From Selling Goods to Selling Expertise: Investigating a New Channel of Firm Response to Import Competition

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Abstract

In the face of increased import competition 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. Using firm-level data for the U.K. we explore the link between import competition in goods and the firm's tradeoff between goods production and the provision of "non-industrial" services, a category that can be broadly considered as sales of expertise. We exploit variation in EU trade policy in order to identify the causal impact of goods imports in the firm's decision. We find that the degree of import competition faced by firms is strongly associated with a shift to greater services provision. Additionally, we find that the firm's stock of R&D is strongly associated with a successful transition.

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In the face of increased import competition domestic firms are often forced out of the market, 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 heirarchy (Bloom, Sadun and Van Reenen, 2010). In this paper we focus on a new channel of adjustment, namely the shift toward increased provision of services in lieu of goods production.

The share of services in global production and trade is substantial, with services accounting for 64 percent of global output and 21 percent of global trade in 2012. For the U.K. these figures are even more striking, with services accounting for 78 percent of GDP and X percent of total trade. This has been the outcome of sustained growth in services provision in recent years, which has averaged just under one percent per year since 1997 (World Bank, 2013), and in 2011 the country overtook Germany as the world's second largest services trader. In this paper the focus will be on firms whose primary activity is goods production and their contribution to these trends. As it turns out, their contribution has been significant: over 1997-2007 the manufacturing sector accounted for X percent of total growth in services provision in the U.K., a contribution that added X percentage points to U.K. GDP. Furthermore, had the manufacturing sector *not* undergone this transition toward increased services provision its share of total output would have been X percent in 2007, rather than the Y percent that it represented. Thus, to the extent that manufacturing has remained a relevant source of growth for the U.K., this suggests it has done so in part by becoming more services-oriented.

A closer look at the data suggests that import competition in goods may be an important force behind these trends. First, U.K. consumption of both goods and services rose significantly over this period; however, as Figure 1(b) indicates, the source of growth was quite different in each case. Whereas the increased demand for services by U.K. consumers was largely met via increased provision of services by U.K. firms, the growth in demand for goods was overwhelmingly met via an increase in imports—in fact, domestic production of goods fell slightly over the period (see Figure 1). The U.K. manufacturing sector thus experienced an aggregate shift away from goods production and toward services provision during a period in which aggregate

consumption of both grew, with an important role for goods imports in meeting demand. Furthermore, this was not simply a composition effect: of the X 4-digit manufacturing industries, Y saw goods production fall and Z saw an increase in services provision, suggesting a common industrial trend.

The firm-level evidence also points to a substantial shift toward services provision, and away from goods production. Specifically, using U.K. firm-level data, 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, within the firm goods and services output was inversely related over the period. Considered in light of the aggregate trends, existing U.K. firms have been, on average, re-orienting production toward services *at the expense of* goods.

Using firm-level data for the U.K. we explore the link between import competition in goods and the firm's tradeoff between goods production and the provision of "non-industrial" services, a category that can be broadly considered as sales of expertise.[1] We exploit variation in trade barriers faced by goods exporters to the U.K. in order to identify the impact of increased goods market competition on the firm's production decisions. We find that the degree of import competition in goods is strongly associated with a shift to greater services provision.

We motivate the empirics with a simple model of import competition. In the model, the firm allocates its (scarce) stock of industry expertise in order to augment the productivity of its goods and services production. The 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 the aggregate stock of industry expertise the easier it is for the firm to adjust its production strategy in the face of changing market conditions. 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 import competition. In other words, we ask: why are some firms able to alter their production strategies in the face of import competition while others are not? In particular, we focus on the role of the firm's accumulated expertise, as embodied by skilled workers, investments in technology and the firm's stock of research and development. The empirical results suggest an important role for these proxies for expertise in facilitating the transition to more intensive

[1] See Appendix A for the services types included in this group.

services provision in the face of goods market competition.

The paper is organized as follows. Section 1 presents a simple model; Section 2 describes the data; Section 3 implements an empirical strategy; and Section 4 concludes.

1. An Illustrative Model

Here we present a partial equilibrium model in which firms producing multiple output types – goods and services – must decide how to allocate their expertise across the production of each. 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 increased import competition.

1.1. Demand

We consider a continuum of industries in which a representative agent consumes industry-specific goods and services. The agent's preferences over total industry output are Cobb-Douglas 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. For reasons described below, all firms will produce both a good and a service variety. The CES demand for the variety of good and the variety of service produced by firm $i = 1, ..., N_j$ in industry j can be written separately as:

$$q_{ijG} = p_{ijG}^{-\sigma} P_{jG}^{\sigma} E_{jG} \tag{1}$$

$$q_{ijS} = p_{ijS}^{-\gamma} P_{jS}^{\gamma} E_{jS} \tag{2}$$

where $\sigma > 1$ denotes the elasticity of substitution across varieties of goods and $\gamma > 1$ denotes the elasticity of substitution across services varieties. In addition, the industry price indices can be written as $P_{jG} = \left[\int_{i=1}^{N_j} (p_{ijG})^{1-\sigma} + \int_{i=1}^{N_j^*} (p_{ijG}^* \tau_{jG})^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$ and $P_{jS} = \left[\int_{i=1}^{N_j} (p_{ijS})^{1-\sigma} + \right.$

$\int_{i=1}^{N_j^*}(p_{ijS}^*\tau_{jS})^{1-\sigma}]^{\frac{1}{1-\sigma}}$, where * denotes foreign values and τ_{jG} and τ_{jS} are industry-specific goods and services trade costs, respectively.

1.2. Production

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

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

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

where $\Lambda_{ijl} T_{ijl}$ is a firm-specific productivity term that is comprised of a fixed, exogenously determined component, Λ_{ijl}, and an endogenously chosen component, T_{ijl}, where $l \in (G, S)$.[2] The firm's labor input is L_{ijl}.

The key feature of the model is our interpretation of T_{ijl} 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. 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:

$$T_{ij} = \left((T_{ijG})^t + (T_{ijS})^t\right)^{1/t} \tag{5}$$

where the substitution parameter $t \in (0, 1)$ governs the extent of rivalry in the use of expertise across output types.

[2]Note that this production structure is identical to Melitz (2003) where the productivity term is endogenously determined here.

Given this setup, the profit maximization problem of the firm is:

$$\max_{\mathbf{p}_{ijG},\mathbf{p}_{ijS},T_{ijG},T_{ijS}} \pi_{ij} = \sum_{j=1}^{J} \left[p_{ijG} Y_{ijG} + p_{ijS} Y_{ijS} - w_{ij} \left(\tau_j^G L_{ijG} + \tau_j^S L_{ijS} \right) \right] \qquad s.t. \;\; T_{ij} = \left((T_{ijG})^t + (T_{ijS})^t \right)^{1/t}$$

which, substituting in (1)−(5), is equivalent to:

$$\max_{\mathbf{p}_{ijG},\mathbf{p}_{ijS},T_{ijG},T_{ijS}} \pi_{ij} = \sum_{j=1}^{J} \left(p_{ijG}^{1-\sigma} P_{jG}^{\sigma-1} E_{jG} + p_{ijS}^{1-\gamma} P_{jS}^{\gamma-1} E_{jS} \right) - w_{ij} \left(\frac{\sum_{j=1}^{J} \tau_j^G p_{ijG}^{-\sigma} P_{jG}^{\sigma-1} E_{jG}}{\Lambda_{ijG} T_{ijG}} + \frac{\sum_{j=1}^{J} \tau_j^S p_{ijS}^{-\gamma} P_{jS}^{\gamma-1} E_{jS}}{\Lambda_{ijS} \left((T_{ij})^t - (T_{ijG})^t \right)^{1/t}} \right)$$

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

$$p_{ijG} = \frac{\sigma}{\sigma - 1} \frac{\tau_j^G w_{ij}}{\Lambda_{ijG} T_{ijG}} \tag{6}$$

$$p_{ijS} = \frac{\gamma}{\gamma - 1} \frac{\tau_j^S w_{ij}}{\Lambda_{ijS} \left((T_{ij})^t - (T_{ijG})^t \right)^{1/t}} \tag{7}$$

The firm faces a clear tradeoff. For instance, by directing more expertise toward goods production, increasing T_{ijG}, the firm is able to lower its output price and improve its competitiveness in the goods market, thus yielding greater production of goods at the expense of services. Ultimately, the firm's optimal allocation will depend on the relative 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):

$$T_{ijG}^{\frac{\sigma-\gamma}{t}} \left(\left(\frac{T_{ij}}{T_{ijG}} \right)^t - 1 \right)^{\frac{1+t-\gamma}{t}} = \frac{\frac{\sigma}{\sigma-1} \mu_{ijG}}{\frac{\gamma}{\gamma-1} \mu_{ijS}} RMA_j \tag{8}$$

where $\mu_{ijG} \equiv \left(\frac{\sigma}{\sigma-1} \frac{w_{ij}}{\Lambda_{ijG}} \right)^{\sigma-1}$ is the markup over the efficiency wage for goods (services is symmetric) and $RMA_j \equiv \frac{\sum_{j=1}^{J} \tau_{jS}^{1-\gamma} P_{jS}^{\gamma-1} E_{jS}}{\sum_{j=1}^{J} \tau_{jG}^{1-\sigma} P_{jG}^{\sigma-1} E_{jG}}$ is the effective "relative market access" associated with each output type. The allocation decision is therefore a function of relative market conditions (RMA), the firm's aggregate stock of expertise (T_{ij}), the substitution parameters associated with goods

and services markets (σ, γ), and the degree of rivalry in the use of expertise (t).

In anticipation of the empirics, we can also derive the (partial equilibrium) revenues that the firm receives in each market, which are given by:

$$R_{ijG} = \left(\frac{\sigma}{\sigma - 1}\right)^{1-\sigma} \left(\frac{\tau_j^G w_{ij}}{\Lambda_{ijG} T_{ijG}}\right)^{1-\sigma} (P_{jG})^{\sigma} E_{jG} \tag{9}$$

$$R_{ijS} = \left(\frac{\gamma}{\gamma - 1}\right)^{1-\gamma} \left(\frac{\tau_j^S w_{ij}}{\Lambda_{ijS} T_{ijS}}\right)^{1-\gamma} (P_{jS})^{\gamma} E_{jS} \tag{10}$$

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

1.2.1. Comparative Statics

The focus of the empirics will be on the extent to which firms alter their production strategy in the face of increased competition in the goods market. More specifically, the increased competition is reflected in the model as a decline in domestic market access. As import tariffs on goods fall, the result is a decline in the goods price index, P_{jG}, and thus a corresponding decline in domestic market access for goods. Reiterating the results from above, condition (8) indicates that the firm's response to this will depend on its aggregate stock of expertise, T_{ij}, the demand parameters σ and γ, along with the extent to which expertise is "freely available" within the firm, governed by t.

We note that this formulation of the firm's problem is in line with recent work by Bloom, Romer and Van Reenen (2010), who also model a supply-side tradeoff in the face of increased competition from imports. In their "trapped factors" model reallocating inputs toward new purposes within the firm is costly, as it is here.[3] In that model, import competition lowers the opportunity cost of reallocation by reducing the profitability of the current production structure relative to an alternative structure, and so induces firms to reorient their production activities.

In contrast, the model here leads to an ambiguous response on the part of firms in response to increased import competition. To see this, we can differentiate the equilibrium condition (8) with respect to the goods price index, P_{jG}. This leads to sufficient conditions under which the

[3] In their model they are specifically interested in reallocation of inputs toward greater innovation activity.

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.

Proposition 1. *Given equilibrium condition (8), the following sufficient conditions hold:*

- *When* $1 + t < \gamma < \sigma$, *then* $\frac{\partial T_{jG}}{\partial P_{jG}} < 0$
- *Conversely, when* $\sigma < \gamma < 1 + t$, *then* $\frac{\partial T_{jG}}{\partial P_{jG}} > 0$

Proof coming soon ■

Thus, there is a fundamental ambiguity regarding the firm's response. The intuition is the following: when the goods elasticity, σ, is large relative to the services elasticity, γ, the marginal increase in profits associated with a small increase in the allocation of expertise toward goods production exceeds the increase from allocating additional expertise toward services provision. Fundamentally this is due to the fact that expertise serves to enhance productivity such that the firm's choice is ultimately in choosing the relative productivity across output types.

In addition, from (5) we can see that for a given stock of expertise, T_{ij}, both T_{ijG} and T_{ijS} are decreasing in t. In effect, this is because for larger t (more rivalrous expertise) there is less "shared" expertise across output types, so each has less to work with. As a result, a further implication of Proposition 1 is that expertise must be sufficiently non-rival in order for reallocation to be efficient – i.e., t must be sufficiently small.

In short, the firm faces a "flee" or "fight" decision. For instance, when demand for goods is relatively elastic, reflected in a relatively large σ, then firms are able to capture a relatively large increase in market share from a given increase in expertise. In this case the firm will find it more profitable to fend off import competition in goods by allocating more expertise toward goods production – i.e., to fight – rather than switching toward increased services provision – i.e., to flee. Again, this is conditional on sufficiently low rivalry in expertise (relatively low t).

One might think that whether the firm will flee or fight may depend on the firm's capacity to do so. The model points to such a possibility. Specifically, for a given value of the rivalry parameter, t, a larger aggregate stock of expertise induces a larger reallocation in response to a given increase in import competition in goods. Again, the direction of the response remains ambiguous, however the more expertise a firm has accumulated the easier it is to reorganize

production to fend off import competition or, alternatively, to re-orient the firm toward increased services provision. Formally:

Proposition 2. *Given equilibrium condition (8), the sign of* $\frac{\partial^2 T_{ijk}}{\partial P_{jl} \partial T_{ij}}$ *will be the same as the sign of* $\frac{\partial T_{ijk}}{\partial P_{jl}}$ *for* $k \in (G, S)$ *and* $l \in (G, S)$*. Proof coming soon* ■

These two results motivate the empirics to come. To sum up, we motivated the structure of our model in large part by pointing to the parallel growth in import competition in the U.K. goods market and sales of services by domestic goods producers. This simple structure led straightforwardly to Propositions 1 and 2 which predict: 1. It is unclear whether firms will "fight" or "flee" in the face of increased goods market competition and 2. The magnitude of the response will be increasing in the firm's stock of accumulated expertise. We next describe the data we will use to formally test these predictions.

2. Data and Empirical Measures

2.1. Data

The primary dataset used is the Annual Census of Production Respondent's 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 U.K. businesses and is the U.K. 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.[4] Our final dataset contains 330,200 individual firms covering 243 4-digit manufacturing industries over 1997-2007.

The ARD includes many establishment-level variables and, for our purposes, the most relevant will be the total value of industrial services provided by the establishment, the total value of non-industrial services provided by the establishment, and the total value of goods of own production produced. Appendix A provides the exact survey questions asked in constructing the ARD for the primary variables used in our empirical section. As suggested by these variables we will distinguish between industrial and non-industrial services. Since industrial services are

[4]For a comprehensive description of this dataset see Criscuolo, Haskel and Martin (2003) or for a summary see Breinlich and Criscuolo (2010).

comprised primarily of repair and maintenance services, we set these aside in the empirical analysis. The provision of these services is highly correlated with goods production and so variation in their provision does not provide much additional information or insight. Thus, the focus of the empirical analysis is on firms' relative output of goods and non-industrial services.

While the exact composition of non-industrial service types produced by firms is unavailable (though Appendix A lists the possible service types), we can gain some sense of the specific services being provided by firms by looking at the services that they export. The International Trade in Services (ITIS) dataset contains this information at the firm level and, though it is a survey, it has wide coverage of the U.K. firms most likely to engage in export activity. It can also be merged with the ARD allowing us to gain a good descriptive sense of the relationship between services producers and their exports. Table 1 lists some basic facts regarding services producers. To begin with, 55 percent of firms who produce any services also export services, providing some hope that the features of services exporters may be consistent with services producers overall.

We can see that the top service types being exported tend to consist of what we think of as forms of expertise, and these are also the fastest growing export types. This is consistent with the idea that firms are increasingly selling their accumulated technical know-how along with (or perhaps in lieu of) their physical products.

2.2. Empirical Measures

Our primary empirical exercise will consist of estimating the impact of variation in E.U. import tariffs on U.K. firm revenues, as given by (9) and (10). These revenue functions indicate the need for several controls, which we describe here.

2.2.1. Industry Expenditure

First, variation in aggregate expenditure on industry output of goods and services, E_{jG} and E_{jS} in the model, may explain observed variation in goods and services revenues, both directly as well as indirectly through the effect on the allocation of inputs, as indicated by (8). Since our revenues measures will include exports in some specifications, our controls for industry goods and services expenditures must include foreign expenditure as well. For both goods and services this calculation is straightforward: we simply add up total revenues of goods across

firms in industry j, and then do the same for services. Note that because there are both direct and indirect effects due to variation in expenditure, both goods and services expenditure will be included in each regression.

It is also important to note that by controlling for aggregate expenditures we are narrowing the focus of the investigation to a supply-side mechanism, in effect ruling out any increases in services or goods production that may result from shifts in demand. For instance, to the extent that import competition reduces the average goods price that U.K. consumers face, a corresponding shift down the demand curve for goods may mitigate any shift by firms away from goods production and toward services production. By controlling for aggregate industry expenditures our specification will rule out this channel.

2.2.2. Trade Barriers

We 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. From (9) and (10), the direct effects are those operating directly through the export barriers, τ_j^G and τ_j^S, as well as through the import barriers, which are embodied by the price indices, P_{jG} and P_{jS}, in the respective revenue functions. In addition, variation in each of these variables will affect revenues through the optimal allocation of expertise, T_{ijS} and T_{ijG}, as both of these firm choice variables are 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. Note again that Proposition 1 indicates that the sign of each partial derivative is ambiguous without further information regarding the relative magnitudes of σ, γ and t.

Throughout the analysis the source of variation we will be most interested in will be due to variation in E.U. import tariffs on goods. In particular, the focus of the empirics will be on the effect of variation in goods import tariffs on services revenues, which from (10) operates via the indirect effect – i.e., a reallocation of expertise. We collect goods import tariffs from the World Trade Organization Tariff Database and note that they include both Most Favoured Nation tariffs as well as any Regional Tariff Agreements signed during the period, which we list in Appendix C. Importantly, these tariffs are likely to be largely exogenous to U.K. industrial trends due to the fact that their values are set in Brussels. In addition, we collect goods tariffs for U.K. exports,

which we aggregate up to the U.K. SIC industry level as a trade-weighted sum across countries and destinations.

It will also be important to control for variation in both import and export barriers to services trade. To do this, we rely on an index of services trade barriers constructed for OECD countries and published by the OECD. Since our empirical analysis will take place at the U.K. 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, again obtained from the ITIS, which we use to construct import and export trade barrier indices at the SIC industry level, consisting of a simple trade-weighted sum of the OECD service type measures.

2.2.3. Firm-level Controls

The revenue functions also suggest the need for firm-level controls for input prices, given by w_{ij}, as well as goods- and services-specific productivity shocks at the firm level, Λ_{ijG} and Λ_{ijS}. To control for input prices we include the wage bill and capital investment for each firm. To control for productivity shocks we first include controls for computer software investments and the firm's use of the internet for sales, as proxies for firm-specific trends in technology adoption. Beyond this, in some specifications we control for 2-digit industry-specific trends.

3. Empirics

Our primary empirical specifications are motivated by the revenue functions (9) and (10). Since these functions are multiplicative, they suggest running a regression that is non-linear in its parameters. In addition, there are many zeroes for the value of services revenue – i.e., there are many firms who provide no services.[5] Most importantly, given the highly skewed distribution of revenues across firms it is unlikely that the unexplained variation in either specification 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. The combinination of these facts suggests that we follow

[5]There are X (no?) instances in which goods output is zero.

the suggestion of Santos-Silva and Tenreyo (2006) in adopting the Poisson Pseudo-Maximum Likelihood (PPML) estimator in our primary specification.

For comparision with this estimator, and because it is a common estimation approach, we first adopt a linear-in-logs specification which estimates the import tariff elasticity via Ordinary Least Squares (OLS) under the assumption of homoskedasticity and log-normally distributed errors (both of which are unlikely to hold in the data). Head and Mayer (2013) also suggest comparing the linear-in-logs and the PPML with a third estimator, the Gamma Pseudo-Maximum Likelihood estimator. However, while this estimator may in fact be more efficient than the PPML estimator (though they are both consistent) it has been shown by SST to be sensitive to the specification used and so we set it aside. The empirical models we wish to estimate can be written as:

$$R^G_{ijt} = exp[\phi_i + \theta_t + \xi_{jt} + \beta_1 \ln \tau^G_{jt} + \beta_x \ln X_{ijt} + \ln \epsilon_{ijt}] \tag{11}$$

and

$$R^S_{ijt} = exp[\phi_i + \theta_t + \xi_{jt} + \beta_1 \ln \tau^G_{jt} + \beta_x \ln X_{ijt} + \ln \epsilon_{ijt}] \tag{12}$$

where R_{ijt} represents firm revenues in goods or services, τ^G_{jt} is the import tariff on goods associated with industry j, X_{ijt} is the set of firm-level control variables, ϕ_i and θ_t are firm and year fixed effects, respectively, and ξ_{jt} is a 2-digit industry time trend. We cluster standard errors at the 4-digit industry level, the level of variation of our regressor of interest.

3.1. Firm Response to Import Competition

As discussed, our primary regressor of interest is the E.U. goods import tariff. Table 1 presents the estimates.

3.2. Determinants of Firms' Response to Import Competition

We next run a regression in which the ratio of services to goods revenues is the dependent variable and the coefficient on the import tariff is now allowed to vary across firms – i.e., we allow for firm heterogeneity in the response to trade liberalization. We first note that by taking the ratio of revenues we create an unbounded dependent variable, and so it is not clear that

heteroskedasticity is an issue in this case. If it is not, then the error term will no longer be (potentially) correlated with the regressors in the mechanical way pointed out by Santos Silva and Tenreyo (2006). However, zeroes will still be dropped in a linear-in-logs regression (i.e., when no services are produced) and the sample will therefore be censored, leading to inconsistent estimates. We therefore prefer to once again consider and compare estimates from the PPML and linear-in-logs specifications previously adopted, where the PPML estimates reflect the "true" aggregate effect – i.e., they reflect $E[R_{it}|x]$, which is the effect due to firms that are just beginning to produce services when they previously produced none as well as the effect due to an increase in existing services provision.

As noted, we allow for a fully flexible firm response to variation in import tariffs, which the model indicates may be due to heterogeneity across firms in the stock of industry-specific expertise. In order to determine the firm features that correlate with production flexibility in the face of import competition, we take a two-step approach. In the first stage we estimate the non-parametric regression in which the industry-varying tariffs are interacted with firm fixed effects. We then use the estimated coefficients as the dependent variable in a second stage regression in order to explore the firm-level correlates of the magnitude of the response to tariff reductions – i.e., the relevant proxies for firm expertise represented by T_i. The first stage specification is given by:

$$R^S_{ijt} / R^G_{ijt} = exp\left[\sum_{h=1}^{N} \psi_{hj}\eta_{hj} + \sum_{h=1}^{N} \lambda_{hj}(\eta_{hj} \times \ln \tau^G_{jt}) + \ln \epsilon_{ijt}\right] \tag{13}$$

where h and i index firms; N is the number of firms in our sample; η_{hj} is a dummy variable equal to zero except for firm h in industry j; ψ_{hj} and λ_{hj} are coefficients to be estimated; τ^G_{jt} is defined as above; and ϵ_{ijt} is a random error term.

The coefficients on the firm fixed effects, ψ_{hj}, represent the mean (log) services-to-goods ratio for each firm when tariffs are zero. The coefficients on the interaction term, λ_{hj}, represent the firm-specific response to a percent decline in tariffs. In the second stage we therefore regress the estimated λ_{hj} on a vector of firm characteristics consisting of the variables outlined in Section **2.2.3.** Again, the list includes skilled workers, investments in technology and the firm's stock of research and development.

Table 2 presents some preliminary results.

4. Concluding Remarks

A Figures and Tables

Effect of Import Competition on Firm Sales of Goods and Services

Dependent Variable:	Rev_{Serv}	Rev_{Serv}	Rev_{Goods}	Rev_{Goods}
EU Goods Import Tariffs	-0.53*** (0.11)	-0.22*** (0.02)	0.39*** (0.10)	0.11*** (0.04)
$\overline{w}_{ijt}$	0.14** (0.08)	0.10* (0.07)	0.15*** (0.02)	0.11*** (0.02)
Software Invest.		0.37*** (0.15)		-0.05 (0.03)
Internet Sales		0.68** (0.37)		0.24* (0.17)
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry Time Trend	Yes	Yes	Yes	Yes

Correlates of the Firm-Specific Response to Import Competition

Dependent Variable:	$\hat{\lambda}_{ij}$	$\hat{\lambda}_{ij}$	$\hat{\lambda}_{ij}$	$\hat{\lambda}_{ij}$
ln(R & D Stock)	-0.16*** (0.01)	-0.09*** (0.02)	-0.08** (0.04)	-0.08** (0.04)
ln(GVA/worker)		-0.04** (0.02)	-0.04* (0.02)	-0.04* (0.02)
ln(Capital Share)			-0.15 (0.16)	-0.15 (0.16)
ln(Outsourced Input Share)				-0.17* (0.11)

B Variable Definitions

For our primary regressors we list here the directions provided to respondents in the ARD survey.

Value of Sales of Goods of Own Production (R_{iG})

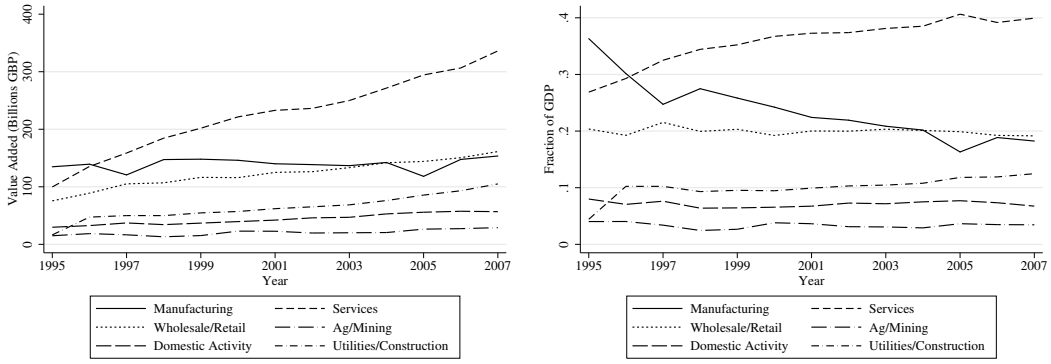
- Sales of goods made by you or for you by others from materials supplied by you;
- Sales of waste products, residues and scrap.

Value of Industrial Services Provided By You (R^{I}_{iS})

- Payments received for entry, exit, system and infrastructure charges;
- Option fees and net amounts receivable under contracts for differences;
- Any repairs, maintenance and installation provided by you to customers.

Value of Non-Industrial Services Provided By You (R^{NI}_{iG})

- Management Fees;
- Income derived from the renting of property;
- Services provided to other organisations such as amounts charged for hiring out plant, machinery and other goods, the provision of transport, computer processing, technical research and studies;



(a) Total Value Added

(b) Fraction of UK Economy

Figure 1: U.K. GDP by Sector

- Amounts received for the right to use patents, trademarks, copyrights, etc., manufacturing rights, technical know-how and advertising revenue;
- Royalty payments received;
- Use of system charges;
- Transport and delivery charges where possible.

C EU Regional Trade Agreements, 1997-2007

The following are regional trade agreements that entered into force during the period we cover.[6] These negotiated tariffs are included along with MFN tariffs in our analysis.

EU-Chile Association Agreement

- Entered into force on interim basis on 1 February, 2003
- Entered fully into force on 1 March, 2005

EU-Mexico Economic Partnership, Political Cooperation and Cooperation Agreement

- Free trade area entered into force in 2000

EU-South Africa Trade, Development and Co-operation Agreement

- Entered into force on a provisional basis since 2000, in full force in 2004.
- Progressively introduced a free trade area.

EU-Gulf Co-operation Council (GCC) Free Trade Agreement

- GCC countries include Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates
- Introduced a free trade area that entered into force in 2003

[6] Note that there were no RTAs negotiated prior to our period.