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*From Selling Goods to Selling Services:
Firm Responses to Trade Liberalization*

By

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From Selling Goods to Selling Services: Firm Responses to Trade Liberalization*

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Abstract

In the face of trade liberalization domestic firms are often forced out of the market, whereas others adapt and survive. In this paper we focus on a new channel of adaptation, namely the shift toward increased provision of services in lieu of goods production. We exploit variation in EU trade policy to show that lower manufacturing tariffs cause firms to shift into services provision and out of goods production. We find that a successful transition is associated with higher firm-level R&D stocks.

Key Words: Services Trade, Trade Liberalization, Import Competition

JEL Codes: F12, F15, F23

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1 Introduction

Domestic firms respond to trade liberalization in a number of ways. As import tariffs fall, some firms shrink and eventually exit their market altogether, whereas others adapt and survive. Those who survive do so in several ways. Recent work has shown that firms respond by increasing their innovation efforts (Bloom, Draca and Van Reenen, 2011; Teshima, 2010), by increasing the quality of their products (Khandelwal, 2010), by refocusing their product scope on core competencies (Mayer, Melitz and Ottaviano, 2013; Liu, 2010), or by decentralizing their management hierarchy (Bloom, Sadun and Van Reenen, 2010).

In this paper we use UK firm-level data to focus on a new channel of adjustment to changes in trade policy. Namely, we demonstrate a shift toward increased provision of services in lieu of goods production. An initial look at the data suggests that this shift was potentially significant. Between 1997 and 2007 UK manufacturing import tariffs fell mostly as a consequence of the implementation of the Uruguay Round (Figure 1). At the same time, UK manufacturing experienced a shift toward services provision relative to goods production (Figure 2). This relative decline in domestic goods production was accompanied by a leveling off of domestic production in absolute terms and happened despite the fact that overall demand for goods grew rapidly over the period.¹ The reorientation toward services has also been important for overall activity in the manufacturing sector. Had the manufacturing sector *not* undergone this transition toward increased services provision its share of total output would have been 10 percent in 2007, rather than the 13 percent that it represented.² Thus, the long-running decline of manufacturing has at least in part been slowed by manufacturing becoming more services-oriented.

The shift into services production is also visible at the level of individual firms. Figure 3 plots the change in goods production versus the change in services provision for individual firms over the period 1997-2007. The negative relationship is highly statistically significant and suggests that the shift towards services took place at the level of individual firms, and was not simply a consequence of the reallocation of output shares toward more service-intensive firms or sectors.³ Considered in light of these trends, existing UK firms seem to have been, on average, re-orienting production toward services.

In this paper we use firm-level data for the UK over the period 1997-2007 to further explore the link between reductions in manufacturing import tariffs and the firm's tradeoff between goods production and the provision of services. We find that lower

¹The value of U.K. manufacturing output grew less than half a percent per year over the period while total U.K. goods consumption nearly doubled. See ONS (2007a).

²As we discuss in more detail below, services produced by manufacturing firms count as manufacturing output in national account statistics. So we arrive at this estimate by removing the growth in services output within manufacturing over the period, and then re-calculating the manufacturing share of total output.

³The coefficient of the regression line in Figure 3 is -0.58 with a standard error of 0.02.

tariffs are strongly associated with a shift to greater services provision relative to goods production. These results are robust to controlling for changes in manufacturing export tariffs, changes in services trade barriers, firm fixed effects and a number of time-varying firm-level covariates, as well as industry-specific time trends. We also show that the relative increase in services provision in response to lower manufacturing tariffs is driven by both an absolute reduction in goods production and, in particular, an absolute increase in services provision.

We discuss a number of potential mechanisms that could explain these results by generating a link between services and goods production within the firm. One possibility is that firms' goods and services outputs may be subject to demand complementarities. However, this possibility seems to be ruled out by the strong negative association between manufacturing and service outputs within firms. It is also inconsistent with the positive impact of lower goods tariffs on services, conditional on several possibly confounding covariates. A second mechanism which is potentially more in line with the evidence is the possibility that UK firms' relative provision of services rose due to an increase in off-shoring activity. In other words, UK firms might respond to goods trade liberalization by moving their goods production overseas to foreign affiliates or arms length suppliers, while intensifying their focus domestically on headquarter services. In our empirical analysis we find that this channel was relatively unimportant. Third, firms might be able to adjust to trade liberalization because they have accumulated substantial amounts of industry-specific expertise which they can sell in the form of services. Finally, we also consider a more traditional Heckscher-Ohlin-type mechanism in which trade liberalization drives UK manufacturing firms towards specialization in skill-intensive services production.

We attempt to distinguish between Heckscher-Ohlin mechanisms and an "expertise-driven" increase in service provision by augmenting our regression specification with a number of interaction terms. We interact import tariffs with traditional Heckscher-Ohlin variables such as initial average wages (as a proxy for workers' skills) and initial capital intensity as well as with a proxy for a firm's accumulated expertise (initial R&D stocks normalized by firm sales).⁴ The empirical results suggest a prominent role for the R&D proxy for expertise in facilitating the transition to more intensive services provision in the face of goods market trade liberalization. In contrast, higher capital intensity and higher average wages are found to be relatively unimportant. These results are robust to controlling for additional interaction terms such as firm productivity and initial service intensity, which might be correlated with R&D intensity. We interpret these findings as favoring an expertise-based mechanism although we acknowledge that they are also consistent with a more sophisticated comparative advantage story in which UK firms' comparative advantage is to be found in expertise-intensive (rather than skill- or capital-

⁴The use of the R&D stock as a measure of accumulated expertise has a long history beginning with Griliches (1979).

intensive) production.

Our finding that the firm’s stock of accumulated expertise is important in promoting production flexibility is consistent with a strand of the management literature. For instance, Wiklund and Sheperd (2003) argue that “Knowledge about markets and technology...potentially have strong performance implications because they increase the ability to discover and exploit opportunities.” A somewhat smaller literature brings these ideas closer to the context we explore here by documenting the “servitization” of manufacturing. Neely, et al. (2011) document global trends in servitization, finding that around the world approximately 30 percent of manufacturing firms with over 100 employees produce services.⁵ In a review of this literature, Baines, et al. (2009) note that a particular focus of the literature is on service provision as “an opportunity to differentiate from products originating from lower cost economies,” which is in line with the question we address here. In contrast to this line of research, we apply a formal econometric strategy to explore a specific determinant of the shift to increased services provision by goods producers, namely trade liberalization. We show that this determinant was quantitatively important over our sample period, with manufacturing import tariff reductions explaining around half of the increase in the ratio of services revenues to goods revenues at the firm-level between 1997 and 2007.

The paper is organized as follows. Section 2 describes the data and provides additional descriptive statistics documenting the nature of services activities carried out by UK manufacturing firms. Section 3 provides a discussion of the potential mechanisms at work and Section 4 describes our research design and specifications. Section 5 presents the results and Section 6 concludes.

2 Data & Stylized Facts

Firm Data

The primary dataset used is the UK Annual Respondents Database (ARD), which contains firm-level variables over the period 1997-2007.⁶ The ARD is drawn from an underlying register of the (near) universe of UK businesses and is the UK equivalent of the U.S. Longitudinal Respondents Database.⁷ The data consist of the full population of large businesses (those with more than 100 or 250 employees depending on the year) as well as a random sample of smaller businesses. Here we focus narrowly on the manufacturing sector. Firms self-report their main industry of activity upon registration with Companies’ House, the UK agency responsible for incorporating companies and maintaining a

⁵See also Crozet and Milet (2014) who document the servitization of French manufacturing.

⁶For a comprehensive description of this dataset see Criscuolo, Haskel and Martin (2003) or for a summary see Breinlich and Criscuolo (2011).

⁷The sample is drawn from the U.K. Inter-Departmental Business Register, which represents 98% of U.K. economic activity.

firm registry. Once registered, firms can (self-) report changes in their industry classification although in practice this happens only rarely, even if a firm’s output mix changes substantially.⁸ We include all firms in our sample that report that their primary activity is in manufacturing in the first year they appear in the data.

The ARD includes many establishment-level variables and, for our purposes, the most relevant will be the total value of services provided by the establishment, the total value of services exported by the establishment, and the total value of goods produced. Additionally, the ARD allows us to construct the physical capital stock of each firm by applying the perpetual inventory method to annual firm investments in plant and machinery. Our labor productivity measure is also recorded in the ARD data as firm value added per worker and the average firm wage is the wage bill per worker.

Additionally, we augment the ARD with the International Trade in Services Inquiry (ITIS), as the ARD does not report services output by product. The ITIS survey collects data on international transactions in services by private sector companies resident in the UK, and is the main input into the trade in services account in the UK balance of payments (ONS, 2007b; Breinlich and Criscuolo, 2011). The ITIS covers firms with ten or more employees and samples around 20,000 firms per year (before 2001 this was 10,000), oversampling firms that are likely to be services traders. In contrast to the ARD, the ITIS asks about the types of services exported or imported, and the countries of destination or origin of exports and imports. The ITIS distinguishes between 38 types of services (grouped into 10 aggregate categories) and records trade with around 220 foreign countries and territories. Thus, if we are willing to assume that the types of services exported and produced for the domestic market are similar, we can use the ITIS to obtain a clearer picture about the service activities of manufacturing firms. Table 1 lists the types of services exported by UK manufacturing firms along with their prevalence in the data. Notably, Royalties and Licenses and Technical Services are the two most common services exports by manufacturing firms, followed with some distance by Agricultural, Mining, and On-Site Processing Services, as well as Business and Professional Services.

Finally, we combine the ARD data with information on the annual R&D investments by firms, drawn from the Business Expenditure on Research and Development (BERD) dataset. We construct the R&D stock for each firm using the perpetual inventory method applied to the BERD flows, adopting an economic depreciation rate of 30 percent.⁹ Throughout, we normalize this measure by firm revenue in order to capture firm intensity in R&D.

⁸Less than 1% of the firms in the ARD report major changes in sectoral classification (switching from manufacturing to services or vice-versa). As a result, around 5% of manufacturing firms report more service than goods sales. This pattern seems to be even more pronounced in other countries. For example, Crozet and Milet (2014) report that in 2007, 33% of French firms classified as manufacturing firms were selling more services than goods.

⁹We choose this value following the convention in the literature – see, for instance, Bloom, Griffith and Van Reenen (2002). However, our results are virtually unchanged for values near this.

Our final dataset contains around 40,000 individual firms depending on the specification (as noted in the regression tables), covering 225 4-digit manufacturing industries over the period 1997-2007.¹⁰ As noted, the sample of small firms in the ARD is a repeated cross-section, such that small firms' tenure in our dataset is variable and usually short. Table 2 documents the number of firms in our dataset by tenure, where we see that indeed the most common tenure is one year. In Table 3 we report the number of entrants, exiters, and stayers for each year in our dataset, as well as the percentage of each, where we see that there is in fact quite a bit of churning of firms into and out of our sample though the extent of the churning is stable across years. By far the most important reason for sample exit is the sample design underlying the ARD, and in particular the random sampling of smaller firms. Nevertheless, we discuss this issue further in our robustness checks and provide evidence that sample entry/exit is unlikely to be problematic for our results. For example, we show that our results are almost identical across sub-samples that include firms with relatively short or relatively long tenures in our dataset. We also present results for attrition probability regressions which show that actual exit of firms is not driven by tariff reductions, and, in particular, that exit probabilities are not higher for firms with initially lower service shares. Finally, for a broader view, in Table 4 we document for each two-digit industry the average number of firms and average industry sales over the period 1997-2007.

Trade Barrier Data

Import tariffs (τ_{jtG}^M) for each industry and year in our sample are collected from the World Trade Organization Tariff Database. We focus on Most Favored Nation (MFN) tariffs, which do not vary across WTO member countries. Changes in MFN tariffs were the most important source of variation during our sample period in the European Union's external tariff which of course also applies to the UK. The EU also negotiated a number of free trade agreements between 1997 and 2007 but these were with smaller trading partners which accounted for only a small share of the UK's non-EU trade.¹¹ While average MFN import tariffs were already relatively low in 1997 (around 5%), this average hides substantial sectoral heterogeneity. In 1997, ad-valorem tariffs ranged from 0% to over 40% in some sectors. By 2007, average tariff levels had halved to around 2.5% and the highest tariffs to just over 20%, implying tariff reductions of up to 20 percentage point.

Our empirical strategy also requires average goods export tariffs (τ_{jtG}^X) faced by UK firms in foreign destinations. These come from the United Nations' Trade Analysis and In-

¹⁰In specifications that include the R&D stock variable the number of firms is reduced due the smaller sample of firms drawn for the BERD.

¹¹See http://ec.europa.eu/trade/policy/countries-and-regions/agreements/index_en.htm for a list of EU trade agreements. Importantly, MFN tariffs applied to all of the UK's major non-EU trading partners such as the U.S., Japan and China. (China had been granted most-favored nation status by the EU in 1985, long before its eventual WTO accession in 2001.)

formation System (TRAINS) as cleaned and expanded by Feenstra and Romalis (2014).¹² We aggregate these product-destination-year specific tariffs up to the UK SIC industry level using trade shares of the importing country in total exports between 1994-1996, and a mapping between SITC and UK SIC provided by the United Nations Statistics Division. The resulting ad valorem tariff varies at the year and 4-digit SIC-level, and captures the average goods export barriers faced by UK manufacturing firms in a given industry and year.

Finally, in one of our robustness checks we also control for intermediate input tariffs which we compute as the weighted average of the UK import tariffs of all industries k supplying a given industry j :

$$\text{Input tariff}_{jt} = \sum_k w_{kj} \times \text{tariff}_{kt}$$

where w_{kj} is the cost share of industry k in the production of goods in industry j in 1995. We obtain information on w_{kj} from the UK's input-output table for 1995 (ONS, 2002).

For measures of services trade barriers (τ_{jtS}^M and τ_{jtS}^X) we rely on the OECD's Product Market Regulation index which quantifies barriers to services trade in different service types for OECD and selected third countries.¹³ Since our empirical analysis will take place at the UK SIC industry level, while the trade barrier index is classified by service type, we need to determine the services types that correspond to each SIC industry. To do this, we focus on the service types that are imported and exported by firms in a particular SIC industry, obtained from the UK ITIS, which we use to construct import and export trade barrier indices at the SIC industry level as a simple trade-weighted sum of the OECD service type measures for each industry.

Note that both manufacturing import and export tariffs are negotiated by the European Commission for the European Union as a whole. They are thus likely to be largely exogenous to UK industrial trends. This is particularly true for MFN tariffs and another reason for focusing on this type of tariff. In contrast to regional trade agreements, MFN tariff changes are the result of multilateral negotiations involving a large number of countries, making it more difficult for individual firms or sectors to influence their outcome. Services trade barriers are more heterogeneous and still more influenced by national policies. But even here, bilateral negotiations with other countries and trading blocks fell within the remit of the European Commission for the second half of our sample period, and services barriers were brought into the remit of the World Trade Organisation as part of the Uruguay Round.¹⁴ We return to this issue in Section 4 below where we report

¹²We thank John Romalis for making these data available to us.

¹³These data are available at www.oecd.org/economy/growth/.

¹⁴The European Commission obtained explicit powers to negotiate services trade policy in addition to goods trade policy in the Treaty of Nice (2001). Trade policy in services is restricted by the General Agreement on Trade in Services (GATS) of 1995, although it is still unclear to what extent the Uruguay

additional econometric evidence showing that tariff reductions were indeed exogenous from the point of view of UK firms and sectors.

Stylized Facts

This section presents basic descriptive statistics on the provision of services by UK manufacturing firms. To begin, we restate two findings presented in the introduction. Figure 2 documents the share of services revenues in total revenues across all UK firms between 1997 and 2007. We see that since 1997 the fraction of service activity within manufacturing firms has grown steadily, reaching 20 percent in 2007. Figure 3 then plots the average annual change in services revenue over the period against the change in goods revenue for each firm in the sample. The fitted line indicates that, on average, goods and services are substitutes within the firm.¹⁵

Focusing in more detail on the evolution of services provision within UK firms, Figure 4 and Table 5 present basic correlations between firms' services provision and standard firm-level variables. The univariate correlations in Figure 4 show that the (log of the) value of services provision is positively correlated with a firm's average wage as well as its capital and R&D stocks. In Table 5, we first document the regression analogues of these correlations. We then include all three variables jointly and finally also control for firm size (measured by the value of total production). We see that the positive correlation between services provision, R&D stock and average wages remains intact, but the coefficient on the capital stock variable switches sign and becomes significantly negative. We therefore conclude that higher services output is associated with higher average wages and higher R&D stocks, but lower capital stocks, *ceteris paribus*.¹⁶

Table 6 provides further information on the evolution of manufacturing firms' services shares and the same firm-level covariates. Specifically, we regress the annual percentage-point change in the share of services in total output (i.e., $share_t - share_{t-1}$) on firm-level variables measured at the beginning of the period (i.e., at $t - 1$). As seen, higher initial wages, R&D stocks and total output are associated with a stronger shift into services, whereas the initial capital stock is negatively (though insignificantly) correlated with the change in the services share. Interestingly, when we include all four determinants jointly, only the coefficient on initial R&D stocks remains positive and significant.

To summarize, UK manufacturing firms mainly provide services that are likely to be closely linked to their manufacturing activities, such as technical services and income from royalties and licenses (Table 1). Services provision is also associated with higher

Round triggered a liberalisation of services trade in addition to goods trade (see Francois and Hoekman, 2010).

¹⁵The coefficient of the regression line in Figure 3 is -0.58 with a standard error of 0.02.

¹⁶The positive correlation with average wages is likely to capture the higher skill level of services-producing manufacturing firms. Unfortunately, the ARD does not contain information on skill levels, so we cannot test for this possibility directly.

average wages and higher R&D stocks. When we look more closely at the correlates of *changes* in services shares (which is the main outcome of interest in this paper), we only find a positive and significant correlation with R&D stocks.

3 Mechanisms

Here we highlight potential theoretical channels relating goods output and services provision at the level of the firm over time. First, it may simply be the case that a firm's goods and services outputs are complements on the demand side. For example, a firm may produce a product that requires some level of ongoing support, such as a manufacturer who provides regular service on their product for some period after purchase. In this case we would observe a strong, positive relationship between the level of goods and services output at the firm level. However, in light of the fact that we find a strong, *negative* correlation between goods and services production within firms, we rule this out as a potential explanation for our results.

We focus instead on three alternative channels. First, a Heckscher-Ohlin mechanism, in which increased global engagement by low-skill abundant developing countries alters global production patterns, may have impacted the relative provision of services across UK firms. More specifically, from the UK perspective increased specialization according to comparative advantage would lead to a shift toward skill- or capital-intensive production, which may manifest as a within-firm shift toward services provision and away from the increasingly-competitive goods sector.

Second, import competition in the goods market may lead to increased offshoring of goods production by UK firms. There is, of course, a large literature exploring the decision by multinational firms to increasingly locate headquarters services in human-capital-intensive developed countries while offshoring low-skill-intensive aspects of the production process to developing countries.¹⁷ By focusing narrowly on a firm's activities within a single country (as we do) one may mistakenly attribute increased offshoring to an overall decline in goods production by firms.

Finally, a shift toward increased relative provision of services may reflect a shift toward sales of accumulated expertise by UK firms. In other words, over time firms may accumulate industry- and product-specific expertise as a byproduct of their research, development and production of goods. When confronted with increased competition in the goods market, firms with a sufficient stock of expertise may then leverage this knowledge in the market for services. In effect, the firms can sell their accumulated market-specific expertise in lieu of goods. One version of this mechanism is explored by Bloom, et. al. (2012). In their "trapped factors" model the opportunity cost of producing services (in their case the focus is on the opportunity cost of innovation, but the model's mechanism

¹⁷See Crinò (2009) for a review of this literature.

is not specific to this case) falls in the face of increased import competition in goods due to the fact that there are adjustment costs associated with moving factors out of one output type and into another. Alternatively, in an Online Appendix we present a similar model in which firm-specific expertise is rival in its use across output types (goods or services) but where larger stocks of expertise reduce the magnitude of the rivalry, thereby making it easier for the firm to transition out of one output type and into another.¹⁸ In both cases it is an increase in the relative profitability of services due to a rise in import competition in the goods market that induces the transition.

4 Empirical Approach

In this section we explore the magnitude of the within-firm response to trade liberalization. Specifically, we estimate specifications relating the ratio of a firm's revenues from services relative to goods (R_{ijTS}/R_{ijTG}) to reductions in MFN import tariffs. As discussed Section 2, we believe that these reductions were largely exogenous given the institutional setting within which they were negotiated. Here, we provide additional evidence that individual UK firms and sectors did not influence WTO tariff negotiations in a way that is systematically related to their current outcomes (e.g., struggling UK firms may make efforts to maintain high tariffs). In Table 7 we present the results of industry-level regressions in which the dependent variable is the change in industry tariffs between 1997 and 2007 and the regressors are the industry growth rates of average wages, employment and sales in the pre-period, 1992 to 1996. In other words, we ask whether observed tariff variation is predicted by lagged industry outcomes. Table 7 suggests that these variables have no predictive power. Thus, to the extent that industry outcomes reflect the experience of the firms within those industries that are most likely to engage in lobbying, these results suggest no relationship between the outcomes of those firms and future tariff changes.

We also include a number of additional firm- and sector-level controls to further reduce the threat of omitted variable bias and to increase the precision of our estimates. At the sectoral level, we control for variation in the other three trade barriers affecting UK firms – i.e., UK import and export barriers for services trade as well as the export tariffs faced by goods producers. Variation in any of these trade barriers will clearly have a direct impact on the optimal choice of production of goods relative to services and we therefore want to control for these potential determinants of relative output. At the level of individual firms, we control for the average wage bill, as a proxy for input prices and the skill level of the work force, and labor productivity, as a proxy for firm-specific productivity shocks. Finally, we also include year fixed effects, which will capture any macro-level trends in input prices and technologies; and in our preferred specifications we add firm fixed effects

¹⁸The Online Appendix is available at http://web.ics.purdue.edu/~asoderbe/Papers/BSW_Appendix.pdf

and two-digit industry time trends to control for firm-specific time-invariant factors and productivity trends as well as trends in aggregate expenditure on each industry's output.

These considerations lead us to the following reduced-form specification relating the ratio of a firm's revenues from services relative to goods (R_{ijtS}/R_{ijtG}) to the channels discussed above:

$$\frac{R_{ijtS}}{R_{ijtG}} = \exp[\eta_i + \theta_t + \beta_1 \tau_{jtG}^M + \beta_2 \tau_{jtG}^X + \beta_3 \tau_{jtS}^M + \beta_4 \tau_{jtS}^X + \beta_5 \ln \bar{w}_{ijt} + \beta_6 \ln \psi_{ijt} + \rho_{mt}] + \epsilon_{ijt} \quad (1)$$

where the τ 's represent import (M) and export (X) barriers for goods (G) and services (S) associated with firm i 's industry j . Firm and year fixed effects are denoted by η_i and θ_t , respectively. The firm's average wage and labor productivity are \bar{w}_{ijt} and ψ_{ijt} , and ρ_{mt} is a 2-digit industry time trend. The main coefficient of interest is on goods import tariffs, β_1 , since its sign indicates whether firms react to tariff reductions by increasing services output relative to goods output ($\beta_1 < 0$) or by reducing it ($\beta_1 > 0$). While our main interest is in the output of services relative to goods, we also estimate versions of (1) in which we use goods or services revenues separately as the dependent variable. This allows us to evaluate whether changes in relative revenues are driven by goods, services, or both.¹⁹

We have chosen an exponential conditional mean function which we estimate via Poisson Pseudo-Maximum Likelihood (PPML) techniques. The use of PPML estimation is motivated by two specific features of our data. First, there are many zeros for the value of services revenue – i.e., the majority of firms in our data do not provide services.²⁰ A log-linear specification would thus need to drop a large part of the sample. Second, given the highly skewed distribution of revenues across firms it is unlikely that the unexplained variation in (1), or its counterparts with goods and services revenues only, will be homoskedastic. As Santos-Silva and Tenreyo (2006) point out, the log of the error term will then be correlated with the regressors, due to the mechanical correlation between the mean and variance of a logged variable. PPML estimation addresses both of these issues.²¹ Throughout, we cluster standard errors at the 4-digit industry level because our

¹⁹Note that we use contemporaneous variation in tariffs rather than lags or leads. On the one hand, it may take time to expand services production relative to good production. On the other hand, the tariff reductions agreed to in the Uruguay round were phased in over several years and the reduction schedule was widely publicized. Thus, UK firms would have been aware of the timing of tariff cuts and might have started the shift into services production before the actual reductions took place. Using contemporaneous variation strikes a balance between these opposing arguments and also maximises our sample size.

²⁰In our baseline specification (see Table 8 below), 70 percent of firm-year observations for service revenues and the ratio of services to goods revenues are zero.

²¹Note that the coefficient on goods tariffs (β_1) measures a semi-elasticity as can be verified by differentiating (1) with respect to τ_{jtG}^M . The corresponding OLS specification would be a regression of the log of R_{ijtS}/R_{ijtG} on the tariff variable. To show that $\log(R_{ijtS}/R_{ijtG})$ is not dominated by outliers, we plot its distribution in the Online Appendix, Figure 1.

regressor of interest (τ_{jtG}^M) only varies by 4-digit industry and year.

In an additional set of specifications we interact a number of firm-level variables with goods import tariffs in order to explore the underlying features that are predictive of a successful transition toward greater relative provision of services in the face of trade liberalization. This will also be helpful in discriminating between the remaining mechanisms discussed in Section 3 (Heckscher-Ohlin versus accumulated expertise). Specifically, we look at the role of firm intensity in skill, firm intensity in capital, and the firm’s accumulated expertise. To do this we proxy the average skill level of the firm with the average firm wage in the first year we observe a firm in our data.²² We also exploit data on the firm’s initial period capital stock and the firm’s initial R&D stock (both normalized by total firm revenues) in order to proxy for capital intensity and firm expertise, respectively. We focus on these time-invariant measures in order to mitigate the potential endogeneity between our dependent variable and each of these variables over the period. Finally, we add terms that interact the firm’s initial labor productivity and initial level of services provision with goods tariffs, since these may be correlated with a firm’s overall capacity to provide services.²³ Formally, we estimate versions of the following specification:²⁴

$$\begin{aligned} \frac{R_{ijtS}}{R_{ijtG}} = & \exp \left[\eta_{ij} + \theta_t + \alpha_1 (\ln R\&D_{ij} \times \tau_{jtG}^M) + \alpha_2 (\ln Cap_{ij} \times \tau_{jtG}^M) + \alpha_3 (\ln \psi_{ij} \times \tau_{jtG}^M) \right. \\ & + \alpha_4 (\ln \bar{w}_{ij} \times \tau_{jtG}^M) + \alpha_5 (\ln InitServ_{ij} \times \tau_{jtG}^M) + \alpha_6 \tau_{jtG}^M + \alpha_7 \tau_{jtG}^X + \alpha_8 \tau_{jtS}^M + \alpha_9 \tau_{jtS}^X \quad (2) \\ & \left. + \alpha_{10} \ln \bar{w}_{ijt} + \alpha_{11} \ln \psi_{ijt} + \rho_{mt} \right] \quad (3) \end{aligned}$$

where $R\&D_{ij}$ and Cap_{ij} denote a firm’s initial R&D and capital stock, ψ_{ij} and \bar{w}_{ij} its initial productivity and average wage, and $InitServ_{ij}$ its initial service share. All remaining regressors are as in specification (1). We are particularly interested in the interaction term coefficients $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ and α_5 .

5 Empirical Results

In this section we present our empirical results. We first show that lower manufacturing import tariffs led firms to increase services provision relative to goods production on average. We then explore the robustness of our results and analyze the firm characteristics that influence the extent of the transition into services.

²²Unfortunately, the ARD does not contain information on more direct proxies for skill intensity, such as education levels or the share of white-collar workers.

²³Labor productivity might play a role if the transition into services production requires a fixed cost investment. This investment would only be profitable for more productive firms and we should observe a stronger shift into services for such firms in response to the tariff reductions.

²⁴Note that the main effects of the initial firm-specific variables are subsumed in the firm fixed effects.

Firm Response to Trade Liberalization

Baseline Results

Table 8 presents the results from estimating (1). In column (1), we include only the import barriers for goods and services as well as year fixed effects. Columns (2)-(7) add additional regressors and fixed effects which progressively make the specifications more restrictive. In column (2), we add export barriers for goods and services, column (3) adds firm-level wages and labor productivity and in column (4) we control for 4-digit industry fixed effects. Finally, columns (5)-(7) add firm fixed effects, where columns (5) and (6) compare the estimates with and without the potentially endogenous firm average wage and productivity controls, while column (7) adds two-digit industry time trends.

Throughout, the coefficient on our main variable of interest (manufacturing import tariffs) is negative and highly statistically significant, indicating that lower import tariffs lead to higher services revenues relative to goods revenues. This demonstrates that, at least on average, firms flee import competition in goods toward increased provision of services. We further note that the inclusion of (potentially endogenous) wage and productivity controls has little effect on the estimates. Finally, controlling for industry or firm fixed effects leads to a steep fall in the coefficient on goods tariffs, suggesting that there is a significant amount of unobserved heterogeneity across firms and industries that is correlated with tariff reductions. The fact that coefficient estimates also change (albeit less) when industry fixed effects are replaced with firm fixed effects further implies that unobserved within-industry heterogeneity might also be a problem. By contrast, including industry-time trends leaves coefficient estimates basically unchanged. We thus consider our firm fixed effects regressions (with or without industry-time trends) to be the most reliable specifications and focus on them for most of the subsequent discussion and results.

The estimated coefficient magnitudes are also economically significant. According to our preferred specifications (columns 5-7 in Table 8), a one percentage point reduction in goods import tariffs led to an approximate increase of 18-22% in the ratio of services to goods revenues. Over the period 1997-2007, goods import tariffs declined by around 2.5 percentage points, so that the tariff-induced increase in the services to goods ratio is around 45-55%. For comparison, the (unweighted) mean of the services-to-goods ratio across the firms in our sample doubled from 5% to 10% between 1997 and 2007.²⁵ That is, our results suggest that around half of the increase in our dependent variable over the sample period can be explained by trade liberalization.

We next explore whether the shift to greater relative services provision is due to

²⁵Note that these the figures are not directly comparable to Figure 2 because they are not size-weighted, are based on a slightly different sample, and the denominator is different (goods revenues in this section, total revenues in Figure 2).

higher services revenues, lower goods revenues or a combination of both. Tables 9 and 10 are similar to those in Table 8, but replace relative revenues by services and goods revenues, respectively. We see that lower manufacturing import tariffs led to both higher services revenues and lower goods revenues.²⁶ The results are most significant for services revenues, where we find a negative and highly significant coefficient on goods import tariffs in all but column (4). For goods, the results are slightly less robust, but the relevant coefficient is also either positive and significant or insignificant, indicating that lower manufacturing import tariffs did decrease goods revenues, or at least did not increase them.

Robustness Checks

In this section we examine the robustness of our baseline results. For conciseness, we focus on our two preferred specifications for each of the following robustness checks (firm fixed effects and firm fixed effects and industry trends, respectively; i.e., those corresponding to columns 6 and 7 from Table 8).

Focus on Domestic Sales

The ratio of services to goods revenues, which is the focus of the baseline specification (1), includes exports as well as domestic sales. Export revenues from any location n will depend on trade barriers imposed by that location on the exports of firm i (proxied by τ_{jtG}^X and τ_{jtS}^X in specification (1)) but also on the barriers imposed on firms from third markets. Unfortunately, we do not have data for such third-market trade barriers and multi-collinearity issues would prevent their inclusion in any case. As a simple robustness check we focus instead on domestic revenues in the construction of our dependent variable, rather than total revenues (which also include export revenues). That is, we construct domestic services revenues (R_{ijtS}^{DOM}) as total services revenues minus services exports. Unfortunately, for our sample period the ARD only contains data on export revenues for services but not for goods. Thus, we continue to use total goods revenues as the denominator of our dependent variable. For comparison with our earlier results from Table 10, we also estimate a specification with R_{ijtS}^{DOM} as the dependent variable.

In Table 11 (columns 1-2), we regress the newly constructed revenue ratio (R_{ijtS}^{DOM}/R_{ijtG}) on the same variables as in our baseline specification. The results are very similar to our baseline results from Table 8. When we use domestic services revenues as our dependent variable in Table 11 (columns 3-4), we obtain slightly larger coefficient estimates in absolute terms on our manufacturing import tariff regressor, but otherwise the pattern of results is very similar to the one presented in Table 9. A possible explanation for these

²⁶In unreported results (available on request) we find that the effect on total sales (goods plus services) is close to zero and not statistically significant for most specifications, including our preferred ones with firm fixed effects.

similarities is that services exports accounted for only a relatively small fraction of total manufacturing services revenues over our sample period (19 percent on average).

Different Samples of the Data

As noted in Section 2 the ARD dataset consists of the universe of large firms and a sample of small and medium sized firms (those with fewer than 100 or 250 employees depending on the year). As a result, some firms are in our dataset for only a brief period (often only a single year) while others are in the dataset in all years (large firms who entered prior to our period and did not exit during it). In this subsection we simply repeat our baseline specification (equation 1, estimates reported in Table 8) but estimate the regressions across a sample of firms with *at least six years* tenure in our dataset, and then across a sample of firms with *at most five years* tenure.²⁷ Table 12 reports the results and, interestingly, show that the estimates are virtually unchanged compared to the baseline results on the full sample. We conclude that there is nothing in particular about our sample of firms that is driving the results.

Attrition and the Role of Firm Exit

The main determinant of firms' disappearance from our dataset is the sampling design of the ARD, which only surveys a randomly chosen sample of smaller firms in a given year. By construction, this form of sample attrition is random and will not be related to trade liberalization. However, firms will also drop out of the sample if they go bankrupt and exit the market. This could potentially explain our results if firms that produce relatively little service output (i.e., are primarily, or solely, goods producers) are driven out of the market due to trade liberalization. In this sense the results may, in part, reflect a change in the composition of firms in the market rather than simply an on-average within-firm shift toward services. In Table 13 we report the results of a standard attrition probability regression in which the dependent variable is a binary indicator for whether a firm exits the sample due to closure at some point during the period 1997-2007.²⁸ The regressors are the average annual change in import tariffs faced by the firm over the firm's tenure (which could be fewer than the maximum 11 years), the firm's initial goods-to-services ratio, and the interaction between tariffs and the initial ratio. We see in Table 13 that goods import tariffs are negatively related to exit probabilities but that the effect is not statistically

²⁷These tenure lengths were chosen as the mid-point of the ranges of tenures in our data (one to eleven years). In unreported results we repeat the analysis for different tenure length cases, and these are available on request. The results are consistently similar across samples.

²⁸We use the Business Structure Database (BSD) to construct this exit indicator. The BSD is constructed from snapshots of the U.K.'s business registry and essentially contains the universe of incorporated firms. Given that the ARD sample is drawn from the BSD, we can link the exit indicator to our regression sample. The indicator takes the value of one if employment reported in the BSD drops to zero or if the firm disappears from the BSD at some point during the period 97-07.

significant (column 1). More importantly, the coefficient on the interaction term is also close to zero and is insignificant, indicating that differential attrition is unlikely to explain our results. In columns 2-3, we also interact the three other trade barriers measures with initial goods-to-services ratio, again finding no evidence for differential attrition.

Estimating the Effect on Services Intensity

We also estimate specifications in which the dependent variable is the service intensity of the firm – i.e., the share of services in total (services plus goods) output, rather than simply the ratio of the two output types. Table 14 reports the results. While the coefficient magnitudes are not directly comparable to Table 8, we see that the estimates are qualitatively similar and the coefficient on goods tariffs continues to be negative and statistically significant at the one percent level.

The Role of Offshoring

We conclude our robustness section by considering evidence for one of the mechanisms discussed in Section 3 – offshoring. It is possible that the pattern observed in the regression results above may be due to an increase in geographic specialization on the part of multinationals. In other words, in response to lower manufacturing import tariffs UK firms may simply be moving their goods production overseas – i.e., offshoring goods production – while increasing their focus on the provision of headquarters services. Relatedly, Bernard and Fort (2013) note the prevalence of factoryless manufacturing firms in the US, which they find primarily consist of firms that focus their activities on goods design while also coordinating the manufacture and assembly of products in (often) overseas locations. It is therefore possible that we are simply observing a trend toward more factoryless firms in the UK. It is important to note that these two phenomena may be distinct: whereas offshoring typically denotes the movement of intermediates production to overseas locations, factoryless firms are typically importing final goods from overseas. We therefore take two approaches in our exploration of this issue, described below. We also note that the possibility of either phenomena occurring does not undermine the goal of the paper, which is simply to estimate the causal relationship between goods trade liberalization and increased services provision on the part of UK firms, independent of the firm’s motivations for the transition. It does, however, potentially add nuance to the story, as it addresses whether firms are simply ceasing goods production in the face of competition, or are relocating goods production.

First, we can test for evidence of this mechanism by simply repeating regression (1) but, rather than using domestic services revenues as the dependent variable, we instead use the total volume of trade in services between UK firms and their foreign affiliates.

This value is independently recorded as a unique service type within the ITIS dataset, and should be associated with increasing production fragmentation within the firm. That is, if firms do indeed respond to goods trade liberalization by focusing their domestic activities on the provision of headquarters services, we should observe a positive correlation between import tariff reductions and exports of headquarters services (captured as affiliate services trade).²⁹ Table 15 shows that there is no evidence for this hypothesis – goods tariff reductions actually seem to reduce exports of affiliate services although the coefficient is not statistically significant.³⁰

As a further test of the specific role of offshoring (i.e., trade in intermediates) we add controls for intermediate input tariffs in our estimation of the revenue functions (see Section 2 for a description of the construction of these tariffs). Intuitively, if UK manufacturing firms offshore manufacturing activities and re-import intermediate inputs, the shift out of domestic goods production and into services should be made easier by lower tariffs on intermediates. Results are reported in columns (3) and (4) of Table 15, where we find that the main results are virtually unchanged when these controls are included. Furthermore, the coefficient on intermediate input tariffs is negative as expected but statistically insignificant. We conclude that a shift toward increased relative provision of headquarters services in response to trade liberalization is unlikely to have played a major role over our sample period.

Determinants of Firms' Response to Trade Liberalization

We next estimate specification (2) in which relative firm-level service-to-goods revenues are still the dependent variable but goods import tariffs are now interacted with additional regressors – i.e., we allow for firm heterogeneity in the response to trade liberalization. As discussed, the aim of this exercise is to provide evidence for or against the remaining mechanisms discussion in Section 3. Table 16 reports the results. Column (1) includes interaction terms between goods import tariffs and initial R&D stocks (normalized by firm sales), initial physical capital stocks (also normalized by firm sales), and the initial firm average wage, respectively. In column (2), we use labor productivity instead of wages

²⁹We construct exports of headquarters services by matching our regression sample (which is from the ARD) to the International Trade in Services Inquiry (ITIS). If a firm cannot be matched and reports zero services exports or zero services production in the ARD, we set exports of headquarter services for that firm to zero. There are also a few firms which report positive services exports in the ARD but cannot be matched to the ITIS; we drop these from our sample. (Results are similar if we set headquarters services exports for such firms to zero instead of dropping them.)

³⁰In unreported results, we also estimated our most basic specification which only includes year fixed effects and the two import barrier variables (similar to column 1 of Table 8). Here, the coefficient on manufacturing import tariffs was indeed negative and significant, although its magnitude was only around one fourth of the effect of import tariffs on total services sales. Once we include additional control variables and more restrictive sets of fixed effects, however, the import tariff regressor becomes insignificant.

as a proxy for the skill-intensity of production and in column (3) we include both.³¹ In column (4), we further control for the initial share of services in total sales to account for the possibility that firms with higher initial service production might find the shift into services easier. Finally, column (5) adds 2-digit industry time trends.

The results indicate a strong role for R&D in promoting the firm's response to trade liberalization. The coefficient on the interaction term is negative and statistically significant throughout and is not much affected by the inclusion of additional control variables. Firms with higher initial R&D stocks thus see a stronger shift into services relative to goods revenues as manufacturing import tariffs fall. At the same time, we find little impact on the transition to services from any of the other variables. A higher initial capital intensity is associated with a less pronounced transition but the effect is not statistically significant at conventional levels. The coefficient on the remaining interaction terms is essentially zero.

Taken together with our earlier empirical findings the results suggest that, on average, trade liberalization in the goods market leads firms to flee toward services provision, and that the most expertise-intensive firms are the most responsive. This evidence seems to favor a mechanism by which accumulated expertise allows firms to shift into increased service provision. We note, however, that it is also consistent with a more nuanced Heckscher-Ohlin mechanism in which R&D intensity itself is a source of comparative advantage.³²

6 Concluding Remarks

In the face of trade liberalization domestic firms are often forced out of the market, whereas others adapt and survive. In this paper we have focused on a new channel of adaptation, namely the shift toward increased provision of services in lieu of goods production. Using firm-level data for the UK over the period 1997-2007, we have explored the link between lower manufacturing import tariffs and the firm's tradeoff between goods production and the provision of services, finding that lower import tariffs on goods caused firms to shift into services provision, and out of goods production. The magnitude of our results is highly significant, both statistically and economically. Results from our preferred specification suggest that around half of the observed increase in the ratio of services to goods revenues among UK manufacturing firms is due to lower manufacturing import tariffs.³³

³¹As discussed previously, labor productivity might also play a role if the transition into services production requires a fixed cost investment. This investment would only be profitable for more productive firms and we should observe a stronger shift into services for such firms in response to the tariff reductions.

³²In addition, to the extent that our proxy for skill is imprecise, our R&D variable may also be picking up additional variation in skill across firms.

³³As a comparison to somewhat related work, Chatterjee, Dix-Carneiro and Vichyanond (2013) explore the response of multi-product firms to exchange rate shocks, finding a large response in terms of the

We also examined the factors influencing the extent of the transition into services. We found that a firm's initial stock of R&D is strongly associated with a successful transition, while the average skill level of the firm (as proxied by average wages), its productivity, its capital stock and initial level of service production play little direct role. While we interpret this as evidence that a firm's accumulated expertise may be a key asset in surviving import competition, we note that this does not rule out a more nuanced Heckscher-Ohlin mechanism in which R&D intensity itself is a source of comparative advantage.

An important question for further research is to what extent the shift into services production matters for other economic variables such as manufacturing wages. The correlations reported in Table 5 suggest that increased service provision is indeed associated with changes in R&D and capital intensity, average wages and total output. Whether these links are causal is of course a more difficult question, and one we leave for future work.

number of products added in the face of an exchange rate depreciation.

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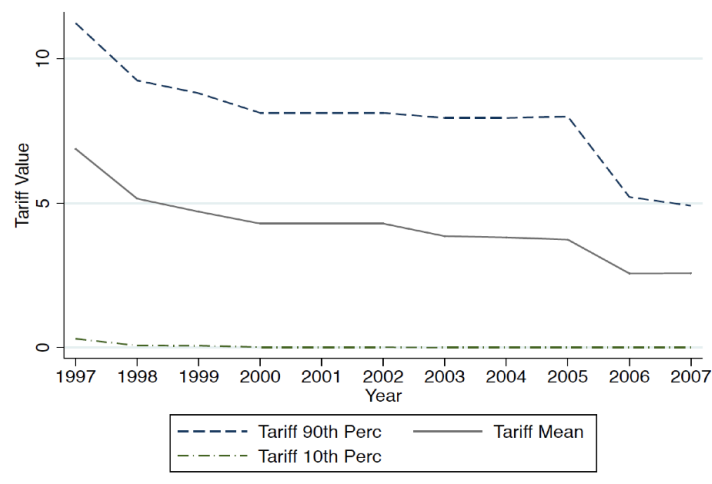
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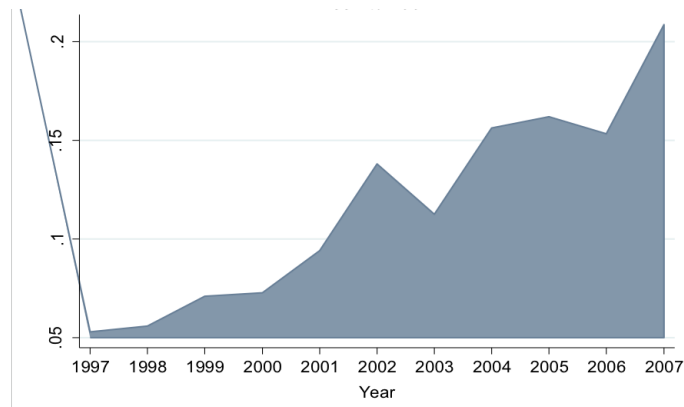
A Tables and Figures

Figure 1: UK Manufacturing Import Tariffs (1997-2007)



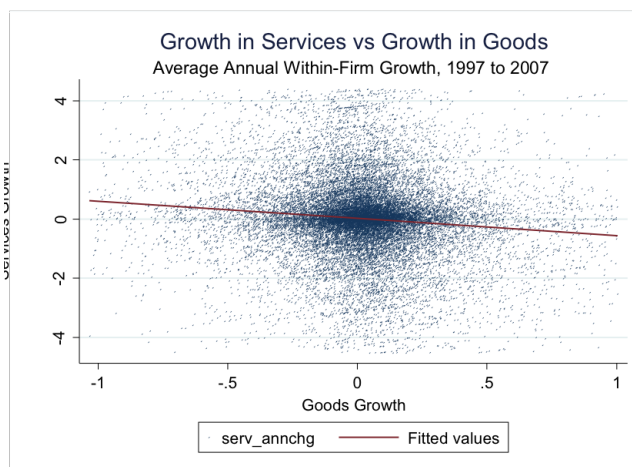
Notes: Figure shows average UK MFN manufacturing import tariffs (ad valorem, in %) over the period 1997-2007. Data Source: World Trade Organization Tariff Database.

Figure 2: Share of Services in UK Manufacturing (1997-2007)



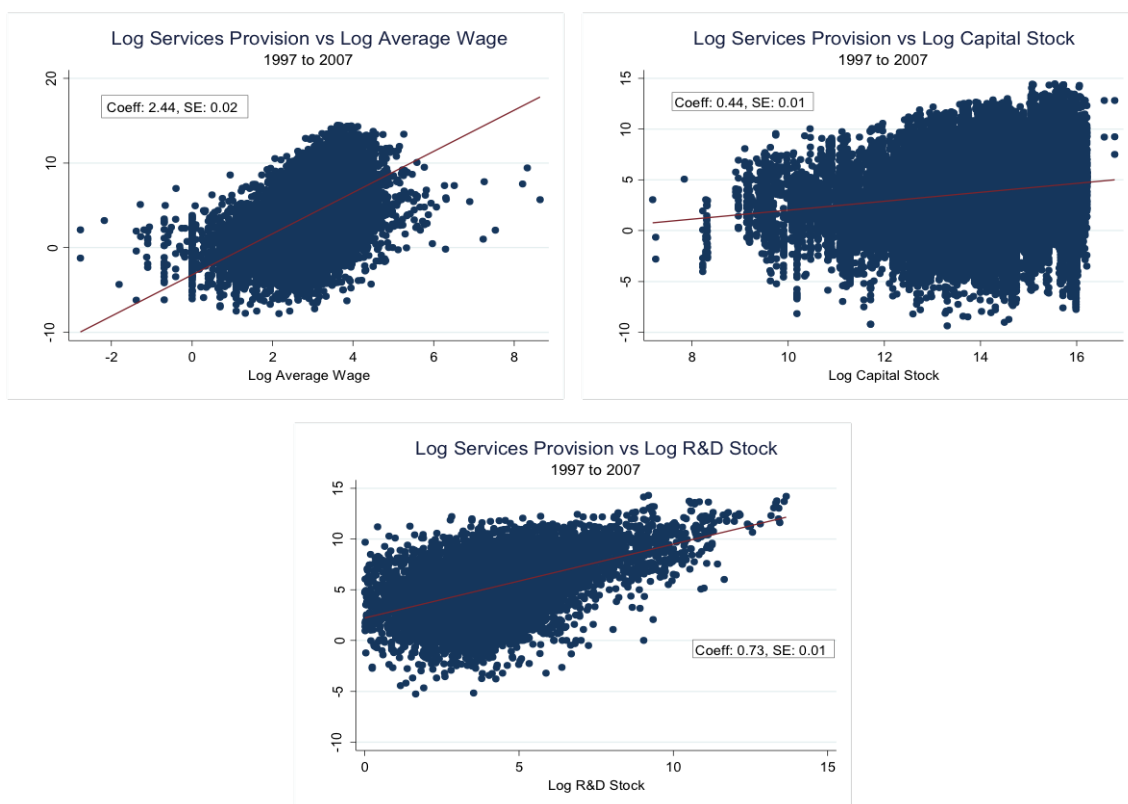
Notes: Figure shows the ratio of services revenues to total revenues in the UK manufacturing sector over the period 1997 to 2007. See Section 2 for details on the underlying data.

Figure 3: Average Annual Within-Firm Growth in Goods versus Services



Notes: Figure plots the average annual log change in Goods production versus Services provision within firms in the UK manufacturing sector over the period 1997-2007. See Section 2 for details on the underlying data.

Figure 4: Value of Services Production and Firm-Level Covariates



Notes: Figures plot the log of the value of service output of individual firms against the log of average wages (total wage bill/employment), capital stocks and R&D stocks. See Section 2 for details.

Table 1: Services Types Exported by UK Manufacturing Firms

Service Type	Enterprise-Years	
	Fraction	Number
Royalties and Licenses	38%	1890
Technical Services	36%	1787
Agricultural, Mining, On-Site Processing Services	20%	986
Business and Professional Services	18%	890
Communications Services	11%	542
Computer and Information Services	8%	382
Merchanting and Other Trade-Related Services	8%	378
Other Trade in Services	3%	169
Personal, Cultural and Recreational Services	2%	86
Construction Services	2%	79
Insurance Services	1%	25

Notes: The table presents the fraction and number of firm-years for which we observe exports of each services category. Fractions are calculated relative to the total number of firm-year observations in our regression sample which can be matched to the ITIS (4,932 observations in total). Firms can export more than one service in a given year, so that percentages add up to more than 100 percent. See Section 2 for details on the underlying data.

Table 2: Tenure of Firms in the Sample

Number of Years in Sample	Number of Firms
1	24350
2	10517
3	4307
4	2542
5	1697
6	1247
7	979
8	718
9	539
10	506
11	676

Notes: The table presents the number of firms by the number of periods they appear in the sample.

Table 3: Firm Entry and Exit

Year	Firms	Entrants		Exiters		Stayers	
		Count	Fraction	Count	Fraction	Count	Fraction
1997	11086	11086	100%	5453	49%	–	–
1998	11386	5753	51%	5621	49%	3737	33%
1999	11161	5396	48%	5568	50%	3164	28%
2000	10974	5381	49%	5482	50%	3196	29%
2001	11457	5965	52%	5812	51%	3082	27%
2002	10541	4896	46%	5226	50%	3280	31%
2003	10307	4992	48%	5013	49%	3151	31%
2004	10020	4726	47%	5064	51%	3019	30%
2005	9417	4461	47%	5035	53%	2596	28%
2006	8587	4205	49%	4171	49%	2602	30%
2007	9448	5032	53%	9448	100%	–	–

Notes: The total number of firms in the full data are reported along with their persistence in the sample. Entrants are firms that were not in the sample in the prior period but are in the sample in the current period. Exiters are firms that are in the sample in the current period but are not in the sample in the following period. Stayers are firms that are in the sample in the prior, current and following period. The fraction is the percentage of total firms in each category – a firm only present in the current period will be both an exiter and an entrant so our fractions need not sum to 100 percent.

Table 4: Firms and Revenues across Industries

Industry (2-digit code)	Number of Firms (average 1997-2007)	Industry Revenue (average 1997-2007, in millions £)
15	1087.1	45674
16	N/A [†]	N/A [†]
17	488.5	3497
18	237.1	1466
19	79.1	564
20	314.1	2084
21	367.8	7081
22	933	15968
23	37.9	920
24	624.3	31152
25	662.9	9388
26	435.7	7273
27	385.5	10518
28	1265.9	7693
29	1070.1	15568
30	100.0	4277
31	445.5	6140
32	239.2	8045
33	403.7	5920
34	346.1	27013
35	251.1	9679
36	618.8	4999

Notes: Firm averages across 2-digit SIC industries. [†] denotes an industry in which there are fewer than 10 firms in our sample, and thus the data cannot be disclosed. Industry revenues are in current £.

Table 5: Value of Services Production and Firm-Level Covariates

Variables	log(Services revenue)				
	(1)	(2)	(3)	(4)	(5)
log(R&D)	0.728*** (0.0116)			0.616*** (0.0126)	0.341*** (0.0137)
log(Capital stock)		0.441*** (0.0107)		-0.042*** (0.0212)	-0.137*** (0.0196)
log(Average wage)			2.438*** (0.0255)	1.710*** (0.0632)	1.163*** (0.0581)
log(Total revenue)					0.657*** (0.0173)
Observations	12104	68392	59077	11342	11293
Number of Firms	5122	37694	31329	4870	4850
R-squared	0.246	0.026	0.205	0.305	0.389

Notes: Results for regressions of the log of services revenue on firm-level variables (listed in column (1)). See Section 2 for details on the underlying data. Standard errors are clustered at the industry level and are in parentheses, where * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Change in Services Share and Beginning-of-Period Firm-Level Covariates

Variables	Δ Ratio of Services/Goods Revenue				
	(1)	(2)	(3)	(4)	(5)
log(Initial avg. wage)	0.00093*** (0.00050)				-0.00175 (0.00142)
log(Initial R&D)		0.00091*** (0.00027)			0.00099*** (0.00031)
log(Initial capital stock)			-0.00013 (0.00016)		-0.00051 (0.00036)
log(Initial total revenue)				0.00042*** (0.00012)	0.00014 (0.00041)
Observations	60880	15346	64160	64160	14644
Firms	22430	5007	23166	23166	4895
R-squared	0.000	0.001	0.000	0.000	0.001

Notes: Table presents results for regressions of the annual percentage-point change in the share of services in total revenue (denoted Δ Ratio of Services/Goods Revenue) on the firm-level variables listed in the first column. Firm-level variables are measured at the beginning of the period over which the change in the dependent variable is calculated. See Section 2 for details on the underlying data. Standard errors clustered at the industry level and are in parentheses, where * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Tariffs and Industry Characteristics

Variables	Δ Goods Import Tariffs			
	(1)	(2)	(3)	(4)
Δ Average wage	-0.021 (0.024)			-0.017 (0.024)
Δ Employment		0.000 (0.004)		0.008 (0.007)
Δ Sales			-0.004 (0.004)	-0.009 (0.006)
Constant	-0.533*** (0.021)	-0.520*** (0.015)	-0.518*** (0.015)	-0.526*** (0.021)
Observations	225	225	225	225
R-squared	0.003	0.000	0.004	0.014

Notes: Industry-level regressions in which the dependent variable (Δ Goods Import Tariffs) is the change in industry tariffs between 1997 and 2007 and the regressors are the industry growth rates of average wages, employment and sales in the pre-period, 1992 to 1996.

Table 8: Baseline Results

Variables	Ratio of Service/Goods Revenue						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Goods import tariffs	-0.916*** (0.301)	-0.893*** (0.329)	-0.859*** (0.326)	-0.141*** (0.063)	-0.184*** (0.062)	-0.209*** (0.064)	-0.217*** (0.066)
Goods export tariffs		-0.148 (0.130)	-0.147 (0.125)	0.0103 (0.138)	-0.038 (0.045)	-0.0522 (0.047)	-0.0507 (0.047)
Services export barriers		0.129 (0.140)	0.14 (0.131)	2.701*** (1.272)	0.015 (0.090)	0.0404 (0.086)	0.119 (0.092)
Services import barriers	0.945 (0.608)	1.115* (0.597)	0.971* (0.575)	4.207 (4.469)	-0.625 (1.118)	-0.21 (1.047)	-0.835 (1.248)
log(Labor productivity)			0.114 (0.239)	-0.0053 (0.204)		-0.275 (0.228)	-0.272 (0.227)
log(Average wage)			0.146*** (0.0671)	-0.0173 (0.0938)		0.957*** (0.359)	0.954*** (0.359)
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	No	No	No	Yes	No	No	No
Firm FEs	No	No	No	No	Yes	Yes	Yes
Time Trends	No	No	No	No	No	No	Yes
Observations	109598	107073	97502	97502	107073	97502	97502
Number of Firms	46164	45232	40948	40948	45232	40948	40948

Notes: PPML regressions of the ratio of a firm's revenues from services and revenues from goods on industry tariffs, the log of firm productivity, and the log average wage. FEs indicate fixed effects in the model. Time trends are 2-digit UK SIC industry time trends. Data Source: ONS Annual Respondents Database (ARD) and International Trade in Services Inquiry (ITIS). Standard errors are clustered at the industry level and are in parentheses, where * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Services Revenues as Dependent Variable

Variables	Services revenue					
	(1)	(2)	(3)	(4)	(5)	(6)
Goods import tariffs	-0.597*** (0.223)	-0.478** (0.209)	-0.319* (0.167)	-0.013 (0.017)	-0.024** (0.011)	-0.026** (0.012)
Goods export tariffs		-0.275 (0.249)	-0.154 (0.121)	0.015 (0.070)	-0.093** (0.046)	-0.095** (0.047)
Services export barriers		-0.720 (1.510)	-0.160 (0.428)	0.082 (0.093)	0.113 (0.082)	0.133 (0.082)
Services import barriers	2.526*** (0.821)	2.598** (1.009)	2.551*** (0.740)	4.281*** (1.323)	0.632 (0.426)	0.711 (0.450)
log(Labor productivity)			0.429** (0.176)	0.522*** (0.192)	0.206*** (0.070)	0.193*** (0.069)
log(Average wage)			1.177*** (0.081)	0.977*** (0.039)	0.403*** (0.137)	0.395*** (0.135)
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	No	No	No	Yes	No	No
Firm FEs	No	No	No	No	Yes	Yes
Time Trends	No	No	No	No	No	Yes
Observations	114006	111436	101383	101383	101383	101383
Number of Firms	47919	46937	42480	42480	42480	42480

Notes: PPML regressions of the ratio of a firm's revenues from services and revenues from goods on industry tariffs, the log of firm productivity, and the log average wage. FEs indicate fixed effects in the model. Time trends are 2-digit UK SIC industry time trends. Data Source: ONS Annual Respondents Database (ARD) and International Trade in Services Inquiry (ITIS). Standard errors are clustered at the industry level and are in parentheses, where * p<0.10, ** p<0.05, *** p<0.01.

Table 10: Goods Revenues as Dependent Variable

Variables	Goods revenue					
	(1)	(2)	(3)	(4)	(5)	(6)
Goods import tariffs	0.059*** (0.012)	0.023* (0.014)	0.007 (0.005)	0.004** (0.002)	0.000 (0.003)	-0.002 (0.002)
Goods export tariffs		0.079*** (0.016)	0.029*** (0.010)	0.011 (0.011)	0.003 (0.005)	0.003 (0.006)
Services export barriers		-0.006 (0.062)	0.011 (0.042)	-0.033* (0.019)	-0.023 (0.015)	-0.025* (0.014)
Services import barriers	0.373* (0.221)	0.322 (0.228)	0.105 (0.104)	0.015 (0.233)	0.111** (0.045)	0.099** (0.046)
log(Labor productivity)			0.316*** (0.055)	0.352*** (0.045)	0.170*** (0.026)	0.168*** (0.023)
log(Average wage)			0.978*** (0.026)	0.956*** (0.015)	0.700*** (0.031)	0.699*** (0.031)
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	No	No	No	Yes	No	No
Firm FEs	No	No	No	No	Yes	Yes
Time Trends	No	No	No	No	No	Yes
Observations	113127	110557	100608	100608	100608	100608
Number of Firms	47594	46648	42199	42199	42199	42199

Notes: PPML regressions of the ratio of a firm's revenues from services and revenues from goods on industry tariffs, the log of firm productivity, and the log average wage. FEs indicate fixed effects in the model. Time trends are 2-digit UK SIC industry time trends. Data Source: ONS Annual Respondents Database (ARD) and International Trade in Services Inquiry (ITIS). Standard errors are clustered at the industry level and are in parentheses, where * p<0.10, ** p<0.05, *** p<0.01.

Table 11: Using Domestic Services Revenues in the Construction of the Revenue Ratio

Variables	Ratio of Service/Goods Revenue		Domestic Services Revenue	
	(1)	(2)	(3)	(4)
Goods import tariffs	-0.248*** (0.078)	-0.253*** (0.079)	-0.085*** (0.023)	-0.087*** (0.023)
Goods export tariffs	-0.129 (0.080)	-0.126 (0.081)	-0.092 (0.066)	-0.092 (0.067)
Services export barriers	0.113 (0.233)	0.167 (0.169)	-0.028 (0.166)	-0.006 (0.163)
Services import barriers	-0.349 (0.798)	-0.889 (0.807)	-0.111 (0.395)	-0.218 (0.522)
log(Labor productivity)	-0.172 (0.231)	-0.171 (0.231)	0.016 (0.122)	0.016 (0.122)
log(Average wage)	0.981** (0.382)	0.992*** (0.383)	0.310** (0.127)	0.308** (0.128)
Year FEs	Yes	Yes	Yes	Yes
Industry FEs	No	No	No	No
Firm FEs	Yes	Yes	Yes	Yes
Time Trends	No	Yes	No	Yes
Observations	90627	90627	94284	94284
Number of Firms	37016	37016	38465	38465

Notes: PPML regressions of the ratio of a firm's revenues from services and revenues from goods on industry tariffs, the log of firm productivity, and the log average wage. FEs indicate fixed effects in the model. Time trends are 2-digit UK SIC industry time trends. Data Source: ONS Annual Respondents Database (ARD) and International Trade in Services Inquiry (ITIS). Standard errors are clustered at the industry level and are in parentheses, where * p<0.10, ** p<0.05, *** p<0.01.

Table 12: Baseline: Limiting Sample to Firms Present for at Least 6 or at Most 5 Years

Variables	Ratio of Service/Goods Revenue			
	At least 6 years		At most 5 years	
	(1)	(2)	(3)	(4)
Goods import tariffs	-0.199** (0.088)	-0.171** (0.087)	-0.215*** (0.073)	-0.222*** (0.078)
Goods export tariffs	-0.082** (0.039)	-0.078** (0.039)	0.044 (0.055)	0.044 (0.056)
Services export barriers	0.058 (0.083)	0.150 (0.094)	0.044 (0.213)	0.216 (0.342)
Services import barriers	-0.458 (1.901)	-1.617 (2.734)	0.322 (0.775)	0.210 (0.878)
Log(Labor productivity)	-0.694** (0.334)	-0.712** (0.341)	0.152 (0.200)	0.149 (0.201)
Log(Average wage)	1.034** (0.489)	0.929* (0.485)	0.616* (0.327)	0.611* (0.327)
Year FEs	Yes	Yes	Yes	Yes
Industry FEs	No	No	No	No
Firm FEs	Yes	Yes	Yes	Yes
Time Trends	No	Yes	No	Yes
Observations	33476	33476	64026	64026
Number of Firms	4476	4476	36472	36472

Notes: PPML regressions of the ratio of a firm's revenues from services and revenues from goods on industry tariffs, the log of firm productivity, and the log average wage on limited samples of firms. At least 6 denotes firms present in the sample for at least six years. At most 5 denotes firms present in the sample for at most five years. FEs indicate fixed effects in the model. Time trends are 2-digit UK SIC industry time trends. Data Source: ONS Annual Respondents Database (ARD) and International Trade in Services Inquiry (ITIS). Standard errors are clustered at the industry level and are in parentheses, where * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 13: Firm Attrition and Tariffs

Variables	Exiter = 1		
	(1)	(2)	(3)
Δ Goods import tariffs	-0.039 (0.034)	-0.045 (0.036)	-0.048 (0.039)
Initial Service/Goods revenue	-0.002 (0.004)	-0.015 (0.019)	-0.030 (0.030)
Δ Goods import tariff * Initial Service/Goods revenue	-0.005 (0.024)	-0.013 (0.026)	-0.019 (0.029)
Δ Services import barriers		-0.193** (0.081)	-0.219** (0.090)
Δ Services import barriers * Initial Service/Goods revenue		-0.131 (0.207)	-0.224 (0.300)
Δ Goods export tariffs			0.016 (0.045)
Δ Goods export tariff * Initial Service/Goods revenue			-0.028 (0.027)
Δ Services export barriers			-0.002 (0.001)
Δ Services export barriers * Initial Service/Goods revenue			0.003 (0.008)
Observations	40723	40317	38827
R-squared	0.000	0.001	0.002

Notes: Dependent variable (Exiter = 1) is 1 if the firm exits the BSD (employment falls to zero) at some point during the period 1997 to 2007. The firm can enter at any point. Independent change variables (denoted Δ) are average annual changes over the lifetime of the firm (could be fewer than 11 years). Standard errors are clustered at the industry level and are in parentheses, where * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 14: Baseline with the Ratio of Service to Total Revenue

Variables	Ratio of Service/ (Goods + Service) Revenue	
	(1)	(2)
Goods import tariffs	-0.028*** (0.009)	-0.030*** (0.009)
Goods export tariffs	-0.036*** (0.013)	-0.034** (0.014)
Services export barriers	-0.003 (0.044)	0.03 (0.041)
Services import barriers	0.381 (0.254)	0.356 (0.255)
log(Labor productivity)	-0.019 (0.041)	-0.022 (0.040)
log(Average wage)	-0.128* (0.071)	-0.123* (0.069)
Year FEs	Yes	Yes
Industry FEs	No	No
Firm FEs	Yes	Yes
Time Trends	No	Yes
Observations	98277	98277
Number of firms	41256	41256

Notes: PPML regressions of the ratio of a firm's revenues from services and revenues from goods on industry tariffs, the log of firm productivity, and the log average wage. FEs indicate fixed effects in the model. Time trends are 2-digit UK SIC industry time trends. Data Source: ONS Annual Respondents Database (ARD) and International Trade in Services Inquiry (ITIS). Standard errors are clustered at the industry level and are in parentheses, where * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 15: Exports of Headquarters Services and Intermediate Inputs

Variables	Exported HQ Services		Ratio of Service/ Goods Revenue	
	(1)	(2)	(3)	(4)
Goods import tariffs	0.065 (0.048)	0.075 (0.047)	-0.211*** (0.064)	-0.221*** (0.066)
Goods input tariffs			-0.107 (0.153)	-0.152 (0.164)
Goods export tariffs	0.174 (0.171)	0.269* (0.151)	-0.053 (0.047)	-0.053 (0.047)
Services export barriers	-2.319 (3.248)	-2.351 (3.502)	0.0382 (0.087)	0.123 (0.094)
Services import barriers	-0.718 (1.070)	-0.454 (1.007)	-0.187 (1.028)	-0.845 (1.244)
Log(Labor productivity)	-0.437*** (0.156)	-0.412** (0.161)	-0.277 (0.227)	-0.274 (0.226)
Log(Average wage)	-0.806** (0.346)	-0.791** (0.346)	0.959*** (0.359)	0.956*** (0.359)
Year FEs	Yes	Yes	Yes	Yes
Industry FEs	No	No	No	No
Firm FEs	Yes	Yes	Yes	Yes
Time Trends	No	Yes	No	Yes
Observations	89858	89858	97502	97502
Number of Firms	37686	37686	40948	40948

Notes: PPML regressions of the ratio of a firm's revenues from services and revenues from goods on industry tariffs, the log of firm productivity, and the log average wage. FEs indicate fixed effects in the model. Time trends are 2-digit UK SIC industry time trends. Data Source: ONS Annual Respondents Database (ARD) and International Trade in Services Inquiry (ITIS). Standard errors are clustered at the industry level and are in parentheses, where * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 16: Interaction Regressions and Beginning-of-Period Firm-Level Covariates

Variables	Ratio of Service/Goods Revenue				
	(1)	(2)	(3)	(4)	(5)
Goods import tariffs	-0.139 (0.244)	-0.198 (0.307)	-0.178 (0.317)	-0.184 (0.341)	-0.148 (0.348)
Goods export tariffs	-0.08 (0.059)	-0.082 (0.059)	-0.081 (0.059)	-0.081 (0.058)	-0.077 (0.059)
Services export barriers	0.129 (0.156)	0.128 (0.157)	0.128 (0.156)	0.129 (0.157)	0.141 (0.157)
Services import barriers	1.242 (0.792)	1.253 (0.795)	1.240 (0.792)	1.228 (0.764)	0.963 (0.744)
Goods import tariff * Initial R&D	-0.110* (0.057)	-0.114** (0.056)	-0.111* (0.058)	-0.112* (0.060)	-0.102* (0.058)
Goods import tariff * Initial Capital investment	0.072 (0.053)	0.074 (0.051)	0.072 (0.052)	0.073 (0.052)	0.066 (0.051)
Goods import tariff * log(Initial Labor productivity)	0.039 (0.035)		0.028 (0.055)	0.027 (0.056)	0.020 (0.053)
Goods import tariff * log(Initial Average wage)		0.063 (0.064)	0.025 (0.110)	0.028 (0.117)	0.027 (0.115)
Goods import tariff * Initial Service revenue				-0.010 (0.081)	-0.009 (0.079)
log(Average wage)	0.311 (0.394)	0.297 (0.386)	0.305 (0.392)	0.303 (0.387)	0.293 (0.384)
log(Labor productivity)	0.578*** (0.171)	0.585*** (0.172)	0.581*** (0.176)	0.580*** (0.172)	0.579*** (0.172)
Year FEs	Yes	Yes	Yes	Yes	Yes
Industry FEs	No	No	No	No	No
Firm FEs	Yes	Yes	Yes	Yes	Yes
Time Trends	No	No	No	No	Yes
Observations	10705	10705	10705	10705	10705
Number of Firms	2474	2474	2474	2474	2474

Notes: PPML regressions of the ratio of a firm's revenues from services and revenues from goods on industry tariffs, the log of firm productivity, and the log average wage. Time trends are 2-digit UK SIC industry time trends. Data Source: ONS Annual Respondents Database (ARD) and International Trade in Services Inquiry (ITIS). Standard errors are clustered at the industry level and are in parentheses, where * p<0.10, ** p<0.05, *** p<0.01.