Sorting It Out:
Technical Barriers to Trade and Industry Productivity*

Gabriel J. Felbermayr and Benjamin Jung†
Eberhard Karls University, Tübingen, Germany

December, 2007

Abstract

The focus of theoretical trade policy analysis traditionally is on variable trade costs. However, in the political discussion, technical barriers to trade (TBT), i.e., the regulatory costs of foreign market access have become increasingly important. We study TBT liberalization in a heterogeneous firms model with variable degrees of scale economies on the aggregate level. TBT reform affects equilibrium input diversity and the productivity distribution. Compared to lower variable trade costs, TBT deregulation may have very different reallocation effects. Industry productivity improves only if the scale effect and the productivity dispersion are strong enough. A simple calibration suggests that this condition may not be met in some industries.

Keywords: Heterogeneous firms, international trade, single European market, technical barriers to trade, regulatory costs.

JEL-Codes: F12, F13, F15

*We are grateful to David Greenaway, Julien Prat, Davide Sala, and seminar participants at the OeNB Workshop 2007 on International Trade and Domestic Growth and at Tübingen university for comments and discussion. All remaining errors are ours. This is a preliminary draft; please do not circulate.

†E-mail: gabriel.felbermayr@uni-tuebingen.de; benjamin.jung@uni-tuebingen.de. Address: Economics Department, Eberhard Karls University Tübingen, Nauklerstrasse 47, 72074 Tübingen, Germany.

1 Introduction

In the last fifty years, import duties on most relevant manufacturing goods have fallen substantially, at least in developed countries. A rising fraction of total trade is covered by free trade agreements and hence totally exempt from tariffs. Yet, even within the European Union, in 2003, on average only 10% of spending falls on products from other EU15 countries (Delgado, 2006). Chen (2004) explains this striking fact by the existence of non-tariff barriers to trade. Indeed, the World Trade Organization (WTO) and the European Commission, have since long identified *technical barriers to trade* (TBT) as potential obstacles towards goods market integration, but progress towards eliminating those barriers has been slow.

TBTs impose additional costs on firms willing to export to some foreign market. Those costs arise when producers must customize their goods to meet national technical standards, or norms relating to human health and the safety of the environment. They are associated to product labeling and conformity assessment procedures.

Both the European Union (EU) and the WTO acknowledge that entry regulation may serve a multitude of legitimate goals; however, entry rules that effectively protect incumbent domestic firms against foreign competition are deemed discriminatory and are hence illegal.[1] The EU champions *mutual recognition* of technical standards. However, Ilzkovitz, Dierx, Kovacs, and Sousa (2007) argue that while about 20% of industrial production and about 26% of intra EU manufacturing trade are covered by mutual recognition, "practical implementation [...] is often hampered by legal uncertainty, administrative hassle and lack of awareness both from the side of the companies and of the Member States' authorities" (p. 61).

Discriminatory use of regulation is notoriously hard to detect; nevertheless, the number of TBT-related complaints notified to the WTO has grown from 365 in 1995 to almost 900 in

[1] The EU tackles TBTS under its Single Market Programme (SMP) which essentially champions the principle of mutual recognition: a product that is lawfully marketed in one EU country should be allowed to be marketed in any other EU country even when the product does not fully comply with the technical rules in the destination country. However, there is the option of refusing the marketing for protection of public safety, health, and the environment. (Articles 28 and 30 of the EC Treaty, similar regulation appears in the WTO TBT Agreement in Article 2.)

2006 (WTO, 2007). Similarly, Conway, Janod, and Nicoletti (2005) document the persistence of discriminatory regulation in the OECD. The stringency of regulatory barriers to trade has increased in many EU countries from 1995-2005, according to the Fraser Institute (see Gwartney, Lawson, Sobel, and Leeson, 2007).

In this paper, we analyze the effects of TBT liberalization on industry productivity. We consider two scenarios. In the first, we assume that any good sold in a market needs to undergo some costly licensing procedure, but there is no discrimination between imported and domestic goods. We then study the effects of lower licensing costs. In the second scenario, there is discriminatory regulation and we analyze the reduction of those costs. Following Baldwin and Forslid (2006), these scenarios are called *domestic de-regulation* and *lower fixed-cost protection*.

As a modeling shell, we use a version of the Melitz (2003) model. Producers of intermediate inputs (components) differ with respect to their productivity and interact in monopolistic competition. They face fixed distribution costs on domestic and foreign markets. TBTs increase foreign market access costs. We deviate from Melitz and allow for a more general CES aggregator that allows the degree of Ethier (1982)-type external scale effects to vary, thereby relaxing the often made implicit assumption that the marginal productivity gain from components is completely pinned down by the elasticity of substitution (e.g., Krugman, 1980; Melitz, 2003).[2] In recent work, Corsetti, Martin, and Pesenti (2007) find that welfare effects of variable trade cost liberalization strongly hinge on the parametrization of love for variety in a standard dynamic general-equilibrium model with homogeneous firms. Ardelean (2006) provides convincing empirical evidence that the scale effect (which is, of course, isomorphic to the love-for-variety effect) exhibits important cross-industry variation and is, in general, lower than the implicitly assumed value in Krugman (1980) or Melitz (2003) type models. This, in turn, has important implications for the productivity effect of input diversity.

We show that lowering TBTs has different productivity implications than reducing variable trade costs, and that the effect can actually be negative. Our argument contrasts with claims in

[2]Actually, the flexible parametrization of the external scale effect goes back to the working paper version of the seminal work by Dixit and Stiglitz (1975). The critique of the arbitrary link between the elasticity of substitution and the marginal productivity gain from components has been put forward by Benassy (1996).

the literature, that TBT reform and variable trade cost reductions lead to qualitatively similar results (Baldwin and Forslid, 2006; Baller, 2007).

TBT reform potentially affects industry productivity through four channels. First, lower discriminatory costs of market access induce more firms to enter the foreign market. This induces a reallocation of market shares and resources away from inefficient (*selection effect*) and efficient firms (*adverse export selection effect*) to new exporters. Depending on the shape of the productivity distribution, the adverse export selection effect offsets the selection effect, thus potentially lowering the productivity of the average firm in response to a TBT reform.[3] Variable trade cost reduction, in contrast, unambiguously reallocates resources towards the most efficient producers.

Second, to the extent that there are economies of scale at the industry level, industry productivity depends not only on the average input producer's productivity but also on the number of available input varieties. TBT liberalization tends to increase the number of available varieties. When the *scale effect* is strong enough, the ambiguity related to the average producer's productivity is resolved. In Melitz (2003), the scale effect is implicitly fixed, so that improved input diversity always overcompensates lower industry productivity.

Third, there is a potential direct *resource saving effect* of lower regulatory costs which may increase the amount of final output per worker in the industry. However, in our model, the resource-saving effect is exactly offset by additional entry so that TBT does not affect productivity through this channel.

Fourth, additional entry may increase competition and reduce the dead-weight loss associated to the existence of monopoly power. In our framework with constant elasticity of substitution between varieties, markups are constant and TBT reform does not lead to *pro-competitive productivity gains*.[4]

[3]These effects rely on firm heterogeneity. Firms select themselves into exporting according to their productivity. There is overwhelming empirical evidence that this is indeed the case, see the survey by Helpman (2006).

[4]There are a number of interesting papers that address pro-competitive effects with heterogeneous firms, e.g., the work by Melitz and Ottaviano (2007). In that framework, there is no natural role for fixed foreign market access costs (and hence TBT), since the partitioning of firms into exporters and domestic sellers is achieved by

We derive the conditions under which TBT reform improves industry productivity, assuming that the sampling distribution of firm productivities is Pareto.[5] TBT liberalization improves productivity if and only if the degree of external economies of scale and the dispersion of firm-level productivity are both sufficiently large. Drawing on recent estimates of those two key parameters (Corcos, Del Gatto, Mion, and Ottaviano, 2007, and Ardelean, 2006), we provide a simple numerical exercise which shows that the average productivity of component producers is likely to decrease in response to a TBT reform, while the effect on industry productivity crucially hinges on the importance of the external scale effect.

Our paper is related to a number of studies, most of them inspired by the SMP. Smith and Venables (1988) simulate the abolishment of trade barriers in terms of tariff equivalents between European countries, and predict substantial welfare gains for several industries. The simulation is based on a Krugman (1979) model of international trade with homogeneous firms. A similar simulation is done by Francois, Meijl, and van Tongeren (2005). They analyze a simultaneous cut in tariffs and TBTs, and obtain an additional real income of 0.3% to 0.5% of global GDP, depending on the country coverage. More recently, Del Gatto, Mion, and Ottaviano (2006) and Corcos, Del Gatto, Mion, and Ottaviano (2007) focus on the productivity effects of intra-EU variable trade costs reduction under quasi-linear preferences with heterogeneous firms and provide simulation results. Our paper complements their work, as we use the Melitz (2003) model as a point of departure and relate TBT to fixed costs.

The remainder of the paper falls into five chapters. Chapter 2 introduces the analytical framework, while Chapter 3 solves for general equilibrium and derives a first lemma on the non-existence of a resource saving effect. Chapter 4 theoretically analyzes the productivity effects of TBT reforms, and Chapter 5 provides a numerical exercise to illustrate the size of the effects for different industries. Finally, Chapter 6 concludes.

---

the linearity of the demand system.

[5] This is a common assumption which receives satisfactory empirical support, see, e.g., Helpman, Melitz, and Yeaple (2004).

2 Theoretical framework

2.1 Demand for components

We study a single market (such as the EU) with $n+1$ identical countries. Each country is populated by a representative consumer who has Cobb-Douglas preferences for final consumption goods produced by H industries. Final output producers in each industry h are perfectly competitive. They assemble their output using a continuum of components $q(\omega)$ according to the same constant elasticity of substitution (CES) production function

$$y_h = M_h^{\frac{\eta_h - 1}{\sigma_h - 1}} \left(\int_{\omega \in \Omega_h} q(\omega)^{\frac{\sigma_h - 1}{\sigma_h}} d\omega \right)^{\frac{\sigma_h}{\sigma_h - 1}}, \sigma_h > 1, \eta_h \geq 0. \quad (1)$$

The set Ω_h represents the mass of available components in industry h, and σ_h is the elasticity of substitution between any two varieties in that industry. M_h is the measure of Ω_h and gives the number of differentiated components available. The generalized CES aggregator parametrizes industry externalities: component producers do not internalize the effect of their entry decisions on industry productivity. $\eta_h / (\sigma_{h-1})$ measures the final output producer's marginal productivity gain from spreading a given amount of expenditure over a basket that includes one additional component.[6]

For $\eta_h = 1$, expression (1) is analogous to the standard CES production function (as used in Melitz, 2003), where the industry externality is completely pinned down by the elasticity of substitution σ_h. If $\eta_h = 0$, variation in the number of available components leaves productivity completely unaffected. This generalization is already discussed in the working paper version of the Dixit-Stiglitz (1977) paper and has been revived by Benassy (1996). Variants of it have been adopted by Blanchard and Giavazzi (2003), Egger and Kreickemeier (2008), and Corsetti, Martin, and Pesenti (2007), as the more general CES aggregator turns out to yield theoretical predictions which are more in line with empirical observations. Recently, Ardelean (2006) provides empirical estimates for η_h and shows that $\eta_h \in [0, 1]$, thereby rejecting the usual

[6] To see this, assume that all inputs have the same price p and that industry spending on inputs equals R_h. Then, $q(\omega) = R_h / M_h p$. Evaluating the integral in (1), one has $y_h = M_h^{\eta_h/(\sigma_h - 1)} R_h / p$.

assumption $\eta_h = 1$.

The optimal demand quantity for each component ω is

$$q(\omega) = M_h^{\eta_h - 1} \frac{R_h}{P_h} \left(\frac{p(\omega)}{P_h} \right)^{-\sigma_h}, \tag{2}$$

where R_h is aggregate industry spending on inputs, $p(\omega)$ is the price charged by a composite producer to the final output producers, and

$$P_h = M_h^{-\frac{\eta_h - 1}{\sigma_h - 1}} \left(\int_{\omega \in \Omega_h} p(\omega)^{1-\sigma_h} d\omega \right)^{\frac{1}{1-\sigma_h}}. \tag{3}$$

is the price index dual to (1).

2.2 Components production

Differentiated components are produced by a continuum of monopolistically competitive firms, who disregard the effect of their actions on the overall price level P_h and their externality on industry productivity. Each industry draws on a single industry-specific input L_h, which is inelastically supplied in equal quantities to all industries in all countries. Industry specificity of inputs and the Cobb-Douglas utility function make sure that trade reforms generate only within rather than between-industry resource reallocation.[7]

Component producers differ with respect to their productivity φ, but share the same domestic and foreign market entry costs, f_h^d and f_h^x, respectively, and the same variable trade costs $\tau_h \geq 1$, which we assume to have the usual iceberg form. All fixed costs have to be incurred in terms of the industry-specific resource. Fixed market costs have a technological component $\bar{f}_h$ that reflect distribution costs, and a regulatory component $\tilde{f}_h$ that capture costs of approval and conformity assessment. The latter is set by national authorities, but differs from a tax since it does not generate revenue.

Let $T_h = f_h^x / f_h^d$ measure the competitive disadvantage of importers relative to domestic component producers and consider the following scenarios. In the first, both domestic and

[7] Allowing for between-industry mobility of factors of production would require a different theoretical framework, see Bernard, Redding, and Schott (2007).

imported components have to meet national requirements, but are treated equally in the approval procedure. Then $\tilde{f}_h^d = \tilde{f}_h^x$. If, moreover, both types of firms share the same distribution costs, $\bar{f}_h^d = \bar{f}_h^x$, we have $T_h = 1$, and entry into production and exporting are purely driven by national regulation. In the second, like under mutual recognition each product that is approved domestically can be exported. However, there are regulatory costs from gathering information and redundant testing and certification procedures. If

$$\tau_h^{\sigma_h - 1} T_h > 1, \tag{4}$$

not all domestic producers find it optimal to engage in exports, since revenues – diminished by the existence of variable trace costs – do not suffice to pay for fixed regulatory and distribution costs.

Following Melitz (2003), productivity levels are drawn prior to entry from a cumulative distribution $G_h(\varphi)$ at a cost f_h^e in terms of labor. Not all firms that have paid the entry fee f_h^e are efficient enough to even bear domestic distribution costs. Hence, there will be cut-off productivities $\varphi_h^* < (\varphi_h^x)^*$, which partition the distribution of component producers into inactive firms, purely domestic ones, and exporters.

We choose a distribution function for φ which does not feature mass points, so that we can identify each differentiated component by the productivity level of the firm which produces that component. The production function is linear: $q(\varphi) = \varphi l_h(\varphi)$, where $l_h(\varphi)$ denotes the number of industry-h specific workers employed by firm φ.

Profit maximization of component producers results in the standard rule for determining the ex-factory (f.o.b.) price

$$p_h(\varphi) = \frac{w_h}{\rho_h \varphi}, \tag{5}$$

where $\rho_h = 1 - 1/\sigma_h$. Since the description of technology (1) is identical over all countries, we may pick the factor price specific to some industry, w_h, as the numeraire. In the following, we focus on that industry.

Using optimal demand (2) and the pricing rule (5), one obtains that revenues earned on the domestic market are given by

$$r_h^d(\varphi) = R_h (P_h \rho_h \varphi)^{\sigma-1} / M_h^\eta, \tag{6}$$

where R_h denotes aggregate revenue. It follows from (6) that the ratio of any two firms' revenues only depends on the ratio of their productivity levels

$$\frac{r_h^d(\varphi_1)}{r_h^d(\varphi_2)} = \left(\frac{\varphi_1}{\varphi_2}\right)^{\sigma_h - 1}. \tag{7}$$

A component producer generates revenue depending on her export status

$$r_h(\varphi) = \begin{cases} r_h^d(\varphi) & \text{if the firm does not export} \\ r_h^d(\varphi) + n r_h^x(\varphi) = r_h^d(\varphi)\left(1 + n\tau_h^{1-\sigma}\right) & \text{if the firm exports.} \end{cases} \tag{8}$$

Clearly, if the firm φ finds it optimal to sell in one market, by symmetry it finds it optimal to sell in all n foreign markets. Similarly, profits can be stated as

$$\pi_h(\varphi) = \begin{cases} \frac{r_h^d(\varphi)}{\sigma_h} - f_h^d & \text{if the firm does not export} \\ \frac{r_h^d(\varphi)}{\sigma_h}\left(1 + n\tau_h^{1-\sigma}\right) - f_h^d(1 + nT_h) & \text{if the firm exports.} \end{cases} \tag{9}$$

2.3 Within-industry aggregation

Recall that any component producer with productivity draw $\varphi < \varphi_h^*$ immediately exits and never produces. Then the ex-ante probability of successful entry into component production is given by $p_h^{in} = 1 - G_h(\varphi_h^*)$. Analogously, $p_h^x = \frac{1-G\left[\left(\varphi_h^x\right)^*\right]}{1-G\left(\varphi_h^*\right)}$ represents the *ex-ante* (and *ex-post*) probability that one of these successful entrants will export. Let M_h^d be the equilibrium mass of domestic component producers. Then the mass of exporters is given by $M_h^x = p_h^x M_h^d$, and the mass of totally available components is $M_h = M_h^d + nM_h^x = M_h^d(1 + np_h^x)$.

The entry cutoff φ_h^* defines the average productivity level of domestic component producers $\tilde{\varphi}_h^d$

$$\left(\tilde{\varphi}_h^d\right)^{\sigma_h - 1} = \frac{1}{1 - G(\varphi_h^*)} \int_{\varphi_h^*}^{\infty} \varphi^{\sigma-1} g_h(\varphi)\, d\varphi; \tag{10}$$

$\tilde{\varphi}_h^x$ is defined analogously. Then the weighted average productivity level of component producers is given by

$$\tilde{\varphi}_h^{\sigma_h-1} = \frac{1}{1+np_h^x}\left[\left(\tilde{\varphi}_h^d\right)^{\sigma_h-1} + np_h^x\left(\tau^{-1}\tilde{\varphi}_d^x\right)^{\sigma_h-1}\right]. \tag{11}$$

Note that $\tilde{\varphi}_h$ does not depend on masses M_h^d and M_h^x. The choice of weights implies that $q\left(\tilde{\varphi}_h\right) = R_h M_h^{-\frac{\eta_h+\sigma_h-1}{\sigma_h-1}}/P_h$. In the absence of industry externalities, i.e., if $\eta = 0$, the weighting implies that the output quantity of the average firm is identical to the average output $R_h/\left(P_h M_h\right)$. As in Melitz (2003), the weighted average $\tilde{\varphi}_h$ determines aggregate variables in the industry. Applying the definition of $\tilde{\varphi}_h$ (11) to the dual industry price index in (3) implies

$$P_h = M_h^{-\frac{\eta_h}{\sigma_h-1}} p\left(\tilde{\varphi}_h\right). \tag{12}$$

Clearly, if $\eta = 0$, then $P_h = p\left(\tilde{\varphi}_h\right)$, so that the price index is equal to the price chosen by the average firm.

Aggregate revenue is given by $R_h = M_h r^d\left(\tilde{\varphi}_h\right)$, which implies an expression for the number of available components

$$M_h = \frac{R_h}{r^d\left(\tilde{\varphi}_h\right)}. \tag{13}$$

The industry productivity level A_h is just the inverse of its price level. Using the expression for the price index (12) together with optimal pricing of components (5), we may write

$$A_h = M_h^{\frac{\eta_h}{\sigma_h-1}}/p\left(\tilde{\varphi}_h\right) = M_h^{\frac{\eta_h}{\sigma_h-1}}\rho\tilde{\varphi}_h. \tag{14}$$

The industry productivity level A_h depends on both, the average productivity level of component producers $\tilde{\varphi}_h$ and the mass of available components M_h. However, the mass is scaled by the degree of the industry externality. The productivity elasticity of M_h is given by $\eta_h/\left(\sigma_h-1\right)$; both, changes in the parameter η_h and in the elasticity of substitution σ_h, shape the productivity effects of increased diversity. The larger σ_h, the smaller the degree of concavity in each components' contribution to total production $q\left(\omega\right)^{1-1/\sigma_h}$, and the weaker it the direct productivity advantage of increased availability of different components. If $\eta_h = 0$, industry productivity is independent of M_h and is fully determined by $\tilde{\varphi}_h$. If $\eta_h = 1$, (14) is formally equivalent to the expression describing total welfare in Melitz (2003). In the following, we solve for the equilibrium mass of available components and the average productivity level of component producers, and analyze how M_h and $\tilde{\varphi}_h$ respond to TBT liberalization.

3 Equilibrium

We need to determine the equilibrium values of the average productivity of component producers, $\tilde{\varphi}_h$, and the total number of components available M_h. The equilibrium is well defined for a very large class of productivity distribution functions. However, since the comparative statics with respect to TBTs turn out to be potentially ambiguous in general, we follow Melitz, Helpman, and Yeaple (2004), or Egger and Kreickemeier (2008) and use the Pareto distribution to obtain algebraic expressions for the interesting endogenous variables. The Pareto distribution is characterized by two parameters: a shape parameter $\gamma_h > \sigma_h - 1$ which controls the skewness of the distribution[8], and a scale parameter φ_h^0 which captures the lower bound of productivity levels. Larger values of γ_h characterize industries in which the productivity distribution is skewed towards inefficient component producers. The scale parameter φ_h^0 captures the lower bound of productivity levels.[9]

Equilibrium is characterized by four conditions:

Zero cutoff profit conditions (ZPCs). The first two conditions identify the productivity levels of the firm that just finds it optimal to take up production φ_h^*, and of the marginal exporter $(\varphi_h^x)^*$

$$\pi_h^d(\varphi_h^*) = 0, \pi_h^x[(\varphi_h^x)^*] = 0. \tag{15}$$

Making use of (7), the zero cutoff profit conditions imply that $(\varphi_h^x)^*$ can be written as a function of φ_h^*

$$\frac{r^x[(\varphi_h^x)^*]}{r^d(\varphi_h^*)} = \tau_h^{1-\sigma_h}\left(\frac{(\varphi_h^x)^*}{\varphi_h^*}\right)^{\sigma_h-1} = T \Leftrightarrow (\varphi_h^x)^* = \varphi_h^* \tau T^{\frac{1}{\sigma_h-1}}. \tag{16}$$

[8]The assumption $\gamma_h > \sigma_h - 1$ makes sure that the equilibrium sales distribution has finite variance.

[9]The Pareto distribution is empirically motivated by Axtell (2001) and takes the form $G_h(\varphi) = 1 - \left(\frac{\varphi_h^0}{\varphi}\right)^{\gamma_h}$.

Moreover, the zero cutoff profit conditions along with (7) yield an expression for revenues earned on the domestic market

$$r_h^d(\varphi) = \left(\frac{\varphi}{\varphi_h^*}\right)^{\sigma_h - 1} \sigma_h f_h^d. \tag{17}$$

Free entry. The free entry condition ensures that ex ante expected profits $\bar{\pi}_h$ cover entry costs f_h^e :

$$f_h^e = \frac{p_h^{in}}{\delta_h}\bar{\pi}_h, \tag{18}$$

where $\bar{\pi}_h = \pi_h^d\left(\tilde{\varphi}_h^d\right) + np_x^x \pi_h^x\left(\tilde{\varphi}_h^x\right)$, and δ_h is the exogenous Poisson destruction rate at which component producers are forced to exit. Recall that $p_h^{in} = 1 - G\left(\varphi_h^*\right)$ denotes the ex-ante probability of successful entry. Along with the zero cutoff profit conditions (15), the free entry condition determines the entry cutoff productivity level φ_h^*

$$\varphi_h^* = \varphi_h^0 \left\{ \frac{\sigma_h - 1}{\gamma_h - (\sigma_h - 1)} \frac{f_h^d}{\delta_h f_h^e} \left(1 + n\tau_h^{-\gamma_h} T_h^{-\frac{\gamma_h - (\sigma_h - 1)}{\sigma_h - 1}} \right) \right\}^{\frac{1}{\gamma_h}}. \tag{19}$$

The fraction of component producers that export p_h^x is given by

$$p_h^x = \tau_h^{-\gamma_h} T_h^{-\frac{\gamma_h}{\sigma_h - 1}}, \tag{20}$$

and the export cutoff productivity level immediately follows from (16)

$$(\varphi_h^x)^* = (p_h^x)^{-\frac{1}{\gamma_h}} \varphi_h^*. \tag{21}$$

The cutoff productivity levels directly translate into the average productivity level of all firms and exporters, respectively,

$$\tilde{\varphi}_h^d = \left(\frac{\gamma_h}{\gamma_h - (\sigma_h - 1)}\right)^{\frac{1}{\sigma_h - 1}} \varphi_h^*, \tag{22}$$

$$\tilde{\varphi}_h^x = \tau_h T_h^{\frac{1}{\sigma_h - 1}} \tilde{\varphi}_h^d. \tag{23}$$

Moreover, one can compute $\tilde{\varphi}_h$ using its definition in (11)

$$\tilde{\varphi}_h = \tilde{\varphi}_h^d \left(\frac{1 + np_h^x T_h}{1 + np_h^x}\right)^{\frac{1}{\sigma_h - 1}}. \tag{24}$$

Stationarity condition. Finally, the fourth equilibrium condition relates the mass of entrants to the number of domestically produced varieties of components by the stationarity condition

$$p_h^{in} M_h^e = \delta_h M_h^d, \qquad (25)$$

which mandates that the mass of successful entrants $p_h^{in} M_h^e$ exactly replaces the mass $\delta_h M_h^d$ of component producers that are hit by a bad shock. Thus, aggregate revenue R_h is exogenously fixed by the size of the labor force L_h. Then, making use of (13) and (17), we obtain the equilibrium mass of components available

$$M_h = \frac{L_h}{\sigma_h f_h^d} \left(\frac{\varphi_h^*}{\tilde{\varphi}_h} \right)^{\sigma_h - 1}. \qquad (26)$$

4 Productivity effects of TBT reform

With heterogeneous firms, variable trade cost liberalization generally has implications for the *intensive* and the *extensive* margin: when trade costs costs fall, additional firms will start to export (extensive margin), and existing exporters and purely domestic firms will see their sales change (intensive margin). Crucially, while reductions in variable trade costs and TBT liberalization have qualitatively similar implications for the cut-off productivity levels φ_h^* and $(\varphi_h^x)^*$ (see the discussion in Baldwin and Forslid, 2006), they imply different patterns of within-industry resource reallocation and may yield opposite results concerning the productivity of the average producer. The literature has not yet fully recognized this point yet.

A reduction in regulatory fixed costs can come in different guises. In the simplest scenario, we assume that imported and domestic components have to meet national requirements, but that there is neither discriminatory regulation nor higher foreign distribution costs that drives foreign market access costs above the domestic levels. Hence, T_h is fixed to 1, and a relaxation of national requirements can be considered as a reduction in f_h^d. Following Baldwin and Forslid (2006), this scenario is called *domestic deregulation.* In the second scenario, we analyze a TBT reform that comes through a reduction in $\tilde{f}_h^x$, whereas domestic regulation costs $\tilde{f}_h^d$ are hold constant. Thus, we consider a cut in discriminatory technical requirements or, once the mutual recognition principle applies, a reduction in costs of gathering information and redundant testing and conformity assessment (*lower fixed-cost protection*).

A priori, the effect of TBT reform on productivity and hence welfare is ambiguous. The decentralized equilibrium does not necessarily feature the efficient amount of components producers if $\eta_h \neq 1$.[10] Neither do producers internalize the effect of entry on the external economies of scale in the industry nor on the profits of incumbent producers. If $\eta_h < 1$, there is over-supply of varieties, if $\eta_h > 1$ (which is empirically implausible) there is under-supply. Only in the special case where $\eta_h = 1$ does the planner solution coincide with the decentralized equilibrium. Hence, the potential negative effect of TBT reform on the average input producer's productivity therefore appear as a straight-forward application of *second-best theory.* Higher regulatory costs reduce entry and thereby mitigate the distortion due to external economies of scale. However, TBTs are not the first-best policy instrument to cope with industry externalities. They are always dominated by entry taxes to regulate input diversity, which would generate tax revenue instead of imposing wasteful red tape.

Before moving to a detailed analysis of within-industry resource reallocation along the two scenarios outlined above, it is worthwhile to inquire about potential resource savings from lower regulatory fixed costs (TBTs). Let F_h denote the number of workers[11] devoted to fixed costs of entry f_h^e, fixed domestic costs f_h^d, and fixed foreign market costs f_h^x. Making use of the stationarity condition (25), the free entry condition (18), the expression for profits (9), and the definition of the mass of components available (13), one obtains $F_h = L_h/\sigma_h$. Hence, irrespectively of the absolute size of f_h^e,f_h^d, and f_h^x, a constant share of the industry-specific labor force is used for the payment of fixed costs. Clearly, this result is specific to the CES production function with constant elasticity of substitution. In this case, the resource saving effect associated to a TBT reform is completely offset by additional entry. The result is summarized in Lemma 1.

Lemma 1 *In a stationary equilibrium, the number of workers devoted to fixed costs of entry, domestic regulation, and fixed costs associated with the foreign market is a constant share* $1/\sigma_h$

[10]Note that the results of Benassy (1996) on the comparison between the decentralized economy outcome and the planner solution continue to hold even in the presence of heterogeneous firms.

[11]Recall: by choice of numeraire, $w_h = 1$.

of the industry-specific labor force.

Proof. In the text. ■

From Lemma 1 it follows that lower regulatory fixed costs obtained either from domestic deregulation or lower fixed-cost protection does not induce resource saving since the share of workers devoted to the payment of fixed costs is constant.

4.1 Domestic deregulation

We shall now turn to the within-industry reallocation of market shares as a response to domestic deregulation. It immediately follows from log-linearizing equation (14) that the response of industry productivity to relaxation of national requirements is composed of changes in the number of inputs available (scale effect) and in the average productivity level of component producers:

$$\frac{\hat{A}_h}{\hat{f}_h^d} = \frac{\eta_h}{\sigma_h - 1}\frac{\hat{M}_h}{\hat{f}_h^d} + \frac{\widehat{\widetilde{\varphi}}_h}{\hat{f}_h^d}, \tag{27}$$

where a 'hat' denotes an infinitesimally small deviation of a variable from its initial level ($\hat{x} = dx/x$).

Differentiating (26), the direct effect on the mass of available inputs, M_h, is

$$\frac{\hat{M}_h}{\hat{f}_h^d} = -1 + (\sigma_h - 1)\left(\frac{\hat{\varphi}_h^*}{\hat{f}_h^d} - \frac{\widehat{\widetilde{\varphi}}_h}{\hat{f}_h^d}\right). \tag{28}$$

Domestic de-regulation makes it easier for unproductive firms to survive; equation (19) implies $\hat{\varphi}_h^*/\hat{f}_h^d = 1/\gamma_h$. Hence, domestic deregulation weakens the selection effect associated to fixed costs. With $T_h = 1$, the *ex ante* probability of exporting remains unchanged as f_h^d falls (see (20)). It follows from (21) that the change in the entry cutoff productivity level $\hat{\varphi}_h^*$ is exactly offset by the change in average productivity $\widehat{\widetilde{\varphi}}_h$. Hence, the second term in (28) is equal to zero, and the mass of inputs available unambiguously rises ($\hat{M}_h/\hat{f}_h^d = -1$).

Inserting these results into (27), for any γ_h, the effect of a change in f_h^d is given by

$$\frac{\hat{A}_h}{\hat{f}_h^d} = -\left(\frac{\eta_h}{\sigma_h - 1} - \frac{1}{\gamma_h}\right). \tag{29}$$

The following proposition is a direct implication.

Proposition 1 *The productivity of the final output good producer only increases in response to a domestic de-regulation, if the marginal gain from an additional component is larger than the inverse dispersion measure of the Pareto*

$$\frac{\eta_h}{\sigma_h - 1} > \frac{1}{\gamma_h}. \tag{30}$$

Proof. Follows from (29). ■

The elasticity of $\tilde{\varphi}_h$ with respect to f_h^d is given by $-1/\gamma_h$ (see equation (10) and (24)). Hence, the productivity of the average component producer falls. The larger γ_h, the more the distribution is skewed towards inefficient component producers, and the smaller is the claim on resources of these small producers when they take up exporting or start production. Hence, the smaller is the adverse effect on the average producer's productivity. To understand the adverse effect on $\tilde{\varphi}_h$ note that deregulation makes it easier for inefficient firms to start production and/or export. Industry resources being in limited supply, there must be some reallocation from more existing firms no start-ups and from incumbent exporters to new ones; see Figure 1 for illustration.[12] Hence, deregulation reduces average productivity $\tilde{\varphi}_h$.

However, the number of available components goes up, which enhances aggregate productivity; see (28). Input diversity M_h rises one-to-one as f_h^d falls. Hence, the aggregate productivity effect – which combines the beneficial diversity effect and the adverse effect on input producers' productivity – depends on the comparison between the marginal gain from increased variety, $\eta_h / (\sigma_h - 1)$ and the loss of input producers' average productivity $-1/\gamma_h$.

In the case of $\eta_h \geq 1$, the above inequality always holds (as we have assumed $\gamma_h > \sigma_h - 1$). Hence, domestic deregulation always makes the final goods producer more productive. However, this result is not general: in the empirically relevant case, where $\eta_h < 1$, the sign of $\hat{A}_h$ is ambiguous.

[12]Melitz (2003) uses this kind of representation from autarky to trade.

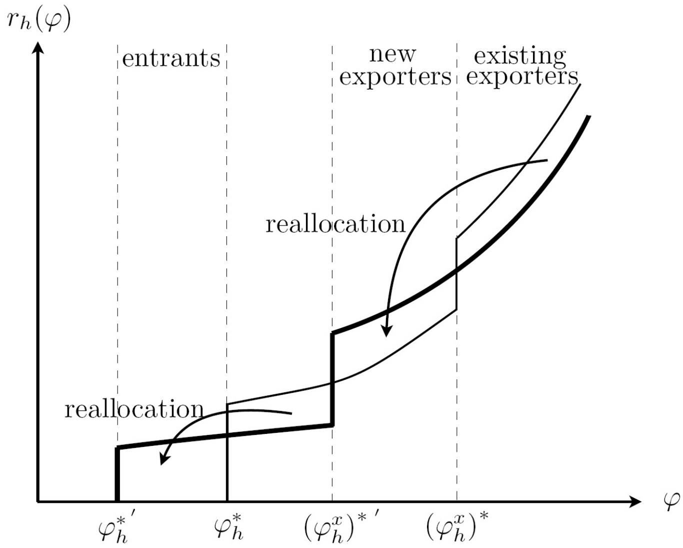

Figure 1: Within-industry reallocation of market shares as a response to domestic deregulation

4.2 Lower fixed-cost protection

As above, the change in industry productivity in response to lower fixed-cost protection is driven by two channels, and (27) becomes

$$\frac{\hat{A}_h}{\hat{T}_h} = \frac{\eta_h}{\sigma_h - 1}\frac{\hat{M}_h}{\hat{T}_h} + \frac{\widehat{\tilde{\varphi}}_h}{\hat{T}_h}. \tag{31}$$

Recall that in this scenario we analyze a TBT reform that comes through a reduction in $\tilde{f}_h^x$, whereas domestic regulation costs $\tilde{f}_h^d$ are hold constant. The mass of component producers responds to changes in the entry cutoff productivity level. Also, the average productivity level of component producers adjusts to changes in the cutoff productivity levels and to the probability of exporting. It turns out from our analysis that lower fixed-cost protection is certain to improve industry productivity only if $\eta_h \geq 1$. In the empirically relevant case of $\eta_h < 1$, however, the effect is ambiguous.

Average productivity of component producers. Although the less productive component producers are forced to exit, the within-industry reallocation mechanism towards more productive firms in case of a TBT reform is different from that operating under variable trade

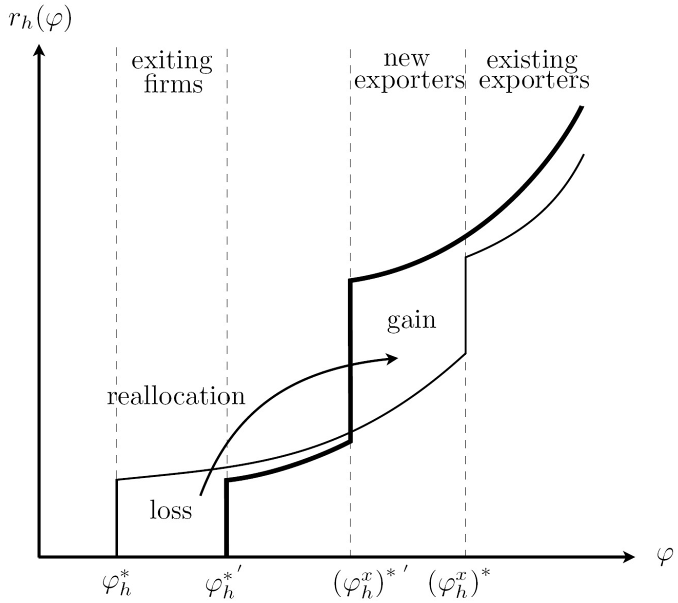

Figure 2: Within-industry reallocation of market shares as a response to variable trade cost liberalization.

cost liberalization.

Consider first the effect of a decrease in τ_h on the intensive and extensive margin. At the intensive margin, inspection of equation (17) shows that all firms lose a proportion of their domestic sales. However, as pointed out in Melitz (2003), the more productive ones who export make up their loss of domestic sales with increased export sales (see equation (8)). At the extensive margin, the least productive firms are forced to exit (selection effect), while new exporters enter (adverse export selection effect). Overall, there is a reallocation of revenues from less productive to more productive firms (reallocation effect), which unambiguously enhances the average productivity level of component producers. Thus, a cut in variable trade costs unambiguously leads to an increase in industry productivity for all degrees of external scale effects. The reallocation mechanism is illustrated in Figure 2.

Now consider a cut in $T_h > 1$, holding f_h^d constant. As above, all component producers lose domestic sales. However, incumbent exporters cannot make up for these losses as their sales do not depend on f_h^d. The least productive firms are driven out of the market (selection effect),

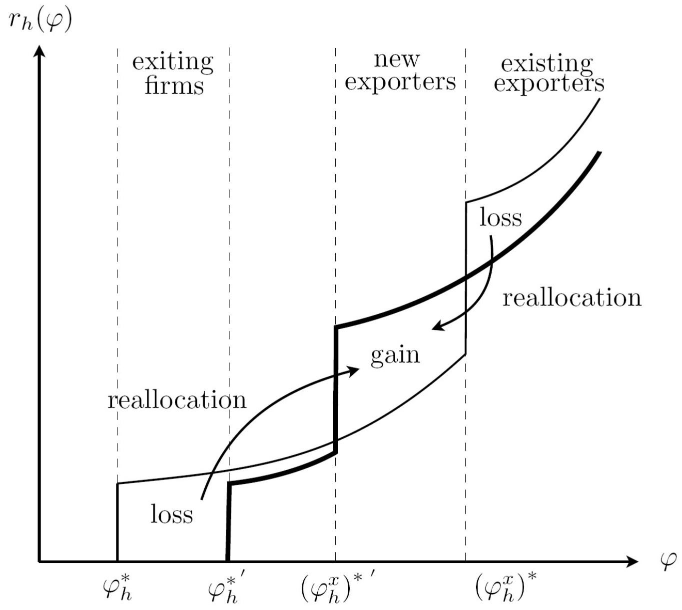

Figure 3: Within-industry reallocation of market shares as a response to TBT liberalization.

and some firms start exporting (adverse export selection effect). Only this group gains from a TBT reform. However, in this scenario there is reallocation of revenues from more productive to less productive firms (adverse reallocation effect). The overall effect on the average productivity level $\tilde{\varphi}_h$ then depends on the the countervailing effects of reallocation of revenues from the exiting firms to new exporters and reallocation from existing exporters to new exporters. Figure 3 visualizes the reallocation of market shares. $\tilde{\varphi}_h$ only increases in response to a cut in $T_h > 1$ if the shape parameter γ_h is large enough. The intuition is straightforward: The larger the shape parameter γ_h, the more mass is given to low productive firms, thus giving a high potential for reallocation from the low productive, exiting firms to the new exporters.

If the initial level of competitive disadvantage of importers is smaller than 1, $\tilde{\varphi}_h$ never increases in response to a TBT reform regardless of the shape parameter γ_h.

Let $\theta(T_h) \equiv 1/\left[1 + np_h^x\right]$ be the weight that is attached to the average domestic firm $\tilde{\varphi}_h^d$ in the calculation of the average productivity level of component producers (11). Then we may summarize the result in Lemma 2.

Lemma 2 *Fix f_h^d and reduce f_h^x. The productivity level of the component producer $\tilde{\varphi}_h$ increases in response to a cut in f_h^x if and only if the initial level $T_h > 1$ and the shape parameter of the Pareto distribution γ_h is large enough, i.e.*

$$\frac{1}{\gamma_h} < \frac{1}{\underline{\gamma}_h} \equiv \frac{1}{\sigma_h - 1}\sqrt{\theta_h \frac{T_h - 1}{T_h}}. \tag{32}$$

Proof. Follows immediately from totally differentiating (24). ■

External economies of scale. A decrease in the productivity level of the component producer $\tilde{\varphi}_h$ can potentially be offset by an increase in the mass of components available, and vice versa. However, for the scale effect to be positive, it is required that the shape parameter γ_h is not too large. The intuition is the following: the higher γ_h, the more mass is given to low productive firms, and the higher the mass of component producers that are forced to exit in response to a TBT reform. However, if $T < 1$, the mass of components available unambiguously increases. We summarize the result in Lemma 3.

Lemma 3 *Fix f_h^d and reduce T_h. The mass of available components M_h increases in response to a cut in T_h if and only if the shape parameter of the Pareto distribution γ_h is not too large, i.e.*

$$\frac{1}{\gamma_h} > \frac{1}{\bar{\gamma}_h} \equiv \frac{1}{\sigma_h - 1}\theta_h \frac{T_h - 1}{T_h}. \tag{33}$$

Proof. Follows immediately from totally differentiating (26). ■

Clearly, industry productivity increases in response to a TBT reform, if the shape parameter γ_h falls into the bracket

$$\bar{\gamma}_h > \gamma_h > \underline{\gamma}_h. \tag{34}$$

We now distinguish two cases: in the first case, condition (32) is violated. Then γ_h is too small or the initial level of $T_h < 1$ is such that the average productivity level of component producers decreases, while the mass of available components increases. It follows from Melitz (2003) that $\hat{A}_h/\hat{T}_h < 0$ for the special case $\eta_h = 1$. Moreover, inspection of (31) shows that $\hat{A}_h/\hat{T}_h > 0$ for $\eta_h = 0$. For the overall effect on industry productivity to be positive ($\hat{A}_h/\hat{T}_h < 0$), the scale of the mass effect has to be sufficiently large.

Consider now the case, where condition (33) is violated. Then the scale of the mass effect is required to be small enough to be completely offset by the average productivity effect. It turns out that this condition always holds if $\eta_h \leq 1$.

These results are summarized in the following Proposition

Proposition 2 *Define* υ^* *as*

$$\upsilon^* \equiv \frac{1}{\gamma_h - \bar{\gamma}_h} \left(\frac{\gamma_h}{\sigma_h - 1} - \frac{\bar{\gamma}_h}{\gamma_h} \right).$$

(i) Under the assumption that condition (32) is violated, industry productivity increases in response to a TBT reform, if and only if the industry externality is large enough, and decreases otherwise, i.e.

$$\frac{\eta_h}{\sigma_h - 1} > \upsilon^*, \tag{35}$$

where $0 < \upsilon^* < 1/(\sigma_h - 1)$.

(ii) Under the assumption that condition (33) is violated, industry productivity increases in response to a TBT reform, if and only if the industry externality is not too large, i.e.

$$\frac{\eta_h}{\sigma_h - 1} < \upsilon^*, \tag{36}$$

where $\upsilon^* > 1/(\sigma_h - 1)$.

Proof. The conditions follow from equation (27). ■

4.3 Comparing tariff and TBT liberalization

Recall the crucial mechanism that drives the difference between tariff and TBT liberalization. Tariff liberalization (or any reduction in variable trade costs) has a direct effect on inframarginal exporters' revenue: export sales go up, and so does the weight of existing exporters in the average productivity calculation. The movement on this intensive margin is strengthened by the fact that the marginal producer becomes more productive, but weakened by the fact that the marginal exporter is now less efficient than before. However, these extensive margin effects are second-order relative to the intensive margin. The net effect on $\tilde{\varphi}_h$ is therefore unambiguously positive.

Lower TBT-related costs, however, have a first-order effect on the extensive margin as new firms start exporting. Existing exporters – the most efficient firms in the industry – do not see increased sales. Quite the contrary, to make the expansion of low-productivity exporters possible, there must be reallocation of resources away from existing exporters and purely domestic firms.

However, it can be shown that total export sales always increase in response to lower fixed cost production.[13] Hence, the correlation between an increase in trade volume and industry productivity is ambiguous: If the increase comes about due to variable trade cost reduction, it is clearly associated with higher industry productivity. However, if the increase in trade volume is driven by a TBT reform, the effect on industry productivity depends on the strength of the external economies of scale as stated in conditions (35) and (36). This theoretical result rationalizes the empirical result by Baller (2007), who finds mixed evidence on the correlation between industry productivity and trade volume. It is also important for cross-country regressions which explain TFP by some measure of trade openness defined as export sales over GDP.[14]

Anecdotal evidence suggests that there is important resistance against TBT reform. Indeed, Gwartney, Lawson, Sobel, and Leason (2007) provide evidence that suggests that the EU25 countries have failed on average to decrease regulatory costs to importers. Our paper allows two interpretations of this result. First, based on efficiency considerations, TBT reform is not necessarily recommendable. Second, TBT reform – even if it leads to industry productivity gains – inflicts losses to the vast majority of firms due to the implied reallocation of resources towards new exporters, by nature a relatively small fraction out of all domestic firms. Hence, it may not be overly surprising that total resistance against TBT reform is strong, and, in particular, stronger than against trade liberalization that involves lower variable trade costs.

[13]Total sales abroad are given by $X_h^{cif} = nM_h^x r^x\left(\tilde{\varphi}_h^x\right)$. Recall that $M_h^x = p_h^x M_h^d$. Using (8), (25) and (26) one finds that $X_h^{cif} = L_h n p_h^x T_h / \left(1 + n p_h^x T_h\right)$, and $\partial X_h^{cif} / \partial T_h < 0$.

[14]Moreover, Gibson (2006) shows that the theoretical measures of industry productivity are not necessarily reflected in the data-based measure of productivity (e.g., value added per worker).

5 Numerical exercise at the industry level

In this chapter, we draw on estimates of the key parameters of our model from the literature, and calibrate the model accordingly. The numerical exercise serves several purposes. First, it allows to calibrate the degree of industry externalities $\eta_h/(\sigma_h - 1)$ and the level of competitive disadvantage of importers T_h. Second, it enables us to check the inequalities derived in the theoretical section of this paper and to sort out the ambiguous effects associated to domestic deregulation and lower fixed-cost protection on industry productivity. Finally, the exercise allows to compute the productivity gain relative to *status quo* achieved by setting T_h to the level which maximizes industry productivity A_h.

We find that average productivity of component producers is likely to fall in almost all of the 19 industries in response to lower fixed cost protection. While this finding is rather robust, the effect of TBT reform on industry productivity crucially depends on the strength of industry externalities.[15]

5.1 Calibration

In order to develop a rough understanding of the quantitative behavior of the model, we need to put numbers to the parameters. The key parameters are the strength of the external scale effect (η_h), the elasticity of substitution (σ_h) and the parameter governing productivity dispersion (γ_h). While Ardelean (2006) provides some convincing evidence on η_h for different industries, there do not exist estimates of elasticities of substitution and productivity dispersion on industry level that are estimated in a unified empirical framework and separately identified.

There are independent estimates on industry-level shape parameters, e.g., those suggested by Corcos, Del Gatto, Mion, and Ottaviano (2007)[16], and estimates of the elasticity of substitution,

[15]In the very different context of their open macro model, Corsetti, Martin, and Pesenti (2007) detect a similar lack of robustness.

[16]Corcos, Del Gatto, Mion, and Ottaviano (2007) use European firm-level data to estimate the within-industry productivity distribution, applying the Levinsohn and Petrin (2003) estimator, and fit a Pareto distribution for each industry. For all industries the regression fit (the adjusted R squared) is close to 1, suggesting that the Pareto is a good approximation of the productivity distribution.

e.g., Hummels (2001). Estimates of Pareto shape parameters γ_h on the two-digit industry level are on average close to 2, while those for the elasticity of substitution are usually much larger, ranging from $\sigma_h = 3.53$ for iron and steel to $\sigma_h = 11.02$ for electric machinery.[17] Unfortunately, comparing γ_h and σ_h reveals that the regularity condition that guarantees a finite variance of the truncated productivity distribution $\gamma_h > \sigma_h - 1$ only holds for a small subset of industries.

Without having alternative data at hand, we deal with this problem by using the following specifications. In a first specification we take the shape parameters from Corcos, Del Gatto, Mion, and Ottaviano (2007), and calibrate the elasticity of substitution to the industry sales dispersion measure $disp_h = \gamma_h - (\sigma_h - 1)$ obtained from Helpman, Melitz, and Yeaple (2004). Since $disp_h$ is close to 1 for all industries, we end up with $\sigma_h \approx 2$, which seems to be very small as compared to Hummels' (1999) estimates. Hence, this specification is referred to as the low-σ_h specification.

In the high-σ_h specification, we take the elasticity of substitution from Hummels (1999) and calibrate the shape parameters, again using the dispersion measure $disp_h$ obtained from Helpman, Melitz, and Yeaple (2004). Table 1 reports the parameters taken from the literature and the calibrated parameters for several industries.[18]

Corsetti, Martin, Pesenti (2007, p. 109) argue that there is no obvious benchmark value for η_h available. However, in a working paper Ardelean (2006) provides some convincing evidence on that parameter for different industries. She estimates the average US love of variety parameter (isomorphic to our η_h) is 42% lower than in the standard Dixit-Stiglitz case. Estimates are identified by decomposing the price index into a traditional part and the extensive margin, following the Feenstra (1994) method, and exploiting cross-importer variation. As the strength of the external scale effect is given by $\eta_h/(\sigma - 1)$, it is substantially larger under the low-σ_h than under the high-σ_h specification.

We take data on industry transport costs from Hanson and Xiang (2004). Using data on

[17] These data have been used extensively in the literature, e.g., by Hanson and Xiang (2004).

[18] We find neither significant correlation between the shape parameters obtained from Corcos, Del Gatto, Mion, and Ottaviano (2007) and those imputed from the elasticities of substitution nor between the elasticities of substitution from Hummels (2001) and their imputed counterparts.

freight rates for U.S. imports from Feenstra (1996), they identify the implicit U.S. industry freight rate (insurance and freight charges/import value), and regress it on log distance to the origin country. Transport cost for an industry are reported as projected industry freight rate from these coefficient estimates evaluated at median distance in their sample of importers and exporters.[19]

Finally, we derive values for the competitive disadvantage of importers T_h from calibrating the model to the export participation rate by industry obtained from Eaton, Kortum, and Kramarz (2004).[20] Using the expression for the export participation rate (20) and information on the shape parameter, the elasticity of substitution, and transport cost, one obtains values for T_h by industry.[21] The calibrated values of T_h vary between figures close to 1 and close to 4. This is well in line with the result of the calibration exercise by Ghironi and Melitz (2005), who argue that T_h is substantially above unity for the US. The correlation between the levels of competitive disadvantage of importers T_h obtained under the low- and high-σ_h specification is 0.76 and significant at the 1 percent level.

Table 1 summarizes the parameters taken from the literature and the calibrated parameters for several industries. It is, however, crucial to bear in mind that the parameter estimates used in the numerical exercise come from different sources, that cover different countries, and that are – judged by the theoretical requirements of our model – at least partially incompatible. Hence, for a more elaborate understanding of trade liberalization using approaches based on the Melitz (2003) model, we urgently need more econometric work aimed at structural estimation and identification of the key parameters.

[19]We are grateful to Gordon Hanson for providing their estimated freight rates and the elasticities of substitution.

[20]They report figures for France for 1986, based on Customs and BRN-SUSE data sources.

[21]We also use information on openness (40%), the average transportation costs, and the average T_h to calibrate the number of trading partners n.

Table 1: Parameter description

	Data			low σ_h			high σ_h		
				Data	Calibration		Data	Calibration	
Industry	τ_h	p_h^x	η_h	γ_h	σ_h	T_h	σ_h	γ_h	T_h
Organic chemicals	1.07	0.55	0.53	1.81	1.34	1.09	7.5	7.97	1.06
Dyeing, tanning, coloring	1.12	0.55	0.77	1.81	1.34	1.09	6.37	6.84	1.02
Pharmaceutical products	1.09	0.55	0.57	1.81	1.34	1.1	9.53	10	1.25
Essential oils	1.03	0.55	0.71	1.81	1.34	1.08	5.5	5.97	1.04
Plastics	1.09	0.44	0.7	2.37	2.51	1.42	5.8	5.66	1.16
Leather	1.07	0.26	0.48	2.35	2.51	2.12	8.92	8.76	1.91
Cork and wood	1.15	0.12	0.56	2.45	2.55	3.07	3.99	3.89	3.35
Paper products	1.14	0.45	0.78	1.97	1.94	1.29	4.25	4.28	1.19
Textile	1.11	0.24	0.59	2.25	2.29	1.97	7.82	7.78	1.7
Iron and steel	1.12	0.53	0.73	2.16	2.08	1.21	3.53	3.61	1.16
Nonferrous metals	1.06	0.53	0.71	2.21	1.78	1.2	6.66	7.09	1.23
Fabricated metal products	1.09	0.17	0.67	2.45	2.5	2.61	4.85	4.81	2.99
Machinery except electrical	1.07	0.27	0.39	2.35	2.25	1.86	7.98	8.07	1.99
Electric machinery	1.04	0.3	0.52	1.93	1.44	1.29	9.44	9.93	1.95
Road vehicles	1.1	0.33	0.55	2.06	1.67	1.35	7.11	7.5	1.41
Transport equipment	1.05	0.33	0.8	2.06	1.67	1.39	7.4	7.79	1.79
Wearing apparel	1.09	0.24	0.59	1.8	1.91	1.89	5.61	5.5	2.18
Footwear	1.1	0.26	0.63	2.35	2.51	2.03	7.22	7.06	1.76
Prof. and scientific equip.	1.05	0.13	0.42	1.84	1.51	1.7	7.43	7.76	3.89

Notes. τ_h from Hummels (1999); η_h from Ardelean (2006). T_h calibrated to meet export participation rate p_h^x from Eaton, Kortum, Kramarz (2004). n calibrated to meet openness of 40%. low-σ_h specification: σ_h computed from $disp_h$ using γ_h from γ_h from Corcos, Del Gatto, Mion, and Ottaviano (2007); $n = 5$. high-σ_h specification: γ_h computed from $disp_h$ using σ_h from Hummels (2001); $n = 4$.

5.2 Sorting out the ambiguities

Before quantifying the effects of TBT reform, we use the parameters discussed above to check the inequalities derived in the theoretical section of the paper. We find that the effect of TBT reform on industry productivity strongly depends on the calibration of γ_h and σ_h. The low-σ_h specification implies a larger degree of industry externalities, enabling the scale effect to overcompensate a deterioration in the average productivity level of component producers in more cases than under the high-σ_h specification.

Domestic deregulation. We have shown analytically that domestic deregulation always lead to a fall in the average productivity of component producers unambiguously declines and to a rise in the mass of available components. As a result, industry productivity rises ($\hat{A}_h/\hat{f}_h^d < 0$) if and only if the strength of the industry externality is large enough as compared to the degree of dispersion of the productivity distribution. The strength of the scale effect is calibrated to be higher under the low-σ_h than under the high-σ_h specification. Moreover, under the low-σ_h specification the productivity distribution is assumed to be more skewed towards the less productive firms than under the high-σ_h specification. Both facts together rationalize that domestic deregulation is likely to increase industry productivity in most industries under the first specification, while the scale effect is not efficient to offset the deterioration in the average productivity level of component producers under the second (see Table 2). However, in industries with relatively low value for η_h (leather, cork and wood, and machinery except electrical), the scale effect is not sufficiently large. Moreover, footware barely misses the inequality check.

Lower fixed-cost protection. In this scenario, also the directions of the effects on the mass and the average productivity of component producers are ambiguous from a theoretical point of view. However, under both of our specifications we find that both effects pretty much work like under domestic deregulation: the average productivity of component producers deteriorates in most industries in response to lower fixed-cost protection ($\widehat{\tilde{\varphi}}_h/\hat{T}_h > 0$), whereas more components become available ($\hat{M}_h/\hat{T}_h < 0$, see Table 2).

Again, the effect on industry productivity hinges on the relationship between the degree of

Table 2: Sorting out the ambiguities

	low σ_h				high σ_h			
Industry	$\frac{\hat{A}_h}{\hat{f}_h^d}$	$\frac{\widehat{\widetilde{\varphi}}_h}{\hat{T}_h}$	$\frac{\hat{M}_h}{\hat{T}_h}$	$\frac{\hat{A}_h}{\hat{T}_h}$	$\frac{\hat{A}_h}{\hat{f}_h^d}$	$\frac{\widehat{\widetilde{\varphi}}_h}{\hat{T}_h}$	$\frac{\hat{M}_h}{\hat{T}_h}$	$\frac{\hat{A}_h}{\hat{T}_h}$
Organic chemicals	-	+	-	-	+	+	-	+
Dyeing, tanning, coloring	-	+	-	-	+	+	-	+
Pharmaceutical products	-	+	-	-	+	+	-	+
Essential oils	-	+	-	-	+	+	-	+
Plastics	-	+	-	-	+	+	-	+
Leather	+	+	-	-	+	+	-	+
Cork and wood	+	-	-	-	+	+	-	-
Paper products	-	+	-	-	-	+	-	-
Textile	-	+	-	-	+	+	-	+
Iron and steel	-	+	-	-	-	+	-	-
Nonferrous metals	-	+	-	-	+	+	-	+
Fabricated metal products	-	+	-	-	+	+	-	-
Machinery except electrical	+	+	-	-	+	+	-	+
Electric machinery	-	-	-	-	+	+	-	+
Road vehicles	-	+	-	-	+	+	-	+
Transport equipment	-	+	-	-	+	+	-	-
Wearing apparel	-	+	-	-	+	+	-	+
Footwear	+	+	-	-	+	+	-	+
Prof. and scientific equip.	-	-	-	-	+	+	-	+

Notes. + and − denote respectively $\frac{\hat{x}}{\hat{y}} > 0$ and $\frac{\hat{x}}{\hat{y}} < 0$. See Table 1 for further details on the specifications.

industry externality and the skewness of the productivity distribution. For the same reasons as above, under the low-σ_h specification the scale effect always overcompensate the decrease in average productivity of component, whereas under the high-σ_h specification this is not the case (see Table 2).

5.3 Quantifying the effects of TBT reform

We now strive at quantifying the gains and losses related to TBT reform. In order to fix ideas, consider that the competitive disadvantage of importer relative to domestic component producers is set to the level T_h^* which maximizes industry productivity A_h. Recall that in the light of the externalities at work this is not a first-best policy. We find that under the low-σ_h specification T_h is mostly set to its minimum value that guarantees partitioning $T_h^* = \tau_h^{\sigma_h - 1}$, except for industries with low values of η_h (leather and machinery except electrical).

The effects are the following (see Table 3). First, all component producers start to export, thereby driving the fraction of exporters towards 1, implying $\Delta p_h^x > 0$. Second, since less productive firms start to export, this comes along with a deterioration of their average productivity level ($\Delta\tilde{\varphi}_h < 0$). The drop amounts to approximately 20% in industries with high initial values of T_h (cork and wood, fabricated metal products, wearing apparel, and footwear). Third, due to increased competition the least productive component producers are forced to exit, thereby decreasing the mass of firms operating domestically ($\Delta M_h^d < 0$). However, the mass of components available clearly increases ($\Delta M_h > 0$). Again, the increase is large in industries with high initial values of T_h.[22] Finally, the total effect on industry productivity is dominated by the scale effect and amounts to more than 10%, except for the industries with low values of η_h, which do not value input diversity much.

Under the high-σ_h scenario, the effects are rather different. We find that TBTs may be used to cope with over-supply of components. For most of the industries (except cork and wood, paper products, iron and steel, fabricated metal products, and transport equipment), the level T_h^* which maximizes industry productivity A_h is higher than the initial level (see Table 4).[23] Clearly, higher regulatory fixed costs force some component producers to exit the export markets

[22] From a social planner's perspective, there is over-supply of varieties also under T_h^* as $\eta_h < 1$. However, even if $\Delta M_h > 0$, the over-supply of varieties relative to the planner's solution is smaller for T_h^* than for T_h.

[23] Note that if one of the conditions (32) and (33) is violated, T_h^* is implicitly defined by $\upsilon^*(T_h^*) = \eta_h / (\sigma_h - 1)$.

($\Delta p_h^x < 0$), thereby increasing their average productivity level ($\Delta\tilde{\varphi}_h > 0$). However, the latter effect is rather small and lies in the range of 3% to 8%. Lower competition allows more firms to operate domestically ($\Delta M_h^d > 0$), whereas overall input diversity falls ($\Delta M_h < 0$). The loss in varieties sums up to approximately 30%. After all, the total effect on industry productivity is positive ($\Delta A_h < 1\%$), but modest, since some of component producers' productivity gains are offset by the scale effect.

Table 3: Quantifying gains and losses related to TBT reform. Low-σ_h specification

Industry	T_h	T_h^*	ΔM_h^d	Δp_h^x	$\Delta\tilde{\varphi}_h$	ΔM_h	ΔA_h
Organic chemicals	1.09	0.98	-31.69%	80.51%	-3.70%	8.72%	9.83%
Dyeing, tanning, coloring	1.09	0.97	-31.65%	80.51%	-3.86%	8.77%	16.50%
Pharmaceutical products	1.1	0.99	-31.74%	80.51%	-3.42%	8.63%	11.10%
Essential oils	1.08	0.97	-31.64%	80.51%	-3.92%	8.79%	14.74%
Plastics	1.42	0.84	-20.66%	125.73%	-14.95%	48.06%	1.99%
Leather	2.12	1.85	-5.50%	23.65%	-2.19%	7.20%	0.01%
Cork and wood	3.07	0.81	-43.19%	726.45%	-22.44%	112.36%	1.74%
Paper products	1.29	0.88	-27.58%	120.75%	-13.02%	33.08%	10.22%
Textile	1.97	0.87	-37.05%	314.94%	-19.10%	71.29%	3.52%
Iron and steel	1.21	0.88	-22.22%	89.39%	-10.71%	28.20%	5.60%
Nonferrous metals	1.2	0.96	-28.05%	89.39%	-6.81%	18.60%	8.92%
Fabricated metal products	2.61	0.88	-40.81%	495.24%	-20.21%	93.00%	7.14%
Machinery except electrical	1.86	1.49	-13.24%	51.57%	-3.20%	12.38%	0.38%
Electric machinery	1.29	0.98	-50.11%	231.13%	-3.90%	19.25%	18.32%
Road vehicles	1.35	0.94	-43.56%	203.95%	-8.82%	28.04%	11.74%
Transport equipment	1.39	0.97	-43.76%	203.95%	-8.16%	27.58%	22.91%
Wearing apparel	1.89	0.92	-41.45%	314.94%	-19.18%	59.33%	8.89%
Footwear	2.03	0.86	-30.87%	280.23%	-20.56%	79.18%	1.41%
Prof. and scientific equip.	1.7	0.98	-63.76%	651.88%	2.48%	30.59%	27.81%

Notes. See Table 1 for further details.

Table 4: Quantifying gains and losses related to TBT reform. High-σ_h specification

Industry	T_h	T_h^*	ΔM_h^d	Δp_h^x	$\Delta\tilde{\varphi}_h$	ΔM_h	ΔA_h
Organic chemicals	1.06	3.68	20.83%	-78.23%	6.86%	-44.31%	1.88%
Dyeing, tanning, and coloring materials	1.02	1.17	2.66%	-16.24%	1.34%	-8.82%	0.01%
Medical and pharmaceutical products	1.25	5.15	18.99%	-81.06%	5.98%	-47.47%	1.52%
Essential oils	1.04	1.4	6.89%	-32.50%	3.08%	-17.05%	0.09%
Plastics	1.16	2.97	11.61%	-66.87%	7.67%	-36.10%	0.86%
Leather	1.91	8.75	11.05%	-81.38%	4.39%	-35.28%	1.68%
Cork and wood	3.35	2.58	-4.81%	40.45%	-1.22%	7.74%	0.17%
Paper products	1.19	0.77	-9.17%	77.67%	-7.02%	36.29%	0.16%
Textile	1.7	4.83	9.29%	-69.69%	3.76%	-28.10%	0.84%
Iron and steel	1.16	0.75	-12.70%	86.73%	-8.75%	38.69%	0.28%
Nonferrous metals	1.23	2.03	9.43%	-46.76%	3.96%	-25.30%	0.22%
Fabricated metal products	2.99	2.44	-3.34%	28.86%	-1.26%	7.88%	0.06%
Machinery except electrical	1.99	6.62	13.23%	-75.10%	3.80%	-30.77%	1.69%
Electric machinery	1.95	5.25	12.71%	-68.89%	3.03%	-29.77%	0.81%
Road vehicles	1.41	3.29	12.89%	-64.69%	3.98%	-28.61%	0.87%
Transport equipment	1.79	1.34	-4.35%	42.03%	-2.06%	18.50%	0.04%
Wearing apparel	2.18	3.99	8.05%	-51.32%	3.26%	-19.16%	0.51%
Footwear	1.76	4.93	9.21%	-68.94%	4.44%	-29.39%	0.83%
Professional and scientific equipment	3.89	5.14	3.93%	-28.48%	0.53%	-6.35%	0.10%

Notes. See Table 1 for further details.

6 Conclusion

This paper analyzes the reallocation and industry productivity effects of TBT reform in a single market with heterogeneous firms and variable and fixed trade costs. The model goes beyond the Melitz (2003) model by explicitly parameterizing external scale effects. Our framework allows to disentangle the effect of a TBT reform on the average productivity of component producers $\tilde{\varphi}_h$ and the mass of available components M_h, thereby making the industry productivity effect dependent on the strength of the external economies of scale.

We find that both, domestic deregulation and lower fixed-cost protection, lead to reallocation of market shares from more to less productive firms, potentially negatively affecting industry productivity for a wide range of parameter constellations, while input diversity is usually enhanced. Referring to recent evidence on love for variety, we show that industry productivity is likely to deteriorate in many industries. As we rule out resource and market share reallocation *across* industries, changes in one industry directly translate into the average productivity of the economy.

Both, variable trade cost and TBT liberalization increase the volume of trade. However, in case of TBT reform this increase in trade may come along with a deterioration of industry productivity. Then, inferring productivity changes from changes in trade volumes would require dissection of the margins of trade.

Regarding further research, the present paper motivates to aim at structural estimation and identification of the key parameters in trade models with heterogeneous firms: the shape parameter, the elasticity of substitution, and the degree of external economies of scale.

References

[1] Ardelean, A. (2006). How Strong is Love of Variety? Mimeo: Purdue University.

[2] Axtell, R. (2001). Zipf Distribution of U.S. Firm Sizes. *Science* **293**: 1818-20.

[3] Baldwin, R.E., and R. Forslid (2006). Trade Liberalization with Heterogeneous Firms. *NBER Working Paper* 12192.

[4] Baller, Silja (2007). Trade effects of regional standards: A heterogeneous firms approach. *World Bank Policy Research Working Paper* 4124.

[5] Benassy, J.-P. (1996). Taste for Variety and Optimum Production Patterns in Monopolistic Competition. *Economics Letters* 52: 41-47.

[6] Bernard, A., J.S. Redding, and P.K. Schott (2007). Comparative Advantage and Heterogeneous Firms. *Review of Economic Studies* **74**(1): 31-66.

[7] Blanchard, O., and F. Giavazzi (2003). Macroeconomic Effects of Regulation and Deregulation in Goods and Labor Markets. *The Quarterly Journal of Economics* **118**(3): 879-907.

[8] Chen, N. (2004). Intra-national versus International Trade in the European Union: Why do National Borders Matter? *Journal of International Economics* **63**: 93-118.

[9] Conway, P., V. Janod, G. Nicoletti (2005). Product Market Regulation in OECD Countries: 1998 To 2003. *OECD Economics Department Working Paper* No. 419.

[10] Corcos, G., M. Del Gatto, G. Mion, and G.I.P. Ottaviano (2007). Productivity and Firm Selection: Intra- vs International Trade. *CORE Discussion Paper* No. 2007/60

[11] Corsetti, G., P. Martin, and P. Pesenti (2007). Productivity, Terms of Trade and the 'Home Market Effect'. *Journal of International Economics* **73**:99-127.

[12] Delgado, J. (2006). Single Market Trails Home Bias. *Bruegel Policy Brief* 2006/05. Brussels.

[13] Del Gatto, M., G. Mion, and G.I.P. Ottaviano (2006). Trade Integration, Firm Selection and the Costs of Non-Europe. *CEPR Discussion Paper* No. 5730.

[14] Dixit, A.K., and J.E. Stiglitz (1975). Monopolistic Competition and Optimum Product Diversity. *Warwick Economic Research Paper* No. 64.

[15] Dixit, A.K., and J.E. Stiglitz (1977). Monopolistic Competition and Optimum Product Diversity. *American Economic Review*: **67**(3): 297-308.

[16] Eaton, J., S. Kortum, and F. Kramarz (2004). Dissecting Trade: Firms, Industries, and Export Destinations. *American Economic Review* **94**(2): 150-154.

[17] Egger, H., and U. Kreickemeier (2008). Firm Heterogeneity and the Labour Market Effects of Trade Liberalisation. *International Economic Review*, forthcoming.

[18] Ethier, W.J. (1982). National and International Returns to Scale in the Modern Theory of International Trade. *American Economic Review* **72**(3): 950-959.

[19] Feenstra, R. (1996). U.S. Imports, 1972-1994: Data and Concordances. *NBER Working Paper* 5515.

[20] Francois, J., H. van Meijl, and F. van Tongeren (2005). Trade Liberalization in the Doha Development Round. Economic Policy **20**(42): 349-391.

[21] Ghironi, F., and M.J. Melitz (2005). International Trade and Macroeconomic Dynamics with Heterogeneous Firms. *Quarterly Journal of Economics* **120**(3): 865-915.

[22] Gwartney, J., R. Lawson, R.S. Sobel, and P.T. Leeson (2007). Economic Freedom of the World 2007 Annual Report. Fraser Institute, Vancouver.

[23] Hanson, G., and C. Xiang (2004). The Home-Market Effect and Bilateral Trade Patterns. *American Economic Review* **94**(4): 1108-1129.

[24] Helpman, E., M.J. Melitz, and S.R. Yeaple (2004). Export Versus FDI with Heterogeneous Firms. *American Economic Review* **94**(1): 300-316.

[25] Hummels, D. (2001). Towards a Geography of Trade Costs. Mimeo: University of Chicago.

[26] Ilzkovitz, F., A. Dierx, V. Kovacs, and N. Sousa (2007). Steps. Towards a Deeper Economic Integration: The Internal Market in the 21st Century. European Economy, *Economic Papers* No. 271, European Commission.

[27] Krugman, P.R. (1980). Increasing Returns, Monopolistic Competition and International Trade. *Journal of International Economics* **9**(4): 469-479.

[28] Krugman, P.R. (1980). Scale Economies, Product Differentiation, and the Pattern of Trade. *American Economic Review* **70**(5): 950-959.

[29] Levinsohn, J., and A. Petrin (2005). Estimating Production Functions Using Inputs to Control for Unobservables. *Review of Economic Studies* **70**: 317-342.

[30] Melitz, M.J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica* **71**(6): 1695-1725.

[31] Melitz, M.J., and G.I.P Ottaviano (2007). Market Size, Trade, and Productivity. *Review of Economic Studies*, forthcoming.

[32] Smith, A., and A.J. Venables (1988). Completing the Internal Market in the European Community. Some Industry Simulations. *European Economic Review* **32**: 1501-1521.

[33] World Trade Organization (2007). Twelfth Annual Review of the Implementation and Operation of the TBT Agreement. Geneva