adding tangible products to their offer, including embedded sensors or other forms of hardware, i.e. productization (Harkonen et al., 2015; Rajanna, 2013).

We argue that irrespectively of the firm's primary sector, selling products and services in one offer is positively associated with export intensity. In light of the existing literature, our argument can be rationalized in two ways. First, by providing an opportunity to customize the offer (differentiation), product-service bundling enriches the customer's understanding of it, ultimately raising margins in foreign markets (Aw et al., 2001; Bughin, 1996; Golovko and Valentini, 2011). Second, integrated solutions can lock customers in to long-term agreements (Vargo and Lusch, 2008; Wise and Baumgartner, 1999). In line with this hypothesis, more than 90% of the firms in our sample declare that bundling is indeed a way to increase customer loyalty. Consolidating such loyalty is

likely to generate stable streams of revenues, leading firms to increase their engagement in specific (foreign) markets (Teece, 2014; Vahlne and Johanson, 2017).

We analyse the relation between product–service bundling and exporting using a unique dataset that includes information about more than 4,000 German small and medium enterprises (SMEs) for the years 2011 and 2014. The firms operate in a wide range of industries, enabling us to study industry-level heterogeneities in the implementation of integrated solutions. Interestingly, we find that product–service bundling goes beyond manufacturing and knowledge-based service industries: we find that a non-negligible percentage of firms in transportation, construction, professional services, and retailing, to name a few, offer integrated solutions.

Our findings show that after controlling for productivity and R&D investment, selling integrated solutions increases export intensity. This result is robust across several specifications, including firm-fixed effects models capturing unobserved firm heterogeneity. Moreover, by restricting our analysis to the sample of manufacturing (servitization) and knowledge-based service firms (productization), we find that the competitiveness-enhancing effect of bundling does not stem from the firm's primary sector.

Our contribution to the literature is threefold. First, although previous research has assessed the impact of technological (Cassiman et al., 2010; Cassiman and Golovko, 2011; Roper and Love, 2002; Wheeler et al., 2008) and non-technological innovation on exporting (Azar and Ciabuschi, 2017; Love et al., 2010), to date only a very limited amount of research has analysed how business model innovation affect a firm's export capabilities (Knight and Liesch, 2016). The present study paves the way for such research by considering the effects on firm internationalization of an increasingly adopted business model, the commercialization of integrated solutions.

Second, the focus on SMEs rather than large multinational enterprises (MNEs) is another important contribution of this study. From an international business standpoint, exporting is a priority entry mode to foreign markets for SMEs, as, compared with foreign direct investment, it involves low levels of commitment, resources, risk, and complexity (Sui and Baum, 2014). In the empirical literature on innovation, most of the research on integrated solutions treats large corporations (see Kastalli and Van Looy, 2013; Suarez et al., 2013), but the present paper provides a distinctive approach by looking at smaller firms.

Third, the country of analysis is also an important empirical choice. Germany is leading the journey to the third industrial revolution (Brouthers et al., 2016; Czarnitzki and Spielkamp, 2003; Gomes et al., 2018), and therefore it is an ideal setting to explore the implementation of integrated solutions and its effects on firm internationalization.

This paper is organized as follows. The next section reviews the literature on the relation between innovation and exporting as well as developing a conceptual framework on how integrated

solutions and firm internationalization are connected, developing one testable hypothesis. We then describe the data, present the empirical model and discuss the results and various empirical exercises to show their robustness. Following this, the paper closes with a discussion and some conclusions.

2 RELATED LITERATURE

A substantial body of literature suggests there is a positive link between technological innovation and exporting. This is theoretically grounded on the underlying differentiation and competitive advantage obtained from improved products and processes (Roper and Love, 2002; Cassiman et al., 2010; Wheeler et al., 2008).

There is a broad consensus that innovative firms boost their domestic competitiveness through product and process innovation, which in turn increases the ability to sell in foreign markets, whereas non-technological innovators need to raise productivity before exporting. The empirical work of Cassiman and Golovko (2011) exemplifies this rationale. Using a sample of Spanish manufacturing firms over the period 1990–1998, Cassiman and Golovko concluded that the self-selection into exporting argument (Melitz, 2003) only applies to non-innovators. Their result suggests that innovative firms need a lower level of productivity to start exporting relative to non-innovative ones: the exported product itself differentiates the firm from the competitors in international markets. Along similar lines, Golovko and Valentini (2011) have also found that technical innovation and exporting are complementary in boosting an SME's growth.

While the previous literature has agreed on a number of internal and external enablers of the innovation and exporting linkage, e.g. skills within the workforce (Brambilla et al., 2012), the education of managers (Ganotakis and Love, 2010), investment in R&D (Harris and Moffat, 2011; Ganotakis and Love, 2012; Love and Roper, 2015), public support (Foreman-Peck, 2013; Griliches, 1995) and partnerships with other private firms (Glückler, 2013), the objective of the present paper is to study the link between a particular business model, product–service bundling (or simply *bundling* in this paper), and a firms export behaviour.[1]

To do that we start from the fact that although products and services have conventionally been considered separately, evidence indicates that there are synergies between the two that can potentially enhance firm-level international competitiveness (Vandermerwe and Rada, 1988; Lode-

[1]The literature on innovation goes beyond technological and non-technological innovation. For instance, the US Advisory Committee on Measuring Innovation has defined innovation as 'The design, invention, development, and or implementation of new altered products, services, processes, systems, organizational structures or business models for the purpose of creating new value for customers and financial returns for the firm." so as to include business model innovation as an important form of innovation. Business model innovation is defined in the literature as a firm's ability to develop new value propositions with a given set of product quality and technology that can enhance its competitive advantage and profitability (Chesbrough, 2010).

falk, 2014; Ariu, 2016). In other words, the product–services dichotomy does not fully capture the fact that some firms actually bundle products and services into an integrated solution (referred to as 'product–service bundling' or simply 'bundling' when no confusion can arise), which generates an integrated revenue stream (Davies, 2004). This type of bundling goes beyond the conventional product bundle, which tends to be composed of standardized components (Nalebuff, 2004). Product–service bundling is a customized combination of products and services that are delivered and priced to fulfil a specific customer's needs. As mentioned before, this can happen because manufacturing firms implement services to boost the capabilities of the product, something which is referred to as *servitization* (Crozet and Milet, 2017), or because service firms add tangible components to their offering, which is referred to as *productization* (Harkonen et al., 2015). Despite them sharing several features, e.g. in both cases firms offer integrated solutions, there are important differences between servitization and productization.

In the case of servitization, industrial manufacturing firms upgrade their products by offering outcomes-based contracts to their customers, with the objective of generating revenues for the whole of the product's lifecycle (Baines et al., 2017; Rabetino et al., 2018). Outcomes-based contracts consist in selling the use of the products rather than selling the products in a transactional operation. For instance, Rolls Royce is selling the hourly use of their engines rather than selling the engines themselves, or Alstom, the French train producer, has introduced train life services, offering maintenance and parts supply services to transport companies.[2][3]

In the case of productization, however, service companies embrace tangible products in order to standardize their offer and enhance their overall efficiency through increased economies of scale (Harkonen et al., 2015).[4]To date, the literature on productization and firm performance is very scarce, with Suarez et al. (2013) being an exception.[5]

Regardless of the primary sector, it seems logical to consider sales from product–service bundles as an independent source of revenue, relative to those generated by either products or services alone. In fact, bundling products and services is likely to be a superior business model than selling products

[2]This type of business model is particularly important for advanced economies, characterized by high wages, high skills, and high disposable income, since it would permit them to resume growth in strategic industries and sustain long-term competitiveness (Crozet and Milet, 2017).

[3]There is also a growing literature assessing the financial and economic benefits of servitization in advanced economies. For example the most representative studies have shown that servitization can have positive effects on operative margins (Kastalli and Van Looy, 2013), employment creation (Crozet and Milet, 2017) and sales growth (Kohtamäki et al., 2013; Sousa and da Silveira, 2017). However, to date no research has analysed whether it strengthens a firm's capacity to export.

[4]Productization of services is normally focussed on packaging and delivering Information and Communication Technologies (ICT) services in an industrialised form (Spohrer, 2017). Examples of these strategies are embedded sensors for industrial equipment and handled devices to provide more real-time and high-precision information (Ziaee Bigdeli et al., 2018).

[5]That study covers the period 1990–2006 for almost 400 firms in the US software industry and concludes that selling software as a product provides higher operative margins than selling software as a service.

and services separately, i.e. it creates and captures more value. There are two main reasons that support this argument: (i) Product differentiation and (ii) Long-term commitment.

First, integrated solutions enhance a firm's differentiation capabilities through customer committment and customization (Visnjic et al., 2016; Zhang et al., 2016). Entering into export markets requires internalizing sunk costs (Melitz, 2003) and overcoming these costs is challenging. Product attributes and quality are the main determinants for a firm's capacity to raise profit margins abroad and strengthen their presence in foreign markets (Aw et al., 2001). Differences in product/service quality are highly explained by differences in the capacity for organizational innovation (Golovko and Valentini, 2011). By offering bundles of products and services, the firm likely moves from selling towards more sophisticated packages that create additional value to foreign consumers, enabling the firm to obtain more sustainable streams of revenue from abroad.

Second, product-service bundling can lock in customers by signing long-term agreements with them (Vargo and Lusch, 2008; Wise and Baumgartner, 1999), enabling firms to obtain revenues over the entire lifecycle of the product (Cusumano et al., 2015; Bustinza et al., 2017). According to the Uppsala model of firm internationalization, the firm's capacity to export and its underlying export performance is highly associated to the investment committed to serving abroad (Vahlne and Johanson, 2017). Securing a stable market share and stable revenue streams in a given foreign market quite often provides the correct incentives to increase investment commitment in this particular market (Teece, 2014). By offering integrated solutions, firms might have the opportunity to lock in a foreign customer for a period of time. The promise of secured revenue streams is an incentive to allocating more resources to this market and eventually to increasing the firm's export intensity.

To sum up, we add to the existing literature by showing that SMEs which bundle products and services into one commercial offer increase their competitiveness in foreign markets markets relative to those that export only products or only services. We argue that bundling products and services increase a firm's ability to differentiate and its export commitment, which ultimately raise its export intensity. We thus hypothesize:

Hypothesis 1: *Firms that bundle product and services into one commercial offer exhibit higher export performance than firms selling products and services separately.*

3 DATA

Our analysis is based on survey data for German SMEs. Germany is a particularly interesting country to investigate how product–service bundling is linked to firm internationalization, since German SMEs are essentially leading the European journey to the third industrial revolution

(Czarnitzki and Spielkamp, 2003; Muller and Zenker, 2001) and exporting (Marin et al., 2015).[6]

We combine our survey data with data from Bureau Van Dijk on accounting and financial information, the MARKUS dataset. This database was used as a firm directory and a way of identifying a wide selection of German firms. Those firms were then contacted to conduct a unique survey led by the Cologne Institute for Economic Research (CIER). The survey was validated by a panel of industry experts prior to its administration, and to obtain a longitudinal setting, it was implemented in two waves (2011 and 2014). Special care was taken to ensure that respondents were in key managerial decision-making positions and had a good understanding of innovation practices and the firm's strategy. The survey was conducted in German to ensure that the respondents were able to provide precise answers.

In both waves, the survey was sent by e-mail. The e-mail contained an individual link, username and password to log in on an online platform. The first wave of the survey was sent in December 2010 and January 2011 to 35,730 recipients and the second wave was sent in July and August 2014 to 22,388 recipients. The answer rate obtained was 7.8% in the first wave and 6.7% in the second wave, which is not far from the 9.2% average rate across top journals in the field of international business (Chidlow et al., 2015).

Our sample is a repeated cross-section of 4,646 firms in different industries. The 2011 wave contains information about 3,493 firms, whereas the 2014 one includes 1,153. There were 574 firms that appeared in both waves, providing the possibility of conducting a longitudinal analysis for a sub-sample of firms (we will call this sub-sample the panel).

Table 1 shows that our sample contains almost exclusively SMEs (around 99% of the firms).

Table 1: Size distribution of firms

Class size	# of firms	Percentage
1—9	3613	77.92
10—49	794	17.13
50—249	188	4.06
250—499	17	0.38
500+	24	0.52
Total	4,637	100

As such, it is not representative of the entire economy but only of German SMEs. To ensure its representativeness, we have constructed size-sector weights which, when possible, will be used in the regressions and descriptive statistics.[7] Since we are interested in studying the export performance

[6] In fact, Germany's service jobs in the manufacturing industry have grown by 30% since 1975 (Boddin and Henze, 2014), and (Gomes et al., 2018) show that 10% of German manufacturing firms declare having a secondary industry code in services, much larger than, for example, the Spanish figure (4%).

[7] A detailed illustration of the way the weights were constructed can be found in Section A of the Appendix.

of firms that bundle products and services into one integrated solution, the dependent variable is e^f_{kjt}, export intensity, calculated as the ratio between sales in foreign markets and the the total turnover of firm f in sector k and state j, at time t. As shown in Table 2, exporters (46% of the sample) derive on average 14% of their turnover from selling abroad.

s^f_{kjt}, our variable of interest, is the ratio between revenues obtained from selling product–service bundles and total turnover.[8] Table 2 shows 22% of the firms sell integrated solutions.[9]

Table 2: Summary statistics

Variable	Mean	Std. Dev.	Observations(%)
e^f_{kjt}	14.077	23.86	4,155
# of exporters(%)			1,190(46)
s^f_{kjt}	8.301	22.765	4,526
# of bundling firms(%)			990(22)
lp^f_{kjt}	0.272	1.266	4,466
inv^f_{kjt}	0.135	0.341	4,162
rd^f_{kjt}	4.116	10.852	4,412

Observations are weighted using sample weights as computed in Section A in the Appendix.

lp^f_{kjt} is the logarithm of the turnover divided by the number of employees (labor productivity), which is a common way of defining productivity both in the international trade literature (see e.g. Altomonte et al., 2012) and the international business literature (see e.g. Luo and Bu, 2016).[10] We include labour productivity because both the decision to export (see e.g. Bernard and Jensen, 1999; Melitz, 2003; Altomonte et al., 2012, 2013) and the choice to bundle products with services (see Ariu et al., 2018) are likely to be correlated with the productivity of the firm. inv^f_{kjt} is a dummy equal to 1 if firm f is in sector k and state j reports at time t having production abroad, and 0 otherwise. Clearly, the number of firms producing abroad is relatively small in our sample, in line with the nature of the survey, which is focussed on SMEs (see Table 2). rd^f_{kjt} is the share of R&D expenditures on the turnover of firm f, in sector k and state j at time t.

4 FACTS

In this section, we present some facts about the firms that sell integrated solutions. First, their presence varies considerably from sector to sector. In particular, in our sample, on average only

[8] Suarez et al. (2013) measure servitization in a similar way (service sales as percentage of total assets). However, they do not observe sales generated by integrated solutions, i.e. sales generated by selling bundles of products and services in one offer.

[9] The distribution of sales generated by bundling in each German state is provided in Section B in the Appendix.

[10] In computing labor productivity we use GDP deflators (base year 2009) to deflate sales.

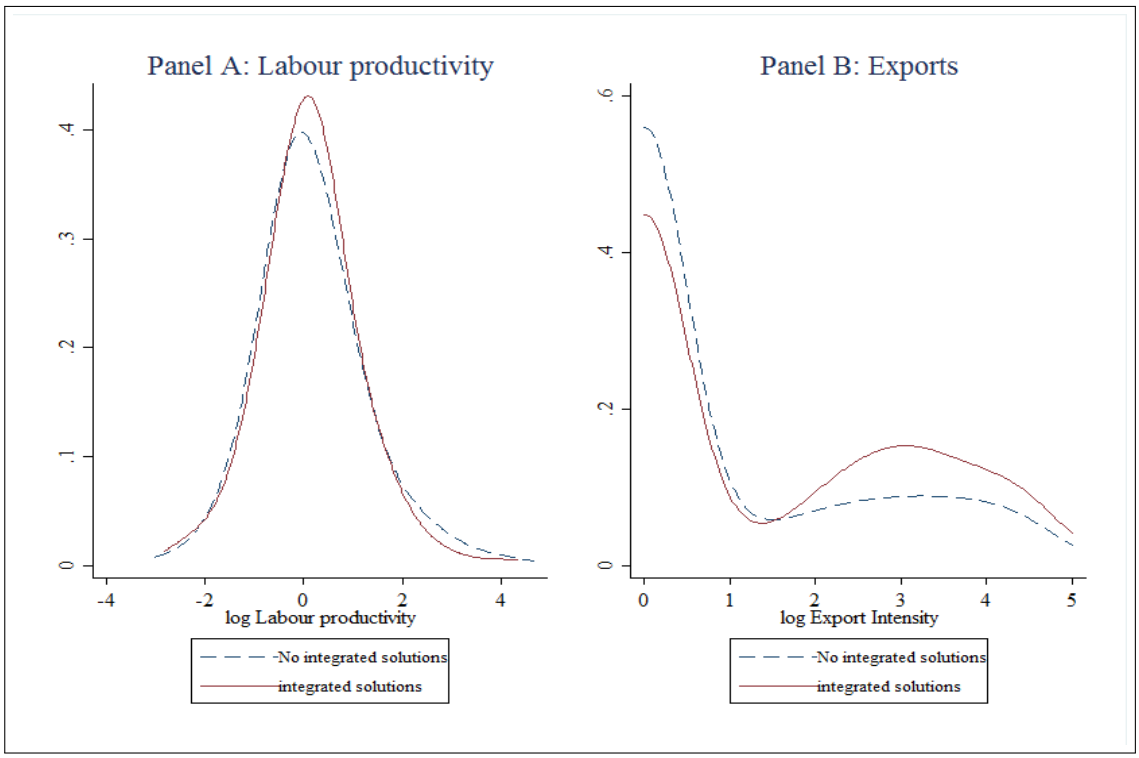
22% sell product–service bundles (Table 3).

Table 3: Bundling by sector

Sector	Description	Share of firms	Share of sales	Observations
58–63	Information and communication	39.24	16.72	443
35	Electricity, gas, steam, etc...	26.48	12.37	143
10–33	Manufacturing	23.00	8.85	1877
45–47	Wholesale and retail trade, repair	22.16	7.54	282
69–75	Professional, scientific and technical	18.91	7.76	896
64–66	Financial and insurance activities	16.08	6.19	21
77–82	Administrative and support service	14.13	6.04	402
37–39	Water supply, sewerage, waste	13.61	1.40	19
68	Real estate activities	11.60	2.37	36
41–43	Construction	9.27	1.49	237
49–53	Transportation and storage	8.70	3.86	161
	Aggregate	21.81	8.66	4,566

Authors' calculation of CIER data. Observations are weighted using sample weights as computed in Section A in the Appendix.

Figure 1: Productivity, bundling and exporting



Notes: Panel A (Panel B) shows the distribution of firm-level labour productivity (exporting intensity), distinguishing between those selling integrated solutions and those which sell products alone or services alone. The distributions in the two panels are statistically different at 1%. Variables are in logarithms. Observations are weighted using sample weights as computed in Section A in the Appendix.

This percentage varies from sector to sector, ranging from 8.70 for 'Transportation and storage' to 39.24 for 'Information and communication'. However, the share of product–service sales does not necessarily increase proportionally with the increase in the number of bundling firms. In the manufacturing sector, for example, around 23% of the firms generate 9% of the bundling sales. A slightly higher percentage of firms in Electricity (26.5%) generates instead a much larger share of sales (12.37%).

Second, we show that SMEs which sell integrated solutions are more productive than those selling products alone or services separately (Figure 1). Third, firms that sell integrated solutions exhibit larger exports (Figure 1). Since our sample consists of SMEs, this is particularly interesting, as it suggests that product–service bundling is a factor of competitiveness not only for large firms (as argued for instance in Ariu et al. (2018)).

5 EMPIRICAL APPROACH

To investigate the effect of bundling on exporting, we start by estimating linear models of the form

$$e^f_{kjt} = \alpha_0 + \alpha_1 s^f_{kst} + \mathbf{\Omega}^f_{kjt} + \vartheta_f + \vartheta_k + \vartheta_j + \vartheta_m + \vartheta_t + \varepsilon^f_{kjt} \tag{1}$$

where e^f_{kjt} is the export intensity of firm f in sector k and state j, at time t, computed as the ratio between sales in foreign markets and total turnover (as in the previous section). s^f_{ijt} is the variable of interest, i.e. the share of firm turnover generated by selling integrated solutions: we expect α_1 to be positive and significant. $\mathbf{\Omega}^f_{kjt}$ is a vector of time-varying firm characteristics (i.e. lp^f_{kjt}, inv^f_{kjt} and rd^f_{kjt}). ϑ_f are firm fixed-effects (FEs). ϑ_k indicates sector dummies/FEs. ϑ_j refers to state dummies/FEs. ϑ_m are size dummies/FEs. ϑ_t are time dummies/FEs. ε^f_{kjt} is the error term.

Even after controlling for firm characteristics, such as productivity and investment, the relation between the exporting and the bundling decisions could be still affected by the presence of omitted variables and reverse causality. On the one hand, there could be unobserved firm characteristics that cause both decisions. On the other hand, causality could run from exporting to bundling: exporters could bundle products and services to meet foreign demand. We attempt to mitigate possible estimation biases in the export decision in two ways.

First, we exploit the panel structure of our data and control for time-invariant unobserved firm heterogeneity (firm fixed-effects, ϑ_f in Equation 1). As mentioned in the previous section, a subset of the surveyed firms appear in both the years of our sample. So, for them, we create a panel that allows us to test our main hypothesis after controlling for any unobserved firm-level time-invariant characteristics (firm fixed-effects) that could be correlated both with bundling and exporting.

Second, as a robustness check on the regression analysis, we implement several doubly-robust propensity score matching (DR-PSM) procedures (Busso et al., 2014; Dehejia and Wahba, 2002; Lechner, 2002; Uysal, 2015). To do that we need to look at the difference

$$[\eta_{kjt}^{1,f} - \eta_{kjt}^{0,f}] \tag{2}$$

where $\eta_{kjt}^{1,f}$ ($\eta_{kjt}^{0,f}$) is the outcome (exporting) for firm f in sector k and state j, at time t that sells (does not sell) product-service bundles. The key problem is related to the fact that $\eta_{kjt}^{0,f}$ is not observable: we do not know what would have happened to the exports of firms that sell product–service bundles had they not chosen to do it. This boils down to building a counterfactual starting from the definition of the average effect of bundling on exporting, $\eta_{kjt}^{1,f} - \eta_{kjt}^{0,f}$. Defining the average effect of bundling on exporting as

$$E[\eta_{kjt}^{1,f} - \eta_{kjt}^{0,f}] = E[\eta_{kjt}^{1,f}] - E[\eta_{kjt}^{0,f}] \tag{3}$$

the probability model of bundling (the propensity score) can be written as

$$Pr[\eta_{kjt}^{0,f} = 1] = \Phi[g(\mathbf{\Omega}^*)] \tag{4}$$

where $\mathbf{\Omega}^*$ is a vector of firm, sector and state characteristics covariates. Imposing common support, if the balancing property holds, in each block the average propensity score is not different for treated and untreated.[11] Within each sub-sample, we can then analyse the data as if they came from a randomized experiment. Defining $\eta_{kjt}^{1,f,DR}$ and $\eta_{kjt}^{0,f,DR}$ as the counterfactual responses (DR stands for Doubly Robust), we can then evaluate

$$\begin{aligned} \zeta_{DR} = E[\eta_{kjt}^{1,f,DR}] - E[\eta_{kjt}^{0,f,DR}] = \\ = \frac{1}{f}\sum_f \left(\frac{s_{kjt}^{f,DR}\eta_{kjt}^f}{\lambda(\mathbf{\Omega}^*;\hat{\beta})} - \frac{s_{kjt}^{f,DR} - \lambda(\mathbf{\Omega}^*;\hat{\beta})}{\lambda(\mathbf{\Omega}^*;\hat{\beta})} \times \chi_1(\mathbf{\Omega}^*;\hat{\gamma}_1) \right) + \\ -\frac{1}{f}\sum_f \left(\frac{(1 - s_{kjt}^{f,DR})\eta_{kjt}^f}{1 - \lambda(\mathbf{\Omega}^*;\hat{\beta})} - \frac{s_{kjt}^{f,DR} - \lambda(\mathbf{\Omega}^*;\hat{\beta})}{1 - \lambda(\mathbf{\Omega}^*;\hat{\beta})} \times \chi_0(\mathbf{\Omega}^*;\hat{\gamma}_0) \right) \end{aligned} \tag{5}$$

where f indexes firms as before; $\lambda(\mathbf{\Omega}^*;\hat{\beta})$ is a postulated model for the true propensity score; $\chi_0(\mathbf{\Omega}^*;\hat{\gamma}_0)$ and $\chi_1(\mathbf{\Omega}^*;\hat{\gamma}_1)$ are postulated regression models for the true relation between the vector of covariates ($\mathbf{\Omega}^*$) and the outcome within each stratum of treatment.

Since bundling is not a characteristic that is randomly assigned to firms but a strategy they choose to increase their competitiveness, the matching procedure relies on conditional independence:

[11] Note that this affects the set of covariates that one can include when estimating the effect of bundling on exporting. More details will be provided in Section 6.2.

the treatment (bundling product and services) is as good as randomly assigned after conditioning on a set of covariates. In other words, we will have to show (as we do in Section 6) that after conditioning on those covariates, the treatment does not affect the means of the potential outcomes.

In Section 6, where we will present the DR-PSM results, we will show that this is the case and provide details of how the procedure is practically implemented. Importantly, the procedure provides us with two possibilities to assess the robustness of the effect of product–service bundling on a firm's exporting: either by matching and eliminating any association between the covariates and bundling, or with regressions by controlling for other factors that are correlated with the treatment. In the latter case, we will essentially estimate weighted linear regressions where we use the weights

$$\frac{s_{kjt}^{f,DR}\eta_{kjt}^{f}}{\lambda(\mathbf{\Omega}^{*};\hat{\beta})}; \qquad \frac{(1-s_{kjt}^{f,DR})\eta_{kjt}^{f}}{1-\lambda(\mathbf{\Omega}^{*};\hat{\beta})}$$

recovered from the PSM procedure. As long as either the matching procedure or the weighted regressions is correctly specified, the effect of the treatment (product–service bundling) on the outcome (exporting) will be correctly estimated.

6 RESULTS

In Section 4, we have established several facts about the performance of firms that sell integrated solutions, including their higher propensity to export relative to firms that sell products or services separately. In this section, we further explore their internationalization behaviour. In Section 6.1 we present the regressions results, while in 6.2, as a robustness check on the regression analysis, we discuss the results of several doubly-robust propensity score matching models.

6.1 REGRESSION ANALYSIS

We start the regression analysis by estimating linear models of the type indicated in Equation 1. We thus begin with a parsimonious specification (first column of Table 4), where e_{ist}^{f} is regressed only on s_{kst}^{f} and a set of industry, state, size and time dummies. We subsequently include lp_{kjt}^{f}, inv_{kjt}^{f} and rd_{kjt}^{f} in columns (2)–(4). We then restrict the sample to only those firms that were surveyed in both years and estimate more demanding regressions that include firm, industry-time and size-time FEs in column (5) and firm, industry-time, size-time and state-time FEs in column (6).[12]

[12]Given the small number of firms with more than 250 employees in our sample, here we group all firms with more than 50 employees into one category.

Irrespective of the econometric specification used, we find that the estimated coefficient for the variable s^f_{kjt} is always positive and highly significant. Thus, firms that bundle products and services into integrated solutions are more likely to have larger exports than firms that sell goods and services separately. Moreover, the magnitude of the coefficient of interest varies little between the specifications, ranging from 7 to 9 percentage points. Importantly, we show that even after controlling for observed firm characteristics such as labour productivity (lp^f_{kjt}), investment in $R\&D$ (rd^f_{kjt}) and whether the firm produces abroad (inv^f_{kjt}), there is still a positive association between bundling and exporting. The same is true when we restrict the sample to only those firms that were surveyed in both years and estimate more demanding regressions that include firm, industry-time and size-time FEs in column (5) or firm, industry-time, size-time and state-time FEs in column (6).

Table 4: Bundling and exporting

	OLS (Full sample)				OLS (Fixed-effects)	
e^f_{kjt}	(1)	(2)	(3)	(4)	(5)	(6)
s^f_{kjt}	0.087***	0.092***	0.084***	0.077***	0.069***	0.089**
	(0.010)	(0.011)	(0.013)	(0.014)	(0.020)	(0.035)
lp^f_{kjt}		1.677**	1.341**	1.783***		
		(0.627)	(0.518)	(0.514)		
inv^f_{kjt}			21.329***	20.746***		
			(2.562)	(2.473)		
rd^f_{kjt}				0.205***		
				(0.050)		
Observations	4,094	3,999	3,985	3,877	1,077	1,077
R^2	0.066	0.075	0.153	0.166	0.047	0.096
$\vartheta_k, \vartheta_j, \vartheta_m, \vartheta_t$	Yes	Yes	Yes	Yes	No	No
$\vartheta_f, \vartheta_{k\times t}, \vartheta_{m\times t}$	No	No	No	No	Yes	No
$\vartheta_f, \vartheta_{k\times t}, \vartheta_{m\times t}, \vartheta_{j\times t}$	No	No	No	No	No	Yes

Estimates of linear regressions. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors, in parentheses, are clustered at the 2-digit NACE industry level. s^f_{kjt} is the share of firm turnover generated by selling integrated solutions. lp^f_{kjt} is the logarithm of labour productivity of firm f in sector k and state j at time t. inv^f_{kjt} is a dummy equal to 1 if firm f belongs to sector k and state j and produces abroad at time t. rd^f_{kjt} is the share of R&D expenditure on turnover of firm f, in sector k and state j at time t. ϑ_k, ϑ_j, ϑ_m and ϑ_t are sector, state, size and time dummies/FEs. Observations are weighted using sample weights as computed in Section A in the Appendix.

Interestingly, we can also get a sense of whether the primary sector the firm belongs to plays a role in moderating the effect of bundling on exporting. To do this, we first restrict the sample to firms in 'Manufacturing' and 'ICT'. The rationale behind this exercise is that when firms servitize,

their primary sector is manufacturing, while in the case of productization, their primary sector is (knowledge based) services. Restricting to these two sectors thus provides us with a relatively homogeneous group of service firms, more than if we included all service firms in one group.

The results are shown in Table 5, where μ^f_{kjt} is a dummy equal to 1 if the firm's primary sector is 'Manufacturing' and the coefficients of interest are those on s^f_{kjt}, μ^f_{kjt} and their interaction $\mu^f_{kjt} \times s^f_{kjt}$. The coefficient on $\mu^f_{kjt} \times s^f_{kjt}$ is not significant while those on s^f_{kjt} and μ^f_{kjt} are, suggesting that it is the bundling per se that is important for exporting, rather than the sector the firm belongs to.

Table 5: Manufacturers vs. ICT firms

e^f_{kjt}	(1)	(2)	(3)	(4)
s^f_{kjt}	0.092***	0.087***	0.086***	0.059**
	(0.018)	(0.016)	(0.013)	(0.018)
μ^f_{kjt}	5.438***	5.571***	4.289**	5.722**
	(0.585)	(0.626)	(1.365)	(1.618)
$\mu^f_{kjt} \times s^f_{kjt}$	0.009	0.015	-0.001	0.029**
	(0.013)	(0.013)	(0.009)	(0.009)
lp^f_{kjt}		-0.010***	-0.011**	-0.012*
		(0.001)	(0.004)	(0.005)
inv^f_{kjt}			21.706***	21.698***
			(3.593)	(3.870)
rd^f_{kjt}				0.201**
				(0.049)
Observations	2,061	2,019	2,010	1,950
R^2	0.075	0.075	0.159	0.177
$\vartheta_k, \vartheta_j, \vartheta_m, \vartheta_t$	Yes	Yes	Yes	Yes

Estimates of linear regressions. The sample is restricted to firms in 'Manufacturing' and 'ICT'. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors, in parentheses, are clustered at the 2-digit NACE industry level. s^f_{kjt} is the share of firm turnover generated by selling integrated solutions. μ^f_{kjt} is a dummy equal to 1 if firm f is in state j and belongs to the manufacturing sector at time t. lp^f_{kjt} is the logarithm of labour productivity of firm f in sector k and state j at time t. inv^f_{kjt} is a dummy equal to 1 if firm f belongs to sector k and state j and produces abroad at time t. rd^f_{kjt} is the share of R&D expenditure on turnover of firm f, in sector k and state j at time t. ϑ_k, ϑ_j, ϑ_m and ϑ_t are sector, state, size and time dummies/FEs. Observations are weighted using sample weights as computed in Section A in the Appendix.

All in all, the results in Tables 4 and 5 are in line with previous research, with at least three important novelties.

First, we go beyond what most of the existing literature focuses on, the effect of servitization on manufacturers' exports, showing that product–service bundling is export-enhancing also for non-manufacturing firms.

As mentioned earlier, bundling is likely to increase a firm's competitive advantage either through

product differentiation or by locking in customers in long-term agreements, or through a combination of the two. Our data allow us to look more closely into what leads firms to bundle. As we show in Table 6, 91% of firms sell integrated solutions to increase customer loyalty and 78% to acquire new customers. In other words, as postulated also by Ariu et al. (2018) for bi-exporters, bundling is primarily a strategy to capture demand. However, supply-side motives are also important, as 70% (67%) of firms declare that bundling is implemented to increase sales (earnings) per customer.

Table 6: The drivers of bundling

Objective	Percentage
Acquisition of new customers	78%
Increase in sales per customer	70%
Increase in earnings per customer	67%
Increase in customer loyalty	91%

The second contribution of this paper is to focus specifically on the effect of bundling on the exporting activities of (German) SMEs: the results suggest that bundling is not only a strategy for superstar firms, but can actually be viable also for very small firms. To the best of our knowledge, this is the first paper to show this result.

Third, since the firms in our sample are directly asked what share of their sales originate from selling products and services as a bundle (integrated solutions), we can be confident that our measure of bundling, although at the firm level, stems from bundles of product and services demanded by the same client (this is not the case in, for example, Ariu et al. (2018)).

6.2 MATCHING ANALYSIS

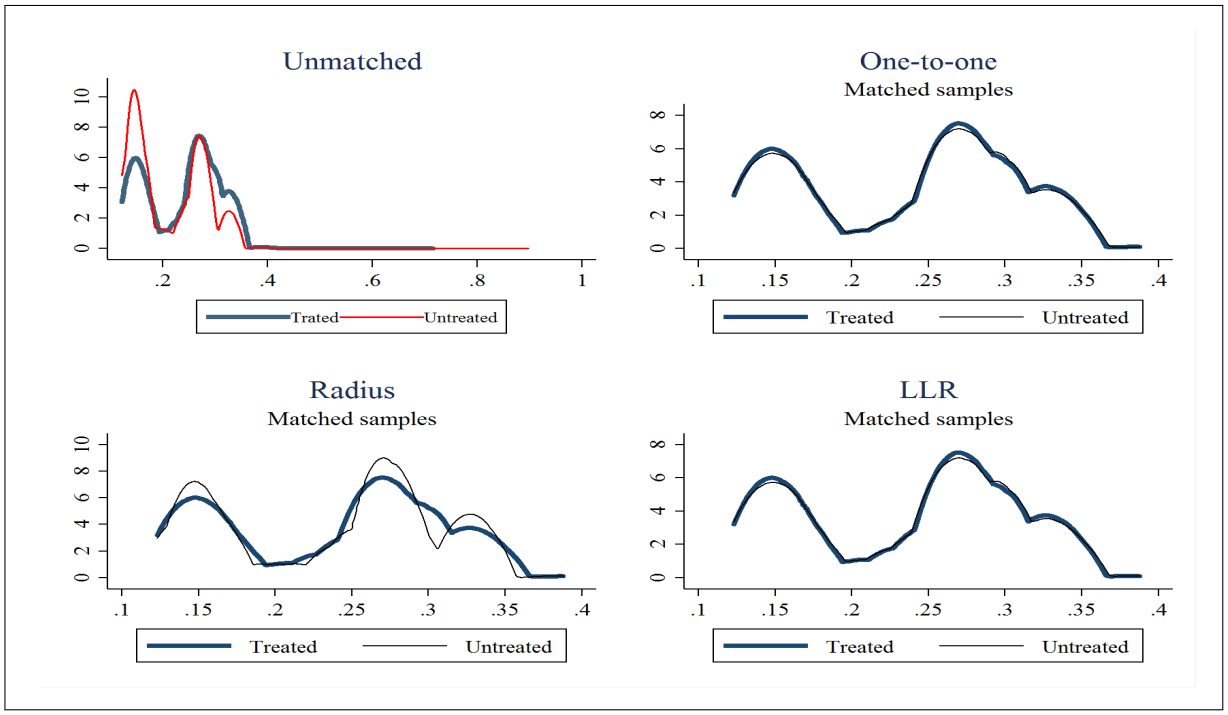
The results in the previous section point to a robust positive association between bundling and export intensity, which holds after controlling for several observed and unobserved firm characteristics. However, the estimates in 4 could still suffer from reverse causality. To mitigate concerns due to this issue, we use propensity score matching methods, as described in Section 5. To implement these techniques, we first compute the propensity score using a logit model where the treatment is a dummy which takes the value 1 if the firm sells integrated solutions and 0 otherwise: the sample is split between 836 treated and 3,218 untreated. In computing the propensity score, we use lp^f_{kjt}, size and 1-digit NACE dummies as covariates and always allow replacement.

We impose common support in two ways. One is by discarding firms that sell integrated solutions whose propensity score is higher than the maximum or less than the minimum propensity score of firms that do not sell integrated solutions. The propensity score is then estimated using the 3,984 on-support observations (70 are off support). By splitting the sample into 6 blocks, we make

sure that the average propensity score is not different for treated and untreated, i.e. we make sure that the balancing property is satisfied. This is clear in Figure 2, where we compare the propensity score of treated and untreated firms (those that sell integrated solutions and those that do not) in the unmatched and matched samples.

While propensity scores for the two sub-samples are different from each other in the unmatched sample (top left hand side panel on Figure 2), for all the three matching techniques we use, the scores are not statistically different from one another (top right hand side and down panels of Figure 2).

Figure 2: Propensity score: Matched vs unmatched sample (baseline)



As an alternative way to impose common support, we trim 5% and 10% percent of the treatment observations at which the propensity score density of the control observations is the lowest. For conciseness, we do not show the propensity scores computed on the trimmed sample, but only the baseline estimates of the Average Treatment Effect (ATE). The ATE of bundling on export intensity ($ATE^{s,f}_{kjt}$) is estimated using three different techniques: 1:1 Nearest Neighbor Matching (1:1), Radius Matching, and Local Linear Regression (LLR). When we trim the sample, the ATE is indicated by $ATE^{s,f,5}_{kjt}$ and $ATE^{s,f,10}_{kjt}$. The results are shown in Table 7.

Irrespective of the matching technique used, the results from both PSM and DR-PSM strongly confirm the regression findings, with the export intensity of firms that sell integrated solutions being systematically larger than for those that sell only products or only services. However, the

point estimates of the regression results are much larger than those of the matching results. This is because in the latter case, s^f_{kjt} is defined as a dummy equal to 1 if the firm sells bundles of product and services and 0 otherwise, thus capturing the effect of bundling vs the effect on not bundling. In Section 6.1, s^f_{kjt} is instead a continuous measure of bundling intensity and captures what the effect of higher or lower bundling intensity is on exporting.

Table 7: Doubly-robust propensity score matching

e^f_{kjt}	*PSM*			*DR-PSM*		
	(1)	(2)	(3)	(4)	(5)	(6)
	1:1	Radius	Kernel	1:1	Radius	Kernel
$ATE^{s,f}_{kjt}$	4.49***	5.59***	5.16***			
ζ_{DR}				2.21**	3.23***	2.21**
Observations	3,984	3,984	3,984	3,889	3,863	1,123
R^2				0.21	0.20	0.21
Sample trimmed at the 5^{th} centile						
$ATE^{s,f,5}_{kjt}$	6.46***	6.10***	5.31***			
$\zeta_{DR,5}$				3.42***	3.96***	3.42***
Observations	3,727	3,727	3,727	3,889	3,692	1,159
R^2				0.26	0.19	0.27
Sample trimmed at the 10^{th} centile						
$ATE^{s,f,10}_{kjt}$	6.17***	6.53***	5.60***			
$\zeta_{DR,10}$				3.40**	4.36***	2.40**
Observations	3,611	3,611	3,611	3,529	3,501	1,088
R^2				0.23	0.18	0.23
lp^f_{kjt}	Yes	Yes	Yes	Yes	Yes	Yes
inv^f_{kjt}	No	No	No	Yes	Yes	Yes
rd^f_{kjt}	No	No	No	Yes	Yes	Yes
ϑ_k, ϑ_m	Yes	Yes	Yes	Yes	Yes	Yes
ϑ_j, ϑ_t	No	No	No	Yes	Yes	Yes

Estimates of the ATE of bundling on exporting intensity in columns (1)–(3) and coefficients of weighted linear regressions in columns (4)–(6). Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. In columns (1)–(3) observations are weighted using sample weights as computed in Section A in the Appendix. In columns (4)–(6) observations are weighted using PSM weights. Standard errors are clustered at the 2-digit NACE industry level in columns (4)–(6). lp^f_{kjt} is the logarithm of labour productivity of firm f is sector k and state j at time t. inv^f_{kjt} is a dummy equal to 1 if firm f belongs to sector k and state j and produces abroad at time t. rd^f_{kjt} is the share of R&D expenditure on turnover of firm f, in sector k and state j at time t. ϑ_k, ϑ_j, ϑ_m and ϑ_t are sector, state, size and time dummies

Note also that the set of covariates we include in the PSM procedure (columns (1)–(3)) is different than the one we include in the DR-PSM (columns (4)–6)). In the former case, achieving the balancing property requires a parsimonious specification, which only includes lp^f_{kjt}, size and 1-digit NACE dummies. The aim is to match and eliminate any association between the covariates and bundling. In the latter, we use weighted regressions to control for further causes of the exporting

that are correlated with bundling and thus include a richer set of covariates.

7 CONCLUSION AND DISCUSSION

There is a large literature on the interplay between innovation, productivity and exports (see e.g. Aghion et al., 2018; Altomonte et al., 2013; Cassiman and Golovko, 2011). However, to what extent new innovation paradigms are transforming the ways SMEs internationalize remain underexplored. This is particularly important in light of the hybridization underlying the third industrial revolution, which is transforming the competition in international markets (Alcacer et al., 2016; Dosi et al., 2013).

In this paper we contribute to filling this gap by studying the effect of bundling (selling products and services in one commercial offer) on the exporting activities of German SMEs. Here, by *bundling*, or sale of integrated solutions, we refer to a business model that goes beyond standardized product bundling (Nalebuff, 2004), as it requires a significant degree of customization (Davies, 2004).

Sitting at the intersection between the literature on business model innovation (e.g. Chesbrough, 2010; Teece, 2014) and that on internationalization and exporting (e.g. Roper and Love, 2002; Wheeler et al., 2008), the present study accounts for the competitiveness-enhancing effect of bundling in two mutually reinforcing ways. First, firms selling integrated solutions gain an international competitive advantage by differentiating their offer through increased customization (Golovko and Valentini, 2011). Such customized and upgraded offers can then provide the opportunity to lock in foreign customers for a longer period of time (Vargo and Lusch, 2008), giving the incentive to increase commitment in foreign markets and eventually increase a firm's export capacity (Teece, 2014).

Based on a unique sample of German SMEs, we have found a robust positive relation between bundling and exporting. In particular, our results hold after controlling for labor productivity and R&D investment as well as firm FEs, which absorb firm-level unobservable heterogeneity. Additionally, to mitigate reverse causality concerns, we implemented several DR-PSM procedures, which leave the results qualitatively unchanged. The strength of this result is an important contribution to our understanding of innovation and exporting in the context of the third industrial revolution, i.e. the fact that incorporating hybrid bundles of products and services increase significantly a firm's international competitiveness.

Our research also contributes to the operations management literature. To the best of our knowledge, it is pioneering in various ways. For one thing, our survey provides a breakdown of the bundling-generated sales, which differs from selling products or services separately, as has been

considered in the previous empirical research (Ariu et al., 2018; Kastalli and Van Looy, 2013; Suarez et al., 2013). This ensures that the revenues come from product–service bundles demanded by the same client. Moreover, while most of the literature focuses on multinational manufacturing firms, our research shows that much smaller firms sell integrated solutions too and that a wide spectrum of industries are selling hybrid product–service bundles, including firms in retailing or construction.

Our research also provides important managerial implications. Exporting SMEs and firms seeking to participate in foreign markets can improve their performance by understanding the mechanisms that enable them to bundle products and services. As mentioned before, combining products and services in the same offer upgrades a firm's ability to differentiate its offers and might open the door to increased foreign market commitment. Importantly, this result transcends industrial boundaries.

This study is a first step towards studying the links between selling integrated solutions and exporting performance. As such, it leaves ample room for further research. For example, our data consists of only two waves and a reasonably large proportion of firms were surveyed twice, which provides the opportunity to control for firm-level unobservable factors. However, a longer time span would allow for a deeper understanding of how bundling affects a firm's export performance over time, not least because it would allow for the implementation of a wider range of causal methods.

Empirically, if firm- and transaction-level data were to increasingly include longitudinal information on product–service bundling, one could, for instance, borrow from the international trade literature and study whether bundling has a larger effects on the intensive margin or on the extensive margin of trade. Moreover, having information about the buyers of the integrated solutions could help the theoretical characterization of this strategy in a buyer–seller repeated interaction setting. This would be particularly interesting in light of the emerging industrial organization literature, which shows that a seller's reputation is key to keeping demand when negative shocks hit (Macchiavello and Ameet, 2015).

Finally, while Germany is an ideal context for analysis, as it is one of the leaders of the third industrial revolution and in the implementation of hybrid business models, future research should analyse bundling in a cross-country perspective that can extend our understanding of how business and institutional environments affect the relation between integrated solutions and export performance: again, if data were to be available, a lot could be borrowed from the international trade literature also in this case. Similarly, it is important to analyse whether other firm- and industry-level factors moderate or mediate this relation.

APPENDIX

A WEIGHTS

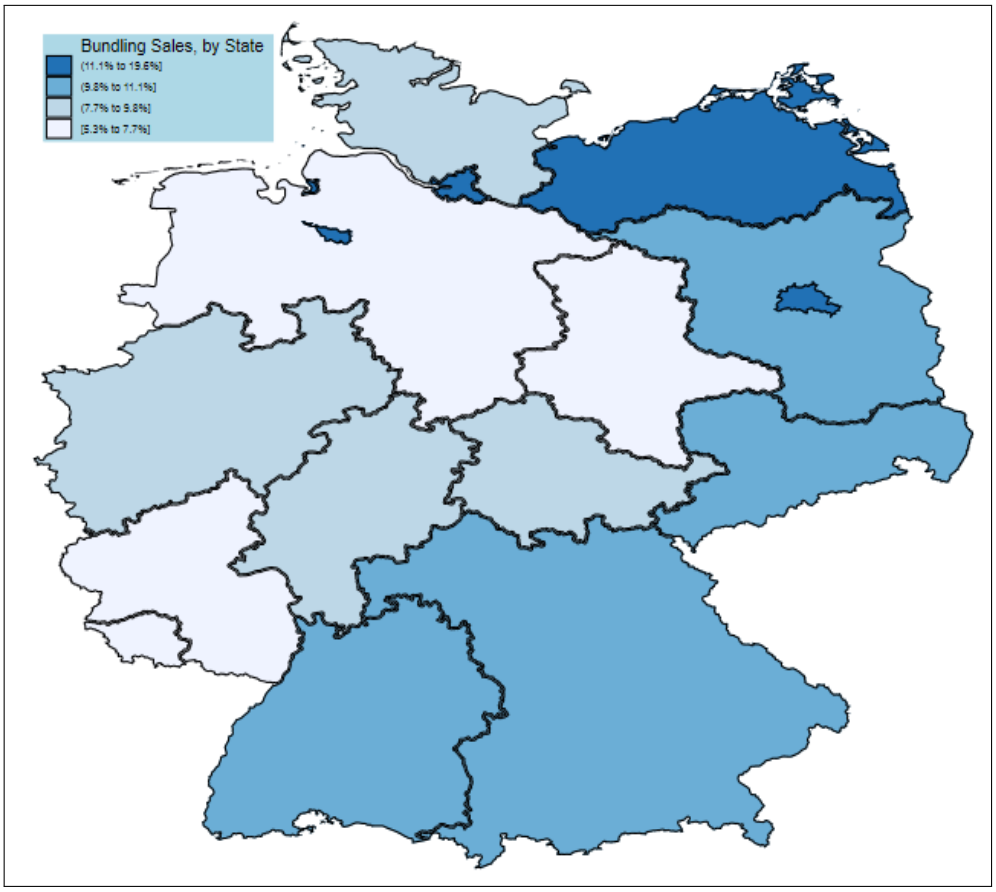
A weighting scheme has been set up to ensure the representativeness of the sample. We constructed the dataset for the German population of firms from the Unternehmensregister. For each wave we sampled firms based on classes of size and sectors. Following (Altomonte and Aquilante, 2012), two types of weights (relative and absolute) have been constructed. For each wave, the relative (rw) and absolute (aw) weights for the firms in sector j and size class m were built as follows.

$$rw^{km} = \frac{\frac{\varphi^{km}}{\varphi}}{\frac{\varrho^{km}}{\varrho}} \quad aw^{km} = \left(\frac{\frac{\varphi^{km}}{\varphi}}{\frac{\varrho^{km}}{\varrho}}\right)\left(\frac{\varphi}{\varrho}\right) \tag{A.1}$$

Here, φ^{km} is the number of firms in industry k and size class m for the population of German firms in a given wave and ϱ^{km} is the number of firms in industry k and size class m in our sample. φ and ϱ are the numbers of firms in the population and our sample respectively.

The essential difference between relative and absolute weights is that for relative weights, the sum of weights over the firms is equal to the total number of firms in the sample by wave, whereas for the case of absolute weights, the sum of weights over the firms is equal to the total number of firms in the reference population. By construction, firms belonging to the same size/sector cell will share the same weights.

B SALES GENERATED BY BUNDLING, PER GERMAN STATE



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