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ABSTRACT

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

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. Additionally, we find that a successful transition is strongly associated with higher firm-level R&D stocks whereas higher physical capital stocks slow the shift into services provision.

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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, namely the 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, in large part 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. 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. Specifically, using UK firm-level data described in more detail below, a simple regression of the log of goods revenues on the log of services revenues, along with firm fixed effects, produces a coefficient on services equal to -0.35, significant at the one percent level. Thus, the shift towards services took place within individual firms, and was not simply a consequence of the reallocation of output shares toward more service-intensive firms or sectors. 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.[2] We find that lower tariffs are strongly associated with a shift to greater services provision relative to goods

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

[2] See Appendix A for more details regarding the types of services provided by UK manufacturing firms.

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 motivate the empirics with a tractable model of trade liberalization and firm-level production choice. In the model, firms allocate their (scarce) stock of accumulated industry expertise in order to augment the productivity of their goods and services production. A firm's expertise is both confined to the firm and rivalrous in its use across goods and services production. We show that one implication of this is that the greater a firm's stock of industry expertise the easier it is for the firm to adjust its production strategy in the face of changing market conditions.[3] In light of the model, we augment our regression specification in order to explore the firm-level determinants of the magnitude of the response to trade liberalization. In other words, we ask: why are some firms able to alter their production strategies in the face of lower manufacturing import tariffs while others are not? Following the prediction of the model we focus on the role of the firm's accumulated expertise, as embodied by the firm's stock of research and development. The empirical results suggest an important role for this proxy for expertise in facilitating the transition to more intensive services provision in the face of goods market trade liberalization. In contrast, a larger physical capital stock is associated with a significantly weaker shift into services.

There is a small literature that documents the "servitization" of manufacturing,[4] and it is usefully reviewed in Baines, et al. (2009). As these authors' describe, 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. Similarly, 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 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 firm-level between 1997 and 2007.

[3]We discuss the notion of expertise which is transferable between goods and services production in more detail below. In the U.K., a well-known example of a manufacturing firm which has used its accumulated manufacturing expertise to successfully shift into service provision is Rolls Royce: around 50 percent of its revenues now come from the provision of services rather than goods (see Neely, 2011).

[4]Vandermerewe and Rada (1988) define servitization as the process of creating value by adding services to products, a definition that is mostly adopted throughout this literature.

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

The paper is organized as follows. Section 2 presents an illustrative model; Section 3 describes our econometric methodology and data; Section 4 presents estimation results; and Section 5 concludes.

2 An Illustrative Model

In the following partial equilibrium model firms produce multiple output types – goods and services – and must decide how to allocate their accumulated expertise, or knowledge, across the production of each. We take the level of expertise as exogenous in the model and explore its content in the empirics. The scarce nature of the expertise, and its confinement to the firm, induces a tradeoff in goods and services production and generates predictions regarding how firms adjust production in the face of changing market conditions, such as lower manufacturing import tariffs.[6]

Demand

We consider a multi-country partial-equilibrium setting. In each country, there is a continuum of industries in which a representative agent consumes industry-specific goods and services. The agents' preferences over total industry output are Cobb-Douglas everywhere such that the share of aggregate expenditure spent on industry j is κ_j, where $\int_0^1 \kappa_j dj = 1$. Furthermore, the share of industry j expenditure that is spent on services output from that industry is ν_j. We therefore denote by $E_{jS} \equiv \kappa_j \nu_j E$ and $E_{jG} \equiv \kappa_j (1-\nu_j) E$ the expenditure on services and goods output, respectively, from industry j, where E is total expenditure in the economy.

We assume that preferences for goods and services are separable and within an industry are given by independent Constant Elasticity of Substitution (CES) utility functions. There is a large number of firms active in each industry and each firm provides one good and one services variety.[7] Firms are monopolistically competitive and ignore the impact of their choices on aggregate quantities when setting prices. The CES demand for the variety of good and the variety of service produced by firm i in industry j from country n can be written separately as:

$$q_{ijnG} = p_{ijnG}^{-\sigma} P_{jnG}^{\sigma} E_{jnG} \tag{1}$$

$$q_{ijnS} = p_{ijnS}^{-\gamma} P_{jnS}^{\gamma} E_{jnS} \tag{2}$$

[6] An alternative framework is that of Bloom et al. (2012) in which firms reallocate production factors in "bad times" when the opportunity cost of doing so is relatively low. Different from that paper, here we focus on the long run while explicitly modeling the degree of rivalry in the use of inputs across different types of production.

[7] Because the number of varieties available to firms is unlimited, no firm would ever want to choose a variety already produced by another firm.

where $\sigma > 1$ denotes the elasticity of substitution across varieties of goods and $\gamma > 1$ denotes the elasticity of substitution across services varieties. The industry price indices in country n can be written as $P_{jnG} = \left[\int_{\omega_G \epsilon \Omega_{nG}} \left[p_G\left(\omega_G\right)\right]^{1-\sigma} d\omega_G + \int_{\omega_G^* \epsilon \Omega_{nG}^*} \left[p_G^*\left(\omega_G^*\right)\right]^{1-\sigma} d\omega_G^*\right]^{\frac{1}{1-\sigma}}$ and $P_{jnS} = \left[\int_{\omega_S \epsilon \Omega_{nS}} \left[p_S\left(\omega_S\right)\right]^{1-\gamma} d\omega_S + \int_{\omega_S^* \epsilon \Omega_{nS}^*} \left[p_S^*\left(\omega_S^*\right)\right]^{1-\gamma} d\omega_S^*\right]^{\frac{1}{1-\gamma}}$, where Ω_G and Ω_S denote, respectively, the set of services and goods varieties available from home producers in country n and Ω_{nG}^* and Ω_{nS}^* the sets of foreign varieties. In the following, we take conditions on all markets (i.e., P_{jnG}, P_{jnS}, E_{jnG}, and E_{jnS}) as exogenous and explore firm production choices in response to changes in these conditions. In the empirics, we will control for market conditions through appropriate proxy variables and fixed-effect combinations. For ease of notation, we drop industry subscripts j from now on.

Production

We assume that firm i's production functions for goods and services take the following form:

$$Y_{iG} = \Lambda_{iG} T_{iG} L_{iG} \tag{3}$$

$$Y_{iS} = \Lambda_{iS} T_{iS} L_{iS} \tag{4}$$

where $\Lambda_{il} T_{il}$ is a firm-specific productivity term that is comprised of a fixed, exogenously determined component, Λ_{il}, and an endogenously chosen component, T_{il}, where $l \in (G, S)$. The firm's labor input is L_{il}.

One of the key feature of the model is our interpretation of T_{il} which, motivated by the stylized facts and discussion above, we assume to reflect the extent to which the firm's accumulated industry-specific expertise is directed toward one output type or the other. Over time firms both passively and actively accumulate knowledge (expertise) about the products they are selling and the markets they are selling to. Since this knowledge is, to some extent, embodied in workers and managers whose time is limited, it must be apportioned efficiently within the firm. This is a notion that the business literature has consistently found evidence for – for instance, Visnjic and Van Looy (2009) summarize the accepted view as follows: "When a firm starts to provide services...there is a natural knowledge relatedness to be exploited on the level of technological capabilities and knowhow that can be transferred from product engineering departments to the service activities of the firm...Technological expertise represents assets that can be leveraged when engaging in service activities."

Formally, we assume that the stock of expertise is both fixed within the firm and rivalrous in its use across output types in the sense that increased use of expertise in producing one output type reduces the expertise available in producing the other output type. We model the degree of rivalry in expertise across goods and services production

in the following reduced-form way:

$$T_i = \left((T_{iG})^t + (T_{iS})^t\right)^{1/t} \tag{5}$$

where we assume that $t \in (0, \infty)$ and governs the extent of rivalry in the use of expertise across output types. Note that a higher t implies less rivalry: for $t \to \infty$, firms can use the full amount of T_i in both goods and services production.

We assume that firms exporting to foreign destinations face standard variable iceberg-type trade costs in goods and services, denoted by τ_j^G and τ_j^S, respectively. Given this setup, the profit maximization problem of firm i selling to N markets is:

$$\begin{aligned} \max_{\mathbf{p}_{iG}, \mathbf{p}_{iS}, T_{iG}, T_{iS}} \pi_i &= \sum\nolimits_{n=1}^{N} \left[p_{inG} Y_{inG} + p_{inS} Y_{inS} - w_i \left(L_{inG} + L_{inS}\right)\right] \\ s.t.\ \ T_i &= \left((T_{iG})^t + (T_{iS})^t\right)^{1/t} \end{aligned}$$

where $\mathbf{p}_{iG}$ and $\mathbf{p}_{iS}$ are price vectors containing the prices charged in each destination market (including the firm's home market), and $L_{inG} = \tau_n^G Y_{inG}/\Lambda_{iG} T_{iG}$ and $L_{inS} = \tau_n^S Y_{inS}/\Lambda_{iS} T_{iS}$ are the amounts of labor required to deliver Y_{inG} and Y_{inS} units of goods and services to country n, respectively.

Substituting in from (1), (2), and (5), this is equivalent to:

$$\begin{aligned} \max_{\mathbf{p}_{iG}, \mathbf{p}_{iS}, T_{iG}} \pi_i &= \sum\nolimits_{n=1}^{N} \left(p_{inG}^{1-\sigma} P_{nG}^{\sigma-1} E_{nG} + p_{inS}^{1-\gamma} P_{nS}^{\gamma-1} E_{nS}\right) \\ &\quad - w_i \left(\frac{\sum_{n=1}^{N} \tau_n^G p_{inG}^{-\sigma} P_{nG}^{\sigma-1} E_{nG}}{\Lambda_{iG} T_{iG}} + \frac{\sum_{n=1}^{N} \tau_n^S p_{inS}^{-\gamma} P_{nS}^{\gamma-1} E_{nS}}{\Lambda_{iS} \left((T_i)^t - (T_{iG})^t\right)^{1/t}} \right) \end{aligned}$$

The solutions for the firm's optimal prices for each industry in each destination are given by:

$$p_{inG} = \frac{\sigma}{\sigma - 1} \frac{\tau_n^G w_i}{\Lambda_{iG} T_{iG}} \tag{6}$$

$$p_{inS} = \frac{\gamma}{\gamma - 1} \frac{\tau_n^S w_i}{\Lambda_{iS} \left((T_i)^t - (T_{iG})^t\right)^{1/t}} \tag{7}$$

The firm faces a clear tradeoff. For instance, by directing more expertise toward goods production, increasing T_{iG}, the firm is able to lower its output price for goods and improve its competitiveness in the goods market at the expense of services production. Ultimately, the firm's optimal allocation will depend on the relative marginal profitability of goods versus services across all markets. Solving for this optimal allocation decision, and substituting in the optimal prices (6) and (7), the equilibrium expertise directed

toward goods production can be written (services is symmetric):

$$T_{iG}^{\frac{\sigma-\gamma}{t}}\left(\left(\frac{T_i}{T_{iG}}\right)^t-1\right)^{\frac{1+t-\gamma}{t}}=\frac{\frac{\sigma}{\sigma-1}\mu_{iG}}{\frac{\gamma}{\gamma-1}\mu_{iS}}RMC_i \tag{8}$$

where $\mu_{iG}\equiv\left(\frac{\sigma}{\sigma-1}\frac{w_i}{\Lambda_{iG}}\right)^{\sigma-1}$, $\mu_{iS}\equiv\left(\frac{\gamma}{\gamma-1}\frac{w_i}{\Lambda_{iS}}\right)^{\gamma-1}$, and $RMC_i\equiv\frac{\sum_{n=1}^{N}\left(\tau_n^S\right)^{1-\gamma}P_{nS}^{\gamma-1}E_{nS}}{\sum_{n=1}^{N}(\tau_n^G)^{1-\sigma}P_{nG}^{\sigma-1}E_{nG}}$ summarizes the "relative market conditions" faced by firm i, i.e., the relative residual demand for its goods and services in all locations. The allocation decision is therefore a function of relative market conditions (RMC), the firm's aggregate stock of expertise (T_i), the elasticity parameters associated with goods and services markets (σ, γ), and the degree of rivalry in the use of expertise within the firm (t).

We can also derive the (partial equilibrium) goods and services revenues that the firm receives in each market, which are given by:

$$R_{inG}=\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left(\frac{\tau_n^G w_i}{\Lambda_{iG}T_{iG}}\right)^{1-\sigma}(P_{nG})^{\sigma}E_{nG} \tag{9}$$

$$R_{inS}=\left(\frac{\gamma}{\gamma-1}\right)^{1-\gamma}\left(\frac{\tau_n^S w_i}{\Lambda_{iS}T_{iS}}\right)^{1-\gamma}(P_{nS})^{\gamma}E_{nS} \tag{10}$$

where the optimal allocation of T_{iS} and T_{iG} is given by (8) and its services counterpart.

Comparative Statics

The focus of the empirics will be on the extent to which firms alter their production strategy in the face of trade liberalization, i.e., in the face of lower tariffs on goods imports. In the model, a decline in domestic import tariffs leads to a fall in the goods price index at home (P_{HG}), and thus a corresponding decline in the domestic residual demand for goods. Reiterating the results from above, condition (8) indicates that the firm's response will depend on its aggregate stock of expertise (T_i), the extent to which expertise is "freely available" within the firm (governed by t), and the demand elasticities σ and γ.

The result is an ambiguous response on the part of firms to lower import tariffs. To see this, we can differentiate the equilibrium condition (8) with respect to the domestic goods price index, P_{HG}.[8] This leads to sufficient conditions under which the firm will respond by reallocating expertise toward services provision. The flip side are conditions under which the firm will respond by increasing the expertise allocated to goods production.

[8] In our partial equilibrium framework, P_{HG} and its components are taken as exogenous so that we can take derivatives with respect to P_{HG}. Differentiating with respect to P_{HG} is equivalent to differentiating with respect to domestic import tariffs in this setting (see below).

Proposition 1 – ***Fight****: Firms will "fight"following a decline in domestic goods import tariffs,* $\frac{\partial T_{iG}}{\partial P_{HG}} < 0$*, when:*

$$(\gamma - \sigma)\left(\frac{T_{iG}}{T_i}\right)^t > \gamma(1-t) - \sigma + t(1+t).$$

That is, when the price index in the domestic goods market falls, firms reallocate T *from provision of services to production of goods. The above will hold for all firms when* $1+t < \gamma < \sigma$*.*

Proof is relegated to the appendix ■

Recall that expertise serves to enhance productivity, such that by choosing the allocation of expertise the firm is in effect choosing its relative productivity across output types. When the goods elasticity (σ) is large relative to the services elasticity (γ), the marginal increase in profits associated with a marginal reallocation of expertise toward goods production *exceeds* the increase from allocating additional expertise toward services provision. Thus, the firm will shift T from services to goods in order to lower the goods price and remain viable in that market.

In addition, from (5) we can see that for a given stock of expertise, T_i, both T_{iG} and T_{iS} decrease as t falls. In effect, this is because for smaller t (more rivalrous expertise) there is less "shared" expertise across output types. As a result, a further implication of Proposition 1 is that expertise must be sufficiently rival in order for reallocation to be efficient – i.e., t must be sufficiently small for firms to remove resources from services in order to maintain standing in the goods market. In this case, firms are willing to reenforce their position in goods because of potentially severe losses in market shares, and have to remove resources from services to do so because knowledge is relatively non-transferrable.

We believe, and our empirics will support, a more intuitive scenario where firms flee from competition.

Proposition 2 – ***Flee****: Firms will "flee" following a decline in goods import tariffs,* $\frac{\partial T_{iG}}{\partial P_{HG}} > 0$*, when:*

$$(\gamma - \sigma)\left(\frac{T_{iS}}{T_i}\right)^t > t(\gamma - 1 - t).$$

That is, when the price index in the domestic goods market falls, firms reallocate T *from production of goods to provision of services. The above will hold for all firms when,* $\sigma < \gamma < 1 + t$*.*

Proof is relegated to the appendix ■

Now, a large t, reflecting less rivalrous expertise within the firm, makes it more likely that firms flee from competition. In this case, firms have more resources simultaneously

available to both output types and can therefore shift production toward the relatively less competitive services sector with only a relatively small loss in market share in the goods market.

In short, firms face a flee or fight decision which turns on the relative price elasticities of the two markets and the degree of rivalry of firm-specific expertise. Since the empirics will exploit reductions in import tariffs (τ_H^G) as a source of trade liberalization, it is worth being explicit about the role of tariffs in the model. Propositions 1 and 2 imply the following:

Corollary 2.1 *When Proposition 1 holds,* $\frac{\partial T_{iG}}{\partial \tau_H^G} < 0$. *When Proposition 2 holds* $\frac{\partial T_{iG}}{\partial \tau_H^G} > 0$.

These conditions follow straightforwardly from the positive relationship between the price indices and import tariffs. The empirics will test these predictions directly.

Finally, for a given value of the rivalry parameter, t, the size of the aggregate stock of expertise matters for firm adjustment. Formally:

Proposition 3 *Given equilibrium condition (8) the sign of* $\frac{\partial^2 T_{iG}}{\partial P_{HG} \partial T_i}$ *will be the same as the sign of* $\frac{\partial T_{iG}}{\partial P_{HG}}$, *as long as the elasticity of expertise in services with respect to total expertise is greater than unity,* $\frac{\partial T_S}{\partial T} \frac{T}{T_S} > 1$.

Proof is relegated to the appendix ■

Consider the case in which firms flee (i.e., $\frac{\partial T_{iG}}{\partial P_{HG}} > 0$). Proposition 3 states that the extent to which a firm flees is heterogeneous across firms, and is a function of the firm's stock of expertise – i.e., firms with a relatively large stock of expertise will shift relatively more into services in response to trade liberalization.

To summarize, we motivated the structure of our model in large part by pointing to the reduction in UK manufacturing import tariffs and the simultaneous growth of services sales by UK manufacturing firms relative to their goods sales. In addition, we found a strong negative correlation between goods and services revenues within UK firms, suggesting a tradeoff in production over the period. The structure of our model led straightforwardly to Propositions 1 and 2, and Corollary 1, which indicate that it is unclear whether firms will flee or fight when faced with trade liberalization, with the response depending on demand conditions in the two sectors and the degree of rivalry in the use of firm-level expertise. Finally, Proposition 3 indicates that having a larger stock of expertise magnifies the extent of reallocation when trade liberalizes, whatever its direction. We next describe the data we use to determine and evaluate the empirically relevant cases.

3 Econometric Specification and Data

Our main empirical specifications are motivated by the firm's revenue functions, (9) and (10), which provide guidance as to which control variables should be included.

First, the revenue functions indicate the need for firm-level controls for input prices, given by w_{ij}, as well as controls for productivity shocks at the firm level, Λ_{iS}. To this end, we include the average wage bill and labor productivity of the firm. Throughout, we also control for year fixed effects which will capture any macro-level trends in input prices and technologies. In our preferred specifications, we also add firm fixed effects and two-digit industry time trends. These will control for, respectively, firm-specific time-invariant components and productivity trends as well as trends in aggregate expenditure on each industry's output, which in the model are given by the terms E_{jS} and E_{jG}.

The revenue functions also indicate that we should control for both the direct and indirect effects of variation in all four trade barriers: import and export barriers associated with both goods and services. Again from (9) and (10), the direct effects are those operating through the export barriers, τ_j^G and τ_j^S, and through the import barriers, which work through the price indices, P_{jG} and P_{jS}. In addition, variation in each of these variables will affect revenues through the optimal allocation of expertise, T_{iS} and T_{iG}, which are both a function of all four trade barriers. These are what we consider the indirect effects, and they are reflected in the partial derivatives of (8) with respect to one of the trade barriers.

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 proxies just discussed:[9]

$$\frac{R_{ijtS}}{R_{ijtG}} = exp\big[\eta_i + \theta_t + \beta_1 \tau^{\mathrm{M}}_{jtG} + \beta_2 \tau^{\mathrm{X}}_{jtG} + \beta_3 \tau^{\mathrm{M}}_{jtS} + \beta_4 \tau^{\mathrm{X}}_{jtS} + \beta_5 \ln \bar{w}_{ijt} + \beta_6 \ln \psi_{ijt} + \rho_{mt}\big] + \epsilon_{ijt} \tag{11}$$

where the τs represent import and export barriers for goods and services associated with firm i's industry j, η_i and θ_t are firm and year fixed effects, respectively, $\bar{w}_{ijt}$ and ψ_{ijt} are a firm's average wage and labor productivity and ρ_{mt} is a 2-digit industry time trend. The main coefficient of interest is the one on goods import tariffs, β_2. Its sign will tell

[9]Equations (9) and (10) show revenues from *individual* markets, including the UK. Total goods and services revenues are the summation of revenues from *all* locations. These revenues will depend on trade barriers imposed by these locations on the exports of firm i (here proxied by τ^X_{jtG} and τ^X_{jtS}) as well as on firms from third markets. Unfortunately, we do not have data for such third-market trade barriers and multi-collinearity issues would probably prevent their inclusion in any case. However, we note that over our sample period, exports only accounted for 19% of total services sales on average, so that the omission of third-market barriers is unlikely to be of major importance. (We do not have firm-level data on goods exports.) In our robustness checks we also estimate a version of (11) in which we subtract the value of exports from R_{ijtS} before dividing by goods revenues, thus using only domestic services revenues.

us whether firms react to tariff reductions by increasing services output relative to goods output ($\beta_2 < 0$) or by reducing it ($\beta_2 > 0$). While our main interest is in the output of services relative to goods, we will also estimate versions of (11) in which we will use goods or services revenues separately as the dependent variable. This will allow us to judge whether changes in relative revenues are driven by goods, services, or both.

Note that we have chosen an exponential conditional mean function which we will estimate via Poisson Pseudo-Maximum Likelihood (PPML) techniques. The use of PPML estimation is motivated by a number of 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.[10] 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 (11), 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 is then likely to 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. Throughout, we cluster standard errors at the 4-digit industry level, the level of variation of our regressor of interest (τ^{M}_{jtG}).

The second key prediction of our model is that to the extent that firms flee the goods market in response to lower import tariffs, those with a larger stock of accumulated expertise (T) should see a stronger shift into services provision. Given the interpretation of T as expertise, the closest empirical proxy available in our data is expenditure on research and development (R&D), and in particular the accumulated stock of R&D expenditure. In practice, however, there might be other determinants which influence the extent to which firms transition into services when faced with lower manufacturing import tariffs. Here, we also examine heterogeneity with respect to firm labor productivity and the stock of physical capital. These variables can be thought of as proxies for firm capabilities more generally and may therefore affect firm responsiveness to trade liberalization. Formally, we estimate the following specification:

$$\begin{aligned}\frac{R_{ijtS}}{R_{ijtG}} = exp\Big[&\eta_{ij} + \theta_t + \alpha_1(\ln R\&D_{ijt} \times \tau^{\mathrm{M}}_{jtG}) + \alpha_2(\ln CapInv_{ijt} \times \tau^{\mathrm{M}}_{jtG}) \\ &+\alpha_3(\ln LabProd_{ijt} \times \tau^{\mathrm{M}}_{jtG}) + \alpha_4(R\&D_{ijt}) + \alpha_5(CapInv_{ijt}) \\ &+\alpha_6(LabProd_{ijt}) + \alpha_7\tau^{\mathrm{M}}_{jtG} + \alpha_8\tau^{\mathrm{X}}_{jtG} + \alpha_9\tau^{\mathrm{M}}_{jtS} + \alpha_{10}\tau^{\mathrm{X}}_{jtS} \\ &+\alpha_{11}\ln\bar{w}_{ijt} + \alpha_{12}\ln\psi_{ijS} + \rho_{mt}\Big] + \epsilon_{ijt}\end{aligned} \tag{12}$$

where we are interested in particular in the interaction term coefficients α_1, α_2 and α_3.

[10] In our baseline specification (see Table 1 below), 70 percent of firm-year observations for service revenues and the ratio of services to goods revenues are zero.

Firm Data

The primary dataset used is the UK Annual Respondents Database (ARD), which contains the relevant firm variables over the period 1997-2007. The ARD is drawn from an underlying register of the universe of UK businesses and is the UK equivalent of the U.S. Longitudinal Respondents Database. 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.[11] 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 of own production produced.[12] In addition, we use the ARD to construct the physical capital stock of each firm, applying the perpetual inventory method applied to annual firm investments in plant and machinery. Our labor productivity measure is calculated from the ARD data as firm value added per worker.

For the estimation of the interaction regression in (12) we combine these data with information on the annual research and development (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.[13] Our final dataset contains between 6,441 and 38,617 individual firms depending on the specification[14], covering 243 4-digit manufacturing industries over the period 1997-2007.

Trade Barriers

We collect goods import tariffs (τ^{M}_{jtG}) from the World Trade Organization Tariff Database and note that they include both Most Favored Nation tariffs as well as regional trade agreements signed during the period. We note that while average import tariffs were already relatively low in 1997 (around 5%), this hides substantial sectoral heterogeneity. In 1997, ad-valorem tariffs reached from 0% to over 40% in some sectors. By 2007, average tariff levels had halfed to around 2.5% and the highest tariffs to just over 20%, implying tariff reductions of up to 20%.

The estimation of (11) also requires average goods export tariffs (τ^{X}_{jtG}) faced by UK firms in foreign destinations. These come from the United Nations' Trade Analysis and

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

[12] The ARD does not provide a breakdown of the types of services produced by manufacturing firms. However, we can observe types of services *exported* by a subset of manufacturing firms by linking the ARD to the International Trade in Services Inquiry (ITIS). See Appendix A for details and the principal services exported by manufacturing firms.

[13] We 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.

[14] In specifications that include the R&D variables the number of firms is considerably reduced due the smaller sample of firms drawn for the BERD.

Information System (TRAINS) and we use the cleaned and expanded version prepared by Feenstra and Romalis (2014).[15] We aggregate these country-product-year specific tariffs up to the UK SIC industry level as a trade-weighted sum across destination countries. 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.

For measures of services trade barriers (τ^{M}_{jtS} and τ^{X}_{jtS}) 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.[16] 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 International Trade in Services Inquiry (ITIS),[17] 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. 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.[18]

4 Empirical Results

In this section we present our empirical results. We first show that lower manufacturing import tariffs led firms to increase services production relative to goods production. We then explore the firm-level characteristics that influence the extent of this transition.

Firm Response to Trade Liberalization

Baseline Results

Table 1 shows the results from estimating (11). In column (1), we only include import barriers for goods and services as well as year fixed effects. Columns (2)-(6) add additional regressors and fixed effects which progressively make the specifications more restrictive.

[15] We thank John Romalis for making these data available to us.

[16] These data are available at www.oecd.org/economy/growth/.

[17] The ITIS is an annual, repeated cross-section survey that collects information on companies' international transactions in services. See Breinlich and Criscuolo (2011) for a detailed description.

[18] The European Commission obtained explicit powers to negotiate services trade policy in addition to goods trade policy in the Treaty of Nice (2001).

In column (2), we add export barriers in goods and services trade faced by British manufacturing firms. In column (3), we add firm-level wages and labor productivity and in column (4), we also control for 4-digit industry fixed effects. Finally, column (5) adds firm fixed effects and column (6) includes two-digit industry time trends as well.

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 rather than fight it.

The estimated coefficient magnitudes are also economically significant. According to our preferred specification which includes the full set of controls, firm fixed effects and 2-digit industry time trends (column 6 in Table 1), a one percentage point reduction in goods import tariffs led to an approximate increase of 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 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.[19] 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.

Our next question is whether the shift to greater relative services sales is due to higher services revenues, lower goods revenues or a combination of both. Tables 2 and 3 show results for the same specifications as in Table 1, but replace relative revenues by services and goods revenues, respectively. As seen, lower manufacturing import tariffs led to both higher services revenues and lower goods revenues. The results are most significant for services revenues, where we find a negative and highly significant coefficient on goods import tariffs throughout. 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

As discussed previously (see footnote 9), the revenue functions (9) and (10) on which we based our baseline specification (11) apply to individual market. In order to achieve a tighter link to the theoretical revenue functions, we now focus 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, the ARD only contains

[19]Note 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).

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 2, we also estimate a specification with R_{ijtS}^{DOM} as the dependent variable.

In Table 4, we regress the newly constructed revenue ratio (R_{ijtS}^{DOM}/R_{ijtG}) on the same variables as in our baseline specification.[20] The results are very similar to our baseline results from Table 1. When we use domestic services revenues as our dependent variable (Table 5), 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 2. A possible explanation for these similarities is that services exports accounted for only a relatively small fraction of total manufacturing services revenues over our sample period (19% on average).

In Table 6, we consider a potential alternative explanation for our findings. 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 while increasingly focusing their activities on headquarters services. We note that this possibility does not undermine the goal of this 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.

We can test for evidence of this mechanism by simply repeating regression (11) but, rather than using domestic services revenues as the dependent variable, we instead use the total volume of "affiliate services" trade associated with each firm. This service type is one of the categories 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 tariff reductions and exports of headquarters services.[21] Table 6 shows that the evidence for this hypothesis is mixed at best. In our most basic specification which only includes year fixed effects and the

[20]Notice that domestic services revenue still depend on all four sets of trade barriers included in specification (11) because these barriers indirectly impact revenues through their influence on the allocation of expertise (compare the discussion in Section 3).

[21]We 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.)

two import barrier variables (column 1), the coefficient on manufacturing import tariffs is indeed negative and significant, although its magnitude is only around one fourth of the effect of import tariffs on total services sales (see Table 2). Once we include additional control variables and more restrictive sets of fixed effects, however, the import tariff regressor becomes insignificant. We conclude that a shift toward increased 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 (12) in which relative firm-level service-to-goods revenues are the dependent variable and goods import tariffs are now interacted with additional regressors – i.e., we allow for firm heterogeneity in the response to trade liberalization. As discussed, we interpret this as an exploration of the relevant proxies for what we term "expertise" in the model, given by T. To reiterate the theoretical result that we are interested in, Proposition 3 states that when firms possess a greater stock of the rival input, they will be more responsive to trade liberalization.

Table 7 reports the results. We again start with a basic specification which includes only year dummies, and become progressively more restrictive by adding additional control variables and combinations of fixed effects. Column (6) contains our preferred specifications, which includes firm-level fixed effects and two-digit industry time trends, respectively. This time, our main interest is with the coefficient on the interaction terms between goods import tariffs and the R&D stock.

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 highly statistically significant in our preferred specifications. Firms with higher R&D stocks thus see a stronger shift into services relative to goods revenues as manufacturing import tariffs come down. Interestingly, we find the opposite sign pattern for the capital stock interaction term. This seems intuitively plausible: firms which have invested heavily in machinery and equipment will find it harder to move into service provision given that the previous investment is of little use in that area. By contrast, we do not find any clear pattern regarding the interaction of goods import tariffs and labor productivity – the relevant coefficients are insignificant throughout.

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 knowledge-intensive firms, and thus with relatively small past investments in physical capital, are the most responsive.

5 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.

We motivated our analysis with an illustrative partial equilibrium model in which a firm has to decide how to allocate a factor in fixed supply ("expertise") between the production of two products. Depending on relative demand elasticities and the degree to which the scarce factor can be shared between products, firms decide to either "fight" or "flee" when faced with an inward shift in the residual demand curve for one of their products. In each case, the reaction is amplified if there is a higher stock of initial expertise.

We tested the model's predictions in the context of UK manufacturing firms' choice between goods and services production when faced with lower EU manufacturing import tariffs. We found that lower tariffs caused firms to shift into service provision, and out of goods provision. 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.

We also examined which factors influence the extent of the transition into services following goods tariff reductions. Consistent with our model's predictions, we found that a firm's stock of R&D is strongly associated with a successful transition. By contrast, a higher capital stock was associated with a significantly weaker shift into services provision.

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A Data Appendix: Services Types in our Data

As discussed in Section 3, our main dataset (the ARD) does not provide a breakdown of the types of services produced by manufacturing firms but only states the total value of services provision and exports. However, we can observe types of services *exported* by a subset of manufacturing firms by linking the ARD to the International Trade in Services Inquiry (ITIS). The ITIS is an annual, repeated cross-section survey that collects information on companies' international transactions in services and is described in detail in Breinlich and Criscuolo (2011).

Table A.1 shows the principal services types exported by the firms in our regression sample which can be linked to the ITIS. As seen, revenues from Royalties and Licenses and from the provision of Technical Services (such as engineering or surveying services) are the most common type of services exports. These are followed by Agricultural, Mining, and On-Site Processing Services, Business and Professional Services, and Communications Services (which includes postal and telecommunications services).

B Proof of Propositions

Proof of Propositions 1 and 2

We begin by totally differentiating (8) with respect to the goods price index, P_G. This yields:

$$\frac{\partial T_G}{\partial P_G} = \frac{\frac{\partial RMC_i}{\partial P_G}}{RMC_i}\frac{T_G}{\Omega} \tag{13}$$

where $\Omega \equiv \frac{\sigma-\gamma}{t} + (\gamma - 1 - t)\left(\frac{T}{T_S}\right)^t$.

The sign is therefore determined by the ambiguous term, Ω, that takes into account the relative use of T in each output type and its relation to the elasticities of substitution in each sector. The sufficient conditions in Proposition 1 can be derived simply by noting that Ω will be positive when both $\sigma > \gamma$ and $\gamma > 1 + t$. Similarly, it will be negative under the reverse conditions. ■

Proof of Proposition 3

Differentiating (13) with respect to T yields:

$$\frac{\frac{\partial RMC_i}{\partial P_{HG}}}{RMC_i}\left(\frac{\frac{\partial T_G}{\partial T}}{\Omega} - \frac{t(\gamma - 1 - t)\frac{T_G}{T_S}\left(\frac{T}{T_S}\right)^{t-1}\left(1 - \frac{T}{T_S}\frac{\partial T_S}{\partial T}\right)}{\Omega^2}\right)$$

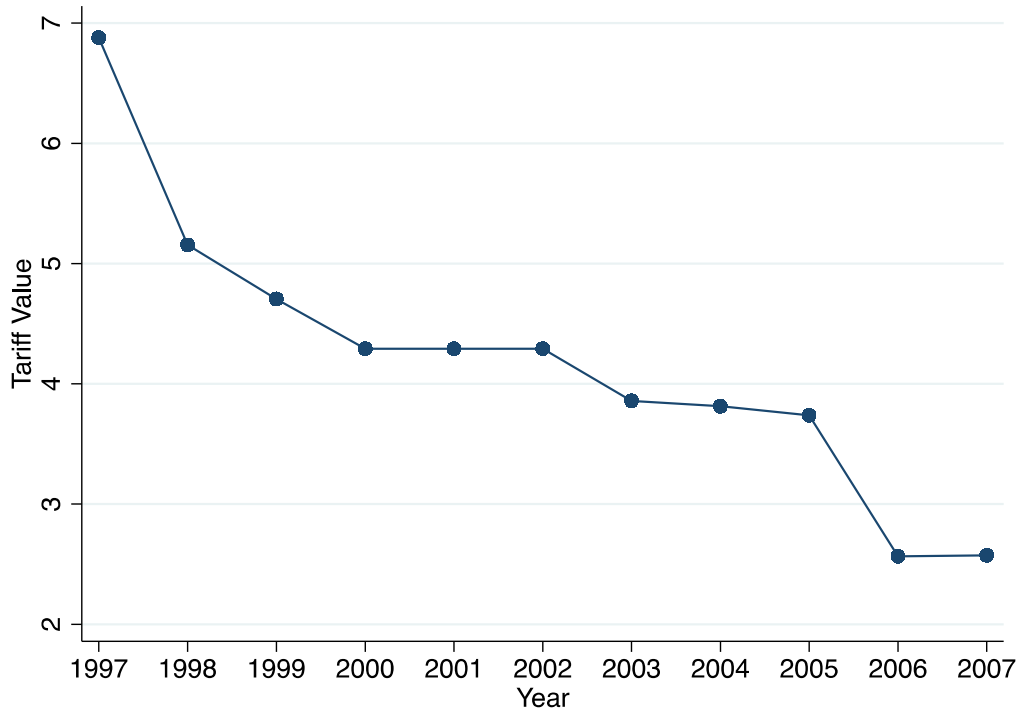
where Ω is defined as above. The sign of this derivative depends once again on the relative values of the substitution parameters (γ, σ, and t). However, under the sufficient conditions from Propositions 1 and 2, we can pin down the direction of the second derivative. We have two cases:

1. When $1 + t < \gamma < \sigma$, Proposition 1 holds since $\Omega > 0$. Since $\frac{\partial T_G}{\partial T} > 0$, $\frac{\partial^2 T_G}{\partial P_{HG} \partial T}$ will be the same sign as $\frac{\partial T_G}{\partial P_{HG}}$ when $1 - \frac{T}{T_S}\frac{\partial T_S}{\partial T} < 0$.

2. When $\sigma < \gamma < 1 + t$, Proposition 2 holds since $\Omega < 0$. Again, since $\frac{\partial T_G}{\partial T} > 0$, $\frac{\partial^2 T_G}{\partial P_{HG} \partial T}$ will be the same sign as $\frac{\partial T_G}{\partial P_{HG}}$ when $1 - \frac{T}{T_S}\frac{\partial T_S}{\partial T} < 0$.

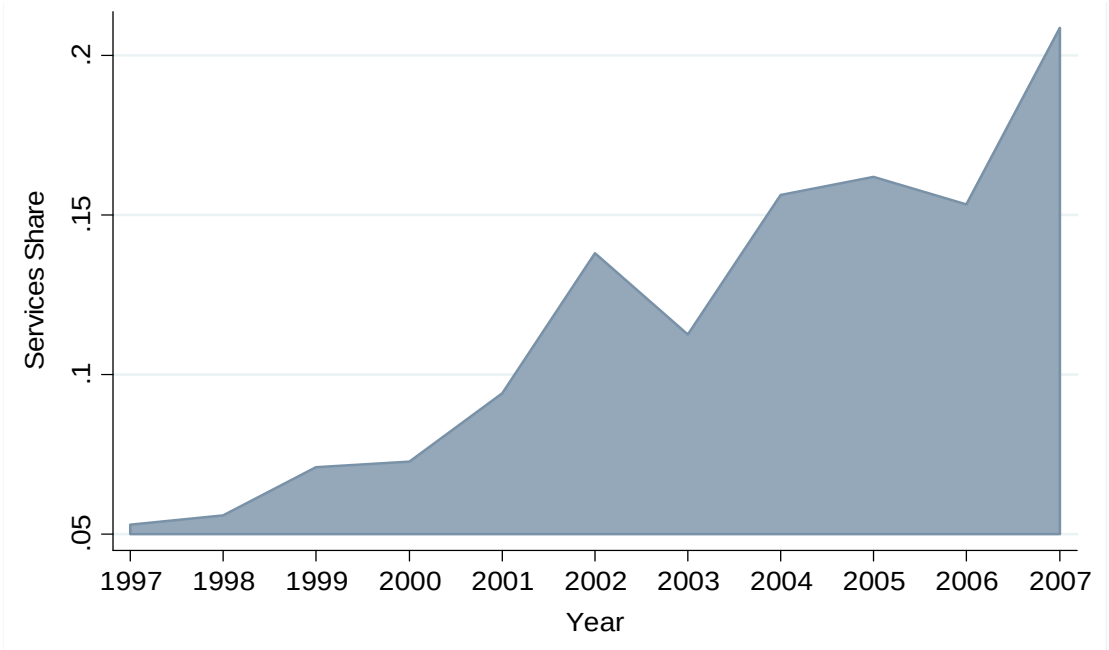
■

Figure 1: UK Manufacturing Import Tariffs, 1997-2007



Notes: Figures shows average UK 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: Figures shows the ratio of services revenues to total revenues in the UK manufacturing sector over the period 1997-2007. Data Source: ONS Annual Respondents Database (ARD).

Table 1: Baseline Results

	(1)	(2)	(3)	(4)	(5)	(6)
Regressor	Ratio Services/Goods	Ratio Services/Goods	Ratio Services/Goods	Ratio Services/Goods	Ratio Services/Goods	Ratio Services/Goods
Goods Import Tariffs	-0.916***	-0.893***	-0.859***	-0.141**	-0.209***	-0.217***
	(0.301)	(0.329)	(0.326)	(0.0634)	(0.0644)	(0.0656)
Goods Export Tariffs		-0.148	-0.147	0.0103	-0.0522	-0.0507
		(0.130)	(0.125)	(0.138)	(0.0468)	(0.0471)
Services Export Barriers		0.129	0.140	2.701**	0.0404	0.119
		(0.140)	(0.131)	(1.272)	(0.0855)	(0.0919)
Services Import Barriers	0.945	1.115*	0.971*	4.207	-0.210	-0.835
	(0.608)	(0.597)	(0.575)	(4.469)	(1.047)	(1.248)
Log(labor productivity)			0.114	-0.00530	-0.275	-0.272
			(0.239)	(0.204)	(0.228)	(0.227)
Log(average wage)			0.146**	-0.0173	0.957***	0.954***
			(0.0671)	(0.0938)	(0.359)	(0.359)
Observations	109,598	107,073	97,502	97,502	97,502	97,502
Fixed Effects	Year only	Year only	Year only	4-digit industry and year	Firm and year	Firm, year and 2-digit industry time trends

Notes: Table shows results of PPML regressions (figures in brackets below coefficient estimates are standard errors, clustered at the 4-digit industry level). The dependent variable is the ratio of a firm's revenues from services and revenues from goods. See text for details. Data Source: ONS Annual Respondents Database (ARD)

Table 2: Services Revenues as Dependent Variable

	(1)	(2)	(3)	(4)	(5)	(6)
Regressor	Services revenues	Services revenues	Services revenues	Services revenues	Services revenues	Services revenues
Goods Import Tariffs	-0.597***	-0.478**	-0.319*	-0.0132	-0.0241**	-0.0255**
	(0.223)	(0.209)	(0.167)	(0.0173)	(0.0114)	(0.0122)
Goods Export Tariffs		-0.275	-0.154	0.0147	-0.0934**	-0.0951**
		(0.249)	(0.121)	(0.0697)	(0.0456)	(0.0466)
Services Export Barriers		-0.720	-0.160	0.0820	0.113	0.133
		(1.510)	(0.428)	(0.0925)	(0.0824)	(0.0823)
Services Import Barriers	2.526***	2.598**	2.551***	4.281***	0.632	0.711
	(0.821)	(1.009)	(0.740)	(1.323)	(0.426)	(0.450)
Log(labor productivity)			0.429**	0.522***	0.206***	0.193***
			(0.176)	(0.192)	(0.0701)	(0.0692)
Log(average wage)			1.177***	0.977***	0.403***	0.395***
			(0.0809)	(0.0391)	(0.137)	(0.135)
Observations	114,006	111,436	101,383	101,383	101,383	101,383
Fixed Effects	Year only	Year only	Year only	4-digit industry and year	Firm and year	Firm, year and 2-digit industry time trends

Notes: Table shows results of PPML regressions (figures in brackets below coefficient estimates are standard errors, clustered at the 4-digit industry level). The dependent variable is a firm's revenues from services sales. See text for details. Data Source: ONS Annual Respondents Database (ARD)

Table 3: Goods Revenues as Dependent Variable

	(1)	(2)	(3)	(4)	(5)	(6)
Regressor	Goods revenues	Goods revenues	Goods revenues	Goods revenues	Goods revenues	Goods revenues
Goods Import Tariffs	0.0588***	0.0229*	0.00673	0.00373**	3.16e-05	-0.00161
	(0.0124)	(0.0135)	(0.00490)	(0.00173)	(0.00251)	(0.00231)
Goods Export Tariffs		0.0793***	0.0294***	0.0113	0.00324	0.00274
		(0.0157)	(0.0101)	(0.0114)	(0.00542)	(0.00578)
Services Export Barriers		-0.00613	0.0106	-0.0331*	-0.0229	-0.0252*
		(0.0616)	(0.0424)	(0.0190)	(0.0145)	(0.0144)
Services Import Barriers	0.373*	0.322	0.105	0.0145	0.111**	0.0998**
	(0.221)	(0.228)	(0.104)	(0.233)	(0.0447)	(0.0455)
Log(labor productivity)			0.316***	0.352***	0.170***	0.168***
			(0.0550)	(0.0454)	(0.0255)	(0.0231)
Log(average wage)			0.978***	0.956***	0.700***	0.699***
			(0.0259)	(0.0153)	(0.0314)	(0.0306)
Observations	113,127	110,557	100,608	100,608	100,608	100,608
Fixed Effects	Year only	Year only	Year only	4-digit industry and year	Firm and year	Firm, year and 2-digit industry time trends

Notes: Table shows results of PPML regressions (figures in brackets below coefficient estimates are standard errors, clustered at the 4-digit industry level). The dependent variable is a firm's revenues from goods sales. See text for details. Data Source: ONS Annual Respondents Database (ARD)

Table 4: Using Domestic Services Revenues in the Construction of the Revenue Ratio

	(1)	(2)	(3)	(4)	(5)	(6)
Regressor	Ratio Services/Goods	Ratio Services/Goods	Ratio Services/Goods	Ratio Services/Goods	Ratio Services/Goods	Ratio Services/Goods
Goods Import Tariffs	-0.795***	-0.734**	-0.694**	-0.191**	-0.248***	-0.253***
	(0.294)	(0.297)	(0.291)	(0.0834)	(0.0779)	(0.0789)
Goods Export Tariffs		-0.160	-0.148	-0.0588	-0.129	-0.126
		(0.155)	(0.141)	(0.145)	(0.0802)	(0.0810)
Services Export Barriers		-2.856	-2.550	0.0611	0.113	0.167
		(2.915)	(2.876)	(0.624)	(0.233)	(0.169)
Services Import Barriers	1.631***	1.493**	1.335**	11.70	-0.349	-0.889
	(0.619)	(0.687)	(0.633)	(7.134)	(0.798)	(0.807)
Log(labor productivity)			0.100	0.00946	-0.172	-0.171
			(0.289)	(0.235)	(0.231)	(0.231)
Log(average wage)			0.208**	-0.00267	0.981**	0.992***
			(0.0962)	(0.113)	(0.382)	(0.383)
Observations	100,470	98,198	90,627	90,627	90,627	90,627
Fixed Effects	Year only	Year only	Year only	4-digit industry and year	Firm and year	Firm, year and 2-digit industry time trends

Notes: Table shows results of PPML regressions (figures in brackets below coefficient estimates are standard errors, clustered at the 4-digit industry level). The dependent variable is the ratio of a firm's domestic services revenues to total goods revenues. Domestic services revenues are constructed as total services revenues minus services exports. See text for details. Data Source: ONS Annual Respondents Database (ARD)

Table 5: Domestic Services Revenues as Dependent Variable

	(1)	(2)	(3)	(4)	(5)	(6)
Regressor	Dom. services revenues	Dom. services revenues	Dom. services revenues	Dom. services revenues	Dom. services revenues	Dom. services revenues
Goods Import Tariffs	-0.696***	-0.553**	-0.389**	-0.0542***	-0.0850***	-0.0872***
	(0.256)	(0.237)	(0.160)	(0.0186)	(0.0227)	(0.0230)
Goods Export Tariffs		-0.305	-0.162	0.0687	-0.0920	-0.0917
		(0.297)	(0.126)	(0.0892)	(0.0661)	(0.0669)
Services Export Barriers		-2.294	-2.047	-0.108	-0.0280	-0.00560
		(2.352)	(2.786)	(0.587)	(0.166)	(0.163)
Services Import Barriers	2.365***	2.209**	2.014***	4.767**	-0.111	-0.218
	(0.847)	(1.067)	(0.741)	(2.336)	(0.395)	(0.522)
Log(labor productivity)			0.334**	0.418**	0.0161	0.0156
			(0.153)	(0.165)	(0.122)	(0.122)
Log(average wage)			1.190***	0.948***	0.310**	0.308**
			(0.0803)	(0.0347)	(0.127)	(0.128)
Observations	104,607	102,293	94,284	94,284	94,284	94,284
Fixed Effects	Year only	Year only	Year only	4-digit industry and year	Firm and year	Firm, year and 2-digit industry time trends

Notes: Table shows results of PPML regressions (figures in brackets below coefficient estimates are standard errors, clustered at the 4-digit industry level). The dependent variable is a firm's domestic services revenue. Domestic services revenues are constructed as total services revenues minus services exports. See text for details. Data Source: ONS Annual Respondents Database (ARD)

Table 6: Exports of Headquarters Services

	(1)	(2)	(3)	(4)	(5)	(6)
Regressor	Exports of Headquarters Services	Exports of Headquarters Services	Exports of Headquarters Services	Exports of Headquarters Services	Exports of Headquarters Services	Exports of Headquarters Services
Goods Import Tariffs	-0.141***	-0.0269	0.00974	-0.0722	0.0650	0.0745
	(0.0427)	(0.0843)	(0.0559)	(0.125)	(0.0476)	(0.0467)
Goods Export Tariffs		-0.303*	-0.248**	-0.184	0.174	0.269*
		(0.168)	(0.125)	(0.300)	(0.171)	(0.151)
Services Export Barriers		-1.329	-1.154	15.30	-2.319	-2.351
		(1.519)	(1.639)	(10.99)	(3.248)	(3.502)
Services Import Barriers	3.726**	3.694**	4.032**	1.820	-0.718	-0.454
	(1.526)	(1.468)	(1.698)	(10.77)	(1.070)	(1.007)
Log(labor productivity)			0.396*	0.255	-0.437***	-0.412**
			(0.221)	(0.306)	(0.156)	(0.161)
Log(average wage)			0.810***	0.746***	-0.806**	-0.791**
			(0.127)	(0.133)	(0.346)	(0.346)
Observations	99,694	97,412	89,858	89,858	89,858	89,858
Fixed Effects	Year only	Year only	Year only	4-digit industry and year	Firm and year	Firm, year and 2-digit industry time trends

Notes: Table shows results of PPML regressions (figures in brackets below coefficient estimates are standard errors, clustered at the 4-digit industry level). The dependent variable is a firm's exports of headquarters services. See text for details. Data Source: ONS Annual Respondents Database (ARD) and International Trade in Services Inquiry (ITIS).

Table 7: Interaction Regressions

	(1)	(2)	(3)	(4)	(5)	(6)
Regressor	Ratio Services/Goods	Ratio Services/Goods	Ratio Services/Goods	Ratio Services/Goods	Ratio Services/Goods	Ratio Services/Goods
Goods Import Tariffs x log(R&D)	-0.0401	-0.0330	-0.0351	0.0387	-0.0545**	-0.0538**
	(0.0600)	(0.0628)	(0.0655)	(0.0387)	(0.0248)	(0.0249)
Goods Import Tariffs x log(capital stock)	0.127**	0.121*	0.0889	0.00663	0.0492*	0.0486*
	(0.0642)	(0.0629)	(0.0798)	(0.0189)	(0.0264)	(0.0264)
Goods Import Tariffs x log(labor productivity)	-0.0337	-0.0100	0.0808	0.0212	0.0544	0.0544
	(0.0908)	(0.0905)	(0.0966)	(0.0341)	(0.0511)	(0.0511)
log(R&D)	0.282*	0.250	-0.0220	-0.0795	-0.00974	-0.0142
	(0.152)	(0.182)	(0.225)	(0.125)	(0.156)	(0.158)
log(capital stock)	-0.384***	-0.363**	-0.344*	-0.455**	-0.341***	-0.340***
	(0.134)	(0.162)	(0.185)	(0.221)	(0.115)	(0.116)
log(labor productivity)	0.638**	0.612**	0.156	-0.0159	-0.212	-0.214
	(0.261)	(0.252)	(0.237)	(0.0886)	(0.316)	(0.317)
Goods Import Tariffs	-0.678	-0.785	-0.928*	-0.472***	-0.187	-0.186
	(0.536)	(0.560)	(0.557)	(0.160)	(0.198)	(0.198)
Goods Export Tariffs		-0.0546	-0.0900	0.451***	-0.0169	-0.0116
		(0.132)	(0.123)	(0.114)	(0.111)	(0.112)
Services Export Barriers		-0.747	-0.386	0.358	2.551	2.548
		(1.848)	(0.810)	(0.333)	(3.236)	(3.249)
Services Import Barriers	0.994**	0.974**	0.991**	2.501	2.694**	2.689**
	(0.446)	(0.427)	(0.404)	(2.520)	(1.286)	(1.291)
log(average wage)			0.731***	0.513**	0.939	0.938
			(0.207)	(0.257)	(0.596)	(0.596)
Observations	19,628	19,297	19,294	19,294	19,294	19,294
Fixed Effects	Year only	Year only	Year only	4-digit industry and year	Firm and year	Firm, year, 2-digit ind. time trends

Notes: Table shows results of PPML regressions (figures in brackets below coefficient estimates are standard errors, clustered at the 4-digit industry level). The dependent variable is the ratio of a firm's revenues from services and revenues from goods. See text for details. Data Source: ONS Annual Respondents Database (ARD) and Business Expenditure on Research and Development (BERD) dataset.

Table A.1: Services Types Exported by UK Manufacturing Firms

Service Type	Fraction of Firm-Years	Number of Firm-Years
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

Note: Table shows the fraction and number of firm-years for which we observe the services export listed in the first column. 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%. Data Source: ONS Annual Respondents Database (ARD), International Trade in Services Inquiry (ITIS).