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Veronika Movchany, Oleksandr Shepotyloz, and Volodymyr Vakhitovx

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Department of International Economics

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Visiting address: C.J. Hambros plass 2d
Address: P.O. Box 8159 Dep.
NO-0033 Oslo, Norway
Internet: www.nupi.no
E-mail: info@nupi.no
Fax: [+ 47] 22 99 40 50
Tel: [+ 47] 22 99 40 00

Non-tariff measures, exporting, and productivity: evidence from microdata in food processing industry*

Veronika Movchan[†], Oleksandr Shepotylo[‡], and Volodymyr Vakhitov[§]

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1 Introduction

Non-tariff measures (NTM) play an increasingly important role in forming trade policy and shaping trade flows. NTMs are often far more trade-restrictive than import tariffs. Looi Kee et al. (2009) find that in 2003 the simple average ad-valorem equivalent of NTMs was 45 percent for product lines affected by NTMs. Moreover, NTMs have an ambiguous effect on trade because they are designed to internalize

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[†]Institute for Economic Research and Policy Consulting, movchan@ier.kiev.ua
[‡]University of Bradford, O.Shepotylo@bradford.ac.uk
[§]Kyiv School of Economics, vakhitov@kse.org.ua

externalitites, such as lack of public information about quality and safety of goods or protection of public health. Hoekman and Nicita (2011) find that NTMs have a positive effect on trade in more technologically advanced sectors and negative effect in agriculture.

Despite importance of NTMs, little is known about their impact on export, selection, and productivity at the level of a firm.[1] Two facts in particular contribute to our lack of understanding. First, there is a measurement problem. NTMs come as a very diverse set of policies, including sanitary and phytosanitary measures (SPS), technical barriers to trade (TBT), and subsidies. These policies are hard to measure and even harder to compare their impacts on firm's performance. To measure the NTM exposure at a firm level is data demanding and requires information on production and trade-related activities. Second, an introduction of an NTM is often justified as a reaction to a public concern about health, quality, and safety of a product and is designed to address the market failures. Therefore, not only they affect the supply side by increasing costs of production, but also shift the demand curve as consumers feel reassured about the product characteristics. As a result, NTMs have an ambiguous effect on firm's performance. It is not possible *ex ante* to predict whether negative effects of the supply side dominate positive effects of the demand side .

This paper looks at the effects of NTMs on export performance of firms in food-processing industry in Ukraine in 2001-2009. We focus on ecology, sanitary, phy-

[1] The effects of tariffs (Pavcnik, 2002; Amiti and Konings, 2007; Khandelwal and Topalova, 2011) and services (Arnold et al., 2011; Fernandes and Paunov (2012); and Shepotylo and Vakhitov, 2015) liberalization on productivity of manufacturing firms and their export performance are well-known.

tosanitary, and veterinary measures, which are closely related to consumers' concerns about safety and quality of products. We investigate how NTMs within an industry influence probability and volumes of firm's export. We also look at the effect of introducing NTMs in the upstream industries on firm's export performance. Finally, we compare those effects with the similar effects of tariff barriers.

To address the data and measurement problem, we transform NTMs into their ad valorem equivalent rates following Looi Kee et al. (2009). We use the Ukrainian firm-level import data in 2001-2009 and the NTM data for the same period constructed by Movchan (2015), which allows us to estimate a unit price elasticity of an NTM. The ad valorem equivalent of the NTM is computed for each HS 2 digit tariff line and for each year. We further construct firm-specific indices of upstream trade barriers and industry-specific indices of tariff and NTM protection. Finally, we estimate the impact of those measures on firm's performance.

Our findings are as follows. First, more stringent health regulations in an industry play a role of a positive demand shifter, because consumers in foreign countries are concerned about the quality and safety of food and, *ceteris paribus*, are more likely to buy products from a country with tougher standards. Second, NTMs are likely to increase cost and change composition of imported inputs from the upstream industries, which have a negative effect on exports. NTMs in upstream industries lower total export, average export per country, and number of countries where a firm exports. However, NTMs do not reduce a probability of being an exporter which hints that NTMs mostly influence . Finally, tariff and non-tariff measures have a differential impacts. Tariffs mostly influence exports through prices, while NTMs works through both price and quantity channels.

The structure of the rest of the paper is as follows. Next section discusses NTMs. Section 3 presents the other data that we use in our analysis. Section 4 describes the methodology and provides results of total factor productivity (TFP) estimation. Section 5 presents results. Section 6 concludes.

2 NTM measures

Non-tariff measures as a part of country's protectionism had existed through ages, but they have drawn a special attention only in the early 70th. This interest is closely connected with the success of the GATT trade rounds in reduction of import tariffs. NTMs are less transparent, more flexible, and extremely variable. These characteristics made the NTMs important substitutes for country's tariff regimes. According to the United Nations Conference on Trade and Development (UNCTAD) classification, there are sixteen distinct groups of non-tariff measures of technical and non-technical character UNCTAD (2013). Recently, non-tariff measures have become in the focus of the trade policy debates in Ukraine. It has happened after the accession of the country to the WTO (2008) and further accelerated after the ratification of Association Agreement (AA) between the EU and Ukraine (2014). The WTO membership has generated a push for the NTM reforms, especially in TBT and SPS measures, as Ukraine committed to align its trade policy with the WTO Agreements. The AA made a further step, envisaging comprehensive harmonization of the TBT and SPS applied by Ukraine with the EU acquis.

Type of NTM	Basic legislation
Veterinary control	Law on Veterinary Medicine
Sanitary control	Law on Food Safety
Phyto-sanitary control	Law on Quarantine of Plants
Ecology control	Law on Environment Protection

Table 1: Ukrainian laws and regulations on non-tariff measure

We rely on Ukrainian NTM data collected and described in Movchan (2015). NTMs applied in Ukraine to safeguard life and health of people, animals and plants include veterinary, sanitary, phytosanitary, and ecology controls.

Information about applied NTMs is taken from legislation. Table 1 describes laws relevant for each type of NTMs.

To identify sectors that are most heavily exposed to NTMs, we constructed an integral measure of NTMs – an NTM intensity index (NTMI). The NTMI shows the percentage of cases when the pre-selected NTMs are actually applied to the given number of tariff lines:

$$NTMI = 100 * \frac{\sum_{i=1}^{N} \sum_{j=1}^{J} NTM_{ij}}{NJ},$$

where NTM_{ij} is a dummy variable that takes a value of unity if a type j NTM is applied to a tariff line i, and zero otherwise. N is a total number of considered tariff lines, and J is a total number of considered types of NTM. This index indicates the percentage of used capacity for the non-tariff protection. $NTMI = 100$ means that each considered type of NTMs is applied to each tariff line. If $NTMI > 100/J$, it means that there is at least one tariff line that is subject to more than one type of the NTMs. Similarly, for each type of NTM, $NTMI_j$ can be computed as

$$NTMI_j = 100 * \frac{\sum_{i=1}^{N} NTM_{ij}}{N},$$

Figure 1 presents index for non-tariff measures intensity in Ukraine estimated for above-mentioned four measures (NTMI) applied in 1996-2012. As shown, the intensity of usage of non-tariff measures clearly reduced over the period of observations. The first significant reduction occurred in 2000, the year of important deregulation reforms in the country. Later on, the NTMs usage somewhat revived, but remained lower than pre-reform level. The second considerable reduction took place in 2009 following Ukraine's membership to the WTO, though this period is not covered by our study.

The downward trend in the NTMI is determined first of all by phytosanitary and sanitary controls, while veterinary control slightly increased over the period of observations and ecology control in 2012 remained very close to its levels in 1996 after the period of higher coverage registered in 2003-2008. Sectoral NTMI is the highest for agriculture and food industry, which is in line with expectations (Figure 2). At the same time, the level of NTMI for these two sectors is between 25 and 50, which means that on average, trade in products in these sectors is subject to two out of four NTMs.

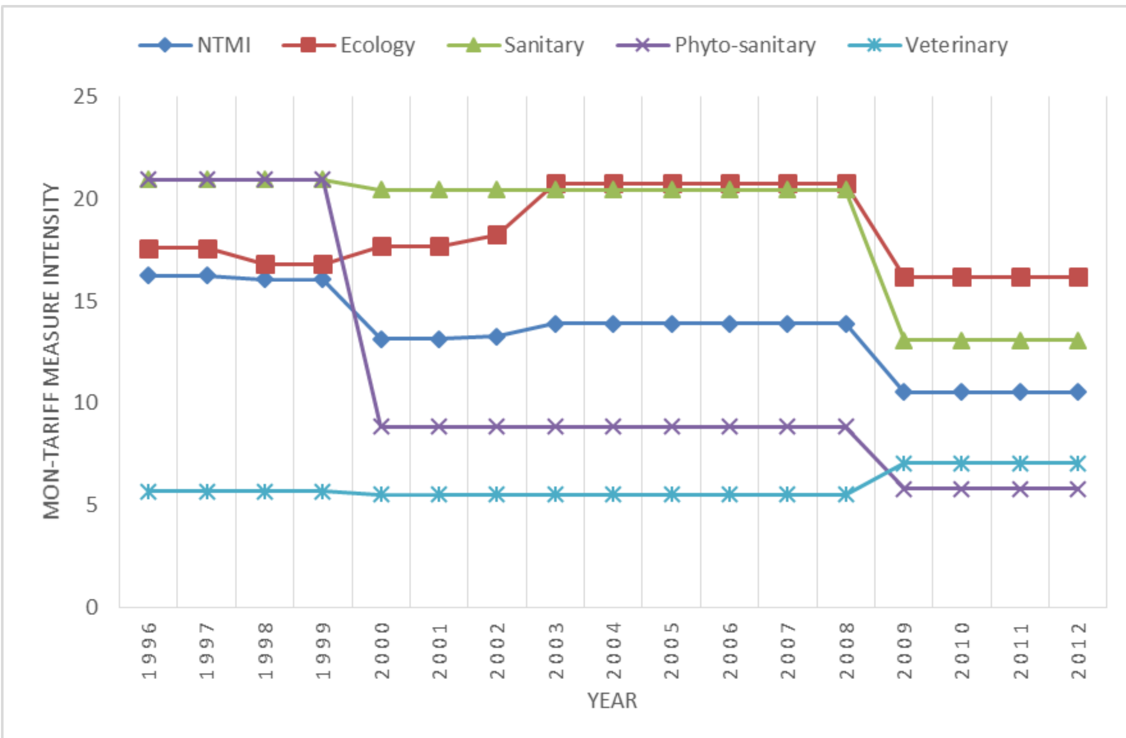

Figure 1: NTMI in 1996-2012

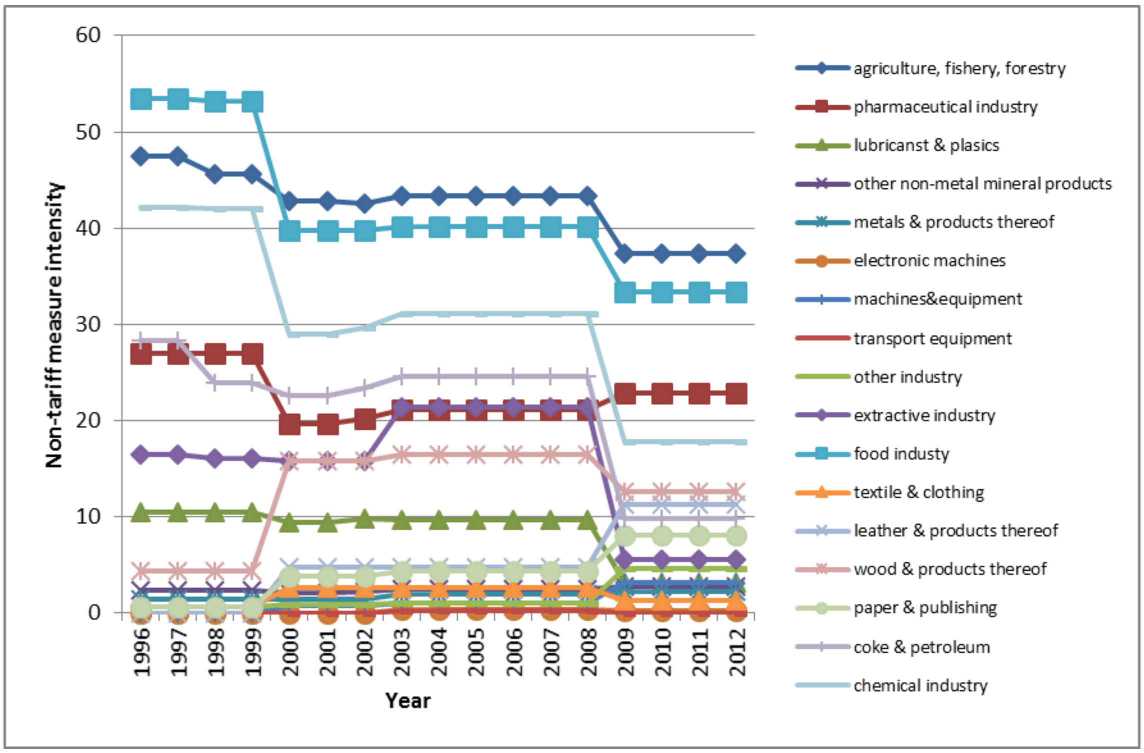

Figure 2: NTMI by sector in 1996-2012

3 Firm-level and tariff data

Firm-level production data

Data for estimating the production function come from statistical forms all firms have to submit to Ukrstat, the State Statistical Service of Ukraine. Balance Sheet statement and Financial Results statement are the most comprehensive sources of the firm-level data, as they contain data on over 350 thousand firms annually. Output is measured as total sales revenues net of excise and other indirect taxes; this measure comes from the Financial Results Statement. The same statement also contains data on material costs, which is measured as the firm's expenditures on materials, supplies, and utilities. The Balance Sheet statement contain data on the end-of-year value of fixed assets, which we use as our measure of capital. Employment, which is reported along with the Balance Sheet statement, is measured as full-time equivalent of the labor force, and calculated as the average number of employees weighted by their time involvement. We also use investments in fixed assets, which is taken from the Enterprise performance statement. This statement was similarly comprehensive as the Balance Sheet statement in 2001-2007, but in 2008-2009, the sample was cut three-fold. Nevertheless, all large firms, those with over 50 employees or annual revenues above 70 mln. UAH, remained in the sample. Finally, each firm has an indicator of the major industry code (at the level of four digit of NACE / KVED classification), and the territory code at the local equivalent level of NUTS-3 level regions and large cities.

Output measures are deflated by corresponding industry (NACE 2 digit) price

Firms	2001	2002	2003	2004	2005	2006	2007	2008	2009	2001-2009 average
Food processing firms	11500	12269	12466	12280	12024	12132	11812	10574	12842	11989
With non-negative output, employment and non-zero capital	8407	9067	9219	8940	8534	8322	8170	7685	6891	8366
With elicited TFP estimates	6888	7249	7156	6725	6351	6173	5837	5392	4893	6287
Exporters	805	913	953	987	934	842	871	895	897	900
Importers	769	822	892	796	851	894	882	873	701	831

Note: table reports total number of firms in food processing industry in Ukraine in 2001-2009. It also reports number of fimrs satisfying certain criteria.

Table 2: Sample composition

deflator. The values of the capital and capital investments are deflated with economy-wise producer price index (PPI), whereas material costs are deflated with consumer-price index (CPI). All deflators used 2001 as the base year.

Firm level export and import data

The comprehensive transaction-level database of foreign trade in goods collected by Ukrainian Customs Service was used for generating our exports and imports variables. Data set provides information on all export and import transactions at a firm level during a year. It contains information on value and quantity of trade, country of origin and country of destination, and the product classification code at four-digit level of the Harmonized System (HS-4). The sample composition is presented at Table 2.

Tariff data

Tariff data has been taken from Trade Analysis and Information System (TRAINS) – a comprehensive database of tariffs. We use Ukrainian applied MFN tariff rates from 2001 to 2009 as our measure of tariff protection. This rate is applied to imports from all countries with the exception of imports coming from the Commonwealth of Independent States (CIS) countries.[2]

4 Model

Our model is based on Melitz (2003). We focus on partial equilibrium analysis of firms operating in a monopolistically competitive industry. Firms are heterogeneous in productivity. They take decisions on how much to produce and whether to export or not given their productivity and aggregate market statistics at home and in foreign countries. We simplify consumer preferences to have a constant elasticity of substitution representation. We also look at only one factor of production, labor.

Consumer

A representative consumer consumes a continuum of goods indexed by ω and maximizes utility

$$U = \left[\int_{\omega \in \Omega} q(\omega)^{\rho} d\omega \right]^{\frac{1}{\rho}}, 0 < \rho < 1 \quad (1)$$

where Ω represents the set of available products, $q(\omega)$ is consumption level, and $\sigma = 1/(1-\rho)$ is constant elasticity of substitution across varieties. Given prices $p = \{p(\omega)\}$, $\omega \in \Omega$, the consumer with food expenditure level R[3] maximizes (1)

[2] Until recently Ukraine has freely traded with the CIS countries. We define the list of those countries not according to their de jure participation into a formal CIS union, but rather loosely as countries in a free trade area, which included Armenia, Azerbaijan, Georgia, Belarus, Kazakhstan, Kyrgyz Republic, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.

[3] We take it as given but it can be modelled as a two-tier utility function with the upper CES utility preferences. In equilibrium, the consumer will allocated a fixed share of his budget to

subject to the budget constraint

$$\int_{\omega\in\Omega} p(\omega)q(\omega) = R. \tag{2}$$

Technology

Each variety ω is produced by a single firm; labor l is the only input; all firms share the same fixed cost $f > 0$, but have different productivity levels indexed by $\theta > 0$. Technology of a firm with productivity θ

$$l = f + q/\theta \tag{3}$$

Export

Firm can export its product to another country after paying a fixed export cost, f^X, and variable transportation cost τ. Profit of an exporter is given by

$$\pi^X(\theta) = \left(\rho\frac{\theta}{\tau}P^*\right)^{\sigma-1}\frac{R^*}{\sigma} - f^X$$

where $R^*$is the foreign country expenditures, and $P^* = \left[\int_{\omega\in\Omega^*} p^*(\omega)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$ is the foreign country price index. Only sufficiently productive firms can earn positive profits by exporting. Export profit cutoff point θ_X^* is determined by

$$\pi^X(\theta_X^*) = 0 \Longleftrightarrow \left(\rho\frac{\theta_X^*}{\tau}P^*\right)^{\sigma-1}\frac{R^*}{\sigma} = f^X \tag{4}$$

consumption of food.

Equation (4) establishes a link between probability of export and firm's productivity, trade costs, and importing country characteristics.

The firm's export sales in foreign country are determined as

$$r_X(\theta) = \begin{cases} p^*(\theta)q^*(\theta) = R^*(P^*\rho\theta/\tau)^{\sigma-1} & ,\theta \geqq \theta_X^* \\ 0 & ,\theta < \theta_X^* \end{cases} \tag{5}$$

4.1 NTM, productivity, and trade costs

We depart from the standard Melitz model in two important ways. First, we assume that the NTMs indirectly influence demand. More stringent NTM regulations may have a positive effect on demand by ensuring public about quality ans safety of a product. We model this by making the food expenditures a function of NTMs as follows: $R^*(NTM) = R^* \exp(\gamma NTM)$, $\gamma > 0$. Second, we introduce a time dimension and allow firm's productivity to evolve over time, t. If an NTM restrict imports of goods which firm i uses as inputs, it can lower its productivity due to lower quality/fewer varieties of inputs, $\theta_{it} = \theta_i * \exp\{\gamma_{inputNTM} * inputNTM_{it} + \chi_{it}\}$, $\frac{\partial \kappa}{\partial NTM} < 0$, where $inputNTM_{it}$ is a measure of non-tariff barriers applied to firm's i inputs at time t, and χ_{it} is a productivity shock. Finally, reduced competition and changes in P^*may also have an impact on exporting.

Trade costs have standard parametric representations. Iceberg type variable cost is $\tau_{ct} = dist_c^{\lambda} \exp(\gamma_\tau NTM + X_\tau \beta_\tau + w_{ct})$, where $dist_c$is distance to country c, $X_\tau$are controls, and w_{ct} is the error term. Fixed cost of exporting is $f_{ct}^X = \exp(\gamma_f NTM + X_f \beta_f + \psi_{ct})$, where X_f are controls, and ψ_{ct} is the error term.

Probability of export and the effect of NTMs is estimated as follows. We define

$$Z_{it} = \left(\rho \frac{\theta_{it}}{\tau_{ct}} P_{ct}^{*}\right)^{\sigma-1} \frac{R_{ct}^{*}}{\sigma} / f_{ct}^{X}. \tag{6}$$

Positive exports occur only when $Z_{it} > 0$. Taking logs of both sides of (6) we get

$$\begin{aligned} z_{it}^{c} &= \mu_{ct} + (\sigma - 1)\ln\theta_{it} + \lambda(\sigma - 1)\ln dist + \gamma^{*} NTM \\ &\quad + \gamma_{inputNTM}^{*} inputNTM_{it} + X^{*}\beta^{*} + \upsilon_{it}^{c} \end{aligned}$$

where $\upsilon = (\sigma - 1)\chi_{it} + (\sigma - 1)w_{ct} + \psi_{ct}$.

However, we observe only the outcome of the firm's decision, which we define as

$$T_{it}^{cn} = \begin{cases} 1 & if \quad z_{it}^{cn} \geqq 0 \\ 0 & if \quad z_{it}^{cn} < 0 \end{cases}$$

Assuming normality of $\upsilon \sim N(0,1)$, we estimate the following Probit model

$$\begin{aligned} \rho_{it}^{cn} &= \Pr(T_{it}^{cn} = 1 | I_t) = \Phi(\mu_{ct} + (\sigma - 1)\ln\theta_{it} + \lambda(\sigma - 1)\ln dist + \gamma^{*} NTM) \\ &\quad + \gamma_{inputNTM}^{*} inputNTM_{it} + X^{*}\beta^{*} \end{aligned} \tag{7}$$

5 Ad valorem equivalent of non-tariff measures

In this section we outline our estimation of an ad valorem equivalent of an NTM, which is based on Looi Kee et al. (2009) . A firm i in a small open economy imports good n (defined as a product category at HS4 classification) at exogenously given world prices wp_t^n .[4] Trade policy distortions generate a wedge between the world prices and domestic prices according to the following formula $p_t^n = wp_t^n f(t_t^n, NTM_t^n)$. We further take a log-linear approximation and estimate the following equation

$$\ln p_{it}^n = ln(wp_t^n) + \beta_{NTM}^{n1} \ln(1 + NTMI_t^n) + \epsilon^{n1} \ln(1 + t_t^n) + X\gamma + \varepsilon_{it} \qquad (8)$$

where p_{it}^n is import' price of firm i at time t of good n. Our main variables of interests are $NTMI_t^n$, which indicates intencities of various types of NTM applied for product n at time t imposed by an importing country (Ukraine).[5] t_t^n is an ad valorem tariff applied to product n at time t. $\ln(wp_t^n)$ captures the product-specific world price. X is a set of controls. We control for market structure, by adding total value $\ln P_{nt}^{im} Q_{nt}^{im}$, the volume of import $\ln Q_{nt}^{im}$, and the total number of importers $\ln N_{nt}^{im}$ for good n at time t. We also control for firm's characteristics by adding its output $\ln q$. We further add gravity type variables to account for the trade costs, $\ln dist$ for distance, contiguity indicator variable to measure the effect of neighbouring countries, and CIS indicator variable.

[4] The 4 digit level of aggregation is chosen due to data availability constraints.

[5] We use four types of NTMIs within a 4 digit HS product category, normalized to take values within a range from 0 to 1, with 1 indicating that all 6 digit HS product lines within the HS 4 digit product category have at least one core NTM imposed. Our NTM data have virtually no time variation, so for practical purposes, the variability comes across product categories within product.

We estimate (8) by the instrumental variables technique, where the tariff and non-tariff measures are endogenous to trade flows due to lobbying of policymakers by the domestic firms. Our set of instruments capture characteristics of exporters that compete with foreign importers of the same products – total value $\ln P_{nt}^{exp} Q_{nt}^{exp}$ and volume $\ln Q_{nt}^{exp}$ of exports and total number of exporters $\ln N_{nt}^{exp}$ of good n at time t, as well as standard deviation of exports , $sd(\ln P_{nt}^{exp} Q_{nt}^{exp})$ to capture distributional characteristics of exporters. Finally, ε_{it} is the error term.

Unlike Looi Kee et al. (2009), we do not impose any specific restrictions on the sign of our NTM measures. We estimate equation (8) separately for each product define at HS 2 digit classification and each t. We compute ad valorem equivalent of NTM as

$$ave_{NTM,t}^{n} = \frac{\partial \ln p_t^n}{\partial \ln(1 + NTM_t^n)} = \beta_{NTM,t}^{n}.$$

Figure 3 summarizes the results of our estimation procedure. Ad valorem equivalents of NTMs do not show a particular trend, which is consistent with the fact that over the investigated period laws and regulation that determine NTMs did not experience substantial changes. A large proportion of ad valorem equivalents of NTMs is negative. However, it does not contradict a theoretical basis of our estimation procedure. An NTM has effect on both demand and supply side of the market, because its main role is to fix an externality accosiated with public concerns related to quality and safty of products, and if the positive demand effect dominates, it is reflected in the negative ad-valorem rate.

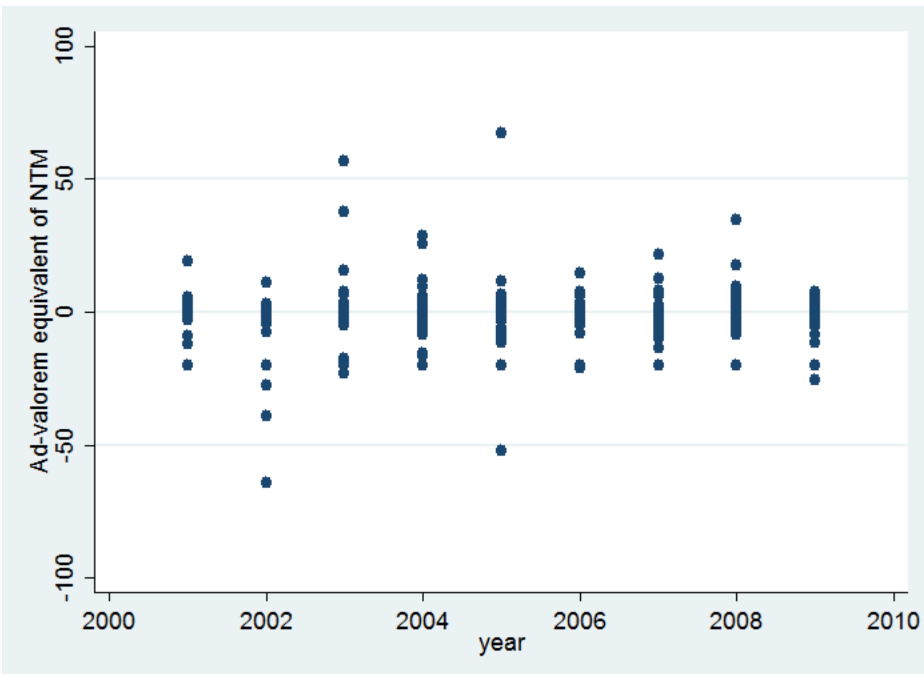

Figure 3: Ad valorem equivalents of non-tariff measures in Ukraine in 2001-2009 by HS2 digit products

Estimating the NTM measure

Our primary variable of interest, the measure of NTM effect, is the firm-specific index of NTM intensity. The index is computed similar to Shepotylo and Vakhitov (2015) as follows:

$$inputNTM_{it} = \sum_{n} a_{it}^{n} \times ave_{t}^{n} \tag{9}$$

where a_{it}^{n} is the share of import of product n to the total import for a firm i at time t . We expect that if a firm sources some of its inputs from a product line affected by an NTM, it may be forced to change its input mix (i.e. switch from the first best supplier to a supplier of lower quality/less suitable product), which could lower the technical efficiency of the firm. The index captures the extent to which the firm is affected by NTMs on its imports of intermediate inputs.

We also create the firm-specific import tariff as given by :

$$inputMFN_{it} = \sum_{n} a_{it}^{n} \times mfn_{t}^{n} \tag{10}$$

where a_{it}^{n} is the share of import of product n to the total import for a firm i at time t, and mfn is the MFN import tariff. Higher tariff for some input used by firm i could lower productivity of the firm similarly to the NTM effect as as described in the previous paragraph. The index captures the extent to which the firm is affected by import tariffs on its imports of intermediate inputs.

6 Estimation of productivity

To recover firm's productivity, we go into more detailed specification of production function that includes capital. We relax the assumption that the utility function for varieties within food processing industry is a constant elasticity of substitution. We estimate a production function for each 3-digit KVED/NACE food processing industries using the Olley-Pakes procedure (Olley and Pakes, 1996). Unlike the original methodology, we control for sub-industry specific demand and price shocks. De Loecker (2011) has developed this methodology under the assumption of the constant elasticity of substitution (CES) demand system. Shepotylo, Uschev and Vakhitov (2015, unpublished manuscript) have extended it to a case of non-specified additively separable utility function, which we use here to estimate productivity. Demand and price shocks are identified by exploiting variation in sub-industry (4-digit NACE classification) output at time t and by controlling for sub-industry and time fixed effects.

TFP estimation

Consider a production technology of a single-product firm i at time t described by production function

$$y_{it} = h_{it}^{\alpha_h} k_{it}^{\alpha_k} mat_{it}^{\alpha_{mat}} \exp(\tilde{\omega}_{it} + \tilde{u}_{it}), \tag{11}$$

where y_{it} units of output are produced using h_{it} units of labor, k_{it} units of capital, and mat_{it} units of material and services inputs. $\tilde{\omega}_{it}$ is firm-specific productivity that includes both technical efficiency and workers' average ability, unobservable by an econometrician, but known to the firm before it chooses variable input h_{it}. $\tilde{u}_{it}$ is an idiosyncratic shock to production that also captures measurement error introduced due to unobservable input and output prices.

Output y_{it} is not observed, because we do not know firm-specific prices p_{it}. Observable sales, $R_{it} = p_{it}y_{it}$, reflect differences in physical quantities as well as variation in markups across firms within the same industry. Therefore, use of R_{it} as the dependent variable in estimation of production function parameters, without controlling for prices, determined among other things by market structure and demand shocks, would bias estimates of the production function if prices are correlated with inputs.

To deal with this issue, we introduce the following inverse demand system:

$$p_{it} = \frac{u_s'(y_{it})}{\lambda_{st}} \exp(\tilde{\xi}_{it}), \quad i \in I_s \tag{12}$$

where I_s is the set of firms in industry s, y_{it} is the output of firm $i \in I_s$ in the period t, $u_s(\cdot)$ is the utility function specific for industry s, $\tilde{\xi}_{it}$ is a random shock in demand, while λ_{st} is the Lagrange multiplier of the consumer's problem.

Taking logs and rearranging (12) yields

$$\ln y_{it} u_s'(Y_{it}) - \ln y_{it} p_{it} = \ln \lambda_{st} + \tilde{\xi}_{it}.$$

Setting $R_{it} \equiv y_{it}p_{it}$, we get

$$\ln R_{it} = \ln y_{it} u_s'(y_{it}) - \ln \lambda_{st} + \tilde{\xi}_{it} \tag{13}$$

We log-linearize it in the neighborhood of the average point $\left(\bar{\mathbf{p}}_s, \bar{Y}_s\right)$, where

$$\bar{\mathbf{p}}_s \equiv \left(\frac{1}{|I_s|}\sum_{j\in I_s} p_{jt}\right)\cdot \mathbf{1}, \quad \bar{Y}_s \equiv \frac{1}{|I_s|}\sum_{j\in I_s} Y_{jt}.$$

This yields

$$\ln(R_{it}/P_{st}) \approx \text{const} + (1+\eta(\bar{Y}_s))\ln y_{it} - \eta(\bar{Y}_s)\ln(Y_{st}/P_{st}) + \tilde{\xi}_{it}, \tag{14}$$

where P_{st} is the price index defined as a simple geometric average of prices in industry s:

$$P_{st} \equiv \left(\prod_{j\in I_s} p_{jt}\right)^{\frac{1}{|I_s|}}.$$

Finally, combining (14) with the production function (11), we arrive at

$$r_{it} = \beta_h \ln h_{it} + \beta_k \ln k_{it} + \beta_m \ln mat_{it} + \beta_s \ln Y_{st} + \omega_{it} + \xi_{it} + u_{it}, \tag{15}$$

where $r_{it} = \ln(R_{it}/P_{st})$ is the log of revenue deflated by corresponding industry (NACE 2 digit) price deflator. $\beta_f = \frac{\sigma_s+1}{\sigma_s}\alpha_f$, where $f = \{h, k, mat\}$. The elasticity of substitution in industry s can be retrieved as $\sigma_s = 1/\eta(\bar{Y}_s) = -1/\beta_s$. Finally, $\omega_{it} = \frac{\sigma_s+1}{\sigma_s}\tilde{\omega}_{it}$, $\xi_{it} = -\frac{1}{\sigma_s}\tilde{\xi}_{it}$, and $u_{it} = \frac{\sigma_s+1}{\sigma_s}\tilde{u}_{it}$ are error terms. In what follows, we suppress the sector index for clarity of presentation.

We estimate equation (15) separately, for each three-digit food processing industry, using the Olley-Pakes methodology (Olley and Pakes, 1996) and accounting for demand shocks as outlined above. Instead of using total industry output, we use more disaggregated sub-industry g output (NACE 4 digit), y_{gt}, to add more variability to the estimation of σ_s. We decompose the overall demand shock into the following components

$$\xi_{it} = \xi_t + \xi_g + \tilde{\xi}_{it}, \tag{16}$$

where ξ_t is industry-specific shock common to all firms at time t, ξ_g is demand factor affecting only firms producing in sub-industry g, and $\tilde{\xi}_{it}$ is an idiosyncratic shock. Plugging in (16) in (15), we obtain the following equation

$$r_{it} = \beta_h \ln h_{it} + \beta_k \ln k_{it} + \beta_m \ln mat_{it} + \beta_s \ln Y_{gt} + \delta_t D_t + \delta_g D_g + \omega_{it} + \varepsilon_{it} \tag{17}$$

where D_t is a a year fixed effect and D_g is a sub-industry fixed-effect. $\varepsilon_{it} = \tilde{\xi}_{it} + u_{it}$ is the error term which is not correlated with inputs and productivity.

Results of the estimation are presented in Table 3. Total factor productivity net of price and demand effects is recovered as

$$\ln \theta_{it} = (r_{it} - \beta_h \ln h_{it} - \beta_k \ln k_{it} - \beta_m \ln mat_{it} - \beta_s \ln Y_{gt})\frac{\sigma_s}{\sigma_s + 1}. \tag{18}$$

Figure 4 presents productivity trends in Ukraine in 2001-2009. All sub-industries experienced substantial productivity growth in 2001-2008. Economic crisis of 2008 led to drop in productivity in all sub-industries except Prepared animal feeds (KVED/NACE 15.7) and Beverages (KVED/NACE 15.9).

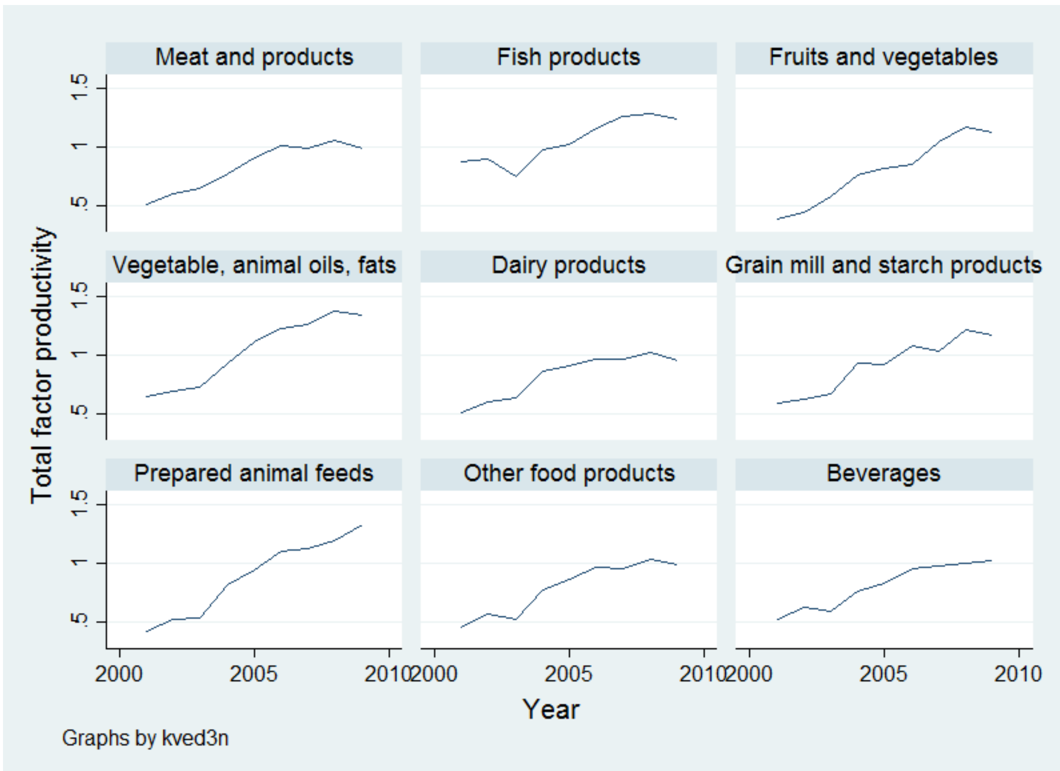

Figure 4: Productivity trends in food processing in Ukraine 2001-2009

Industry	$\ln(K)$	$\ln(L)$	$\ln(M)$	$\ln(Y_{NACE4})$	N	χ^2
NACE-151,152 (Meat and fish products)	0.074**	0.314***	0.652***	-0.114	4013	11292.6
	(0.028)	(0.028)	(0.019)	(0.066)		
NACE-153 (Fruits and vegetables)	0.045	0.321***	0.619***	-0.086	1416	2941
	(0.045)	(0.061)	(0.048)	(0.084)		
NACE154 (Vegetable, animal oils, fats)	-0.004	0.153**	0.672***	0.202	1019	900.6
	(0.073)	(0.059)	(0.034)	(0.121)		
NACE155 (Dairy products)	0.081*	0.315***	0.601***	0.0434	3172	3267.5
	(0.038)	(0.043)	(0.037)	(0.193)		
NACE156 (Grain mill and starch products)	0.082	0.259***	0.658***	0.114	2632	4963.7
	(0.042)	(0.027)	(0.019)	(0.137)		
NACE157 (prepared animal feeds)	-0.023	0.170**	0.713***	0.022	783	1860.7
	(0.060)	(0.065)	(0.031)	(0.353)		
NACE158 (Other food products)	0.053*	0.343***	0.581***	0.030	8053	8376.3
	(0.023)	(0.026)	(0.023)	(0.052)		
NACE159 (Beverages)	0.032	0.302***	0.697***	0.178*	3823	5413.5
	(0.033)	(0.038)	(0.025)	(0.072)		

Notes: * p<0.05, ** p<0.01, *** p<0.001. Bootstrap standard errors are presented in parentheses. Table reports point estimates of revenue function parameters, β for Ukrainian firms in food processing in 2001-2009. Each row in the table represents Olley-Pakes estimation of production function for each industry, defined according to three-digit NACE classification. Each estimation is performed with year and sub-industry dummies, which are not reported for brevity.

Table 3: Estimates of Production Function Coefficients

7 Effect of NTMs on Export

Figure 5 presents some stylized facts about exporters in food processing in Ukraine in 2001-2009. There was a substantial drop in the number of exporters after 2004 that continued through 2005 and 2006, but it slightly recovered after that. Only about 10 percent of firms in food processing exports. The total export has been constantly growing till 2008, when it reached 4.8 bln USD, and then collapsed by 23 percent. Average export per firm has been also following the same pattern, reaching the maximum of 419 thds USD per firm in 2008. Trade also considerably expanded on the extensive margin increasing average number of importing countries per firm from 4.8 in 2001 to 8.5 in 2008, with a slight reduction to 8.03 in 2009.

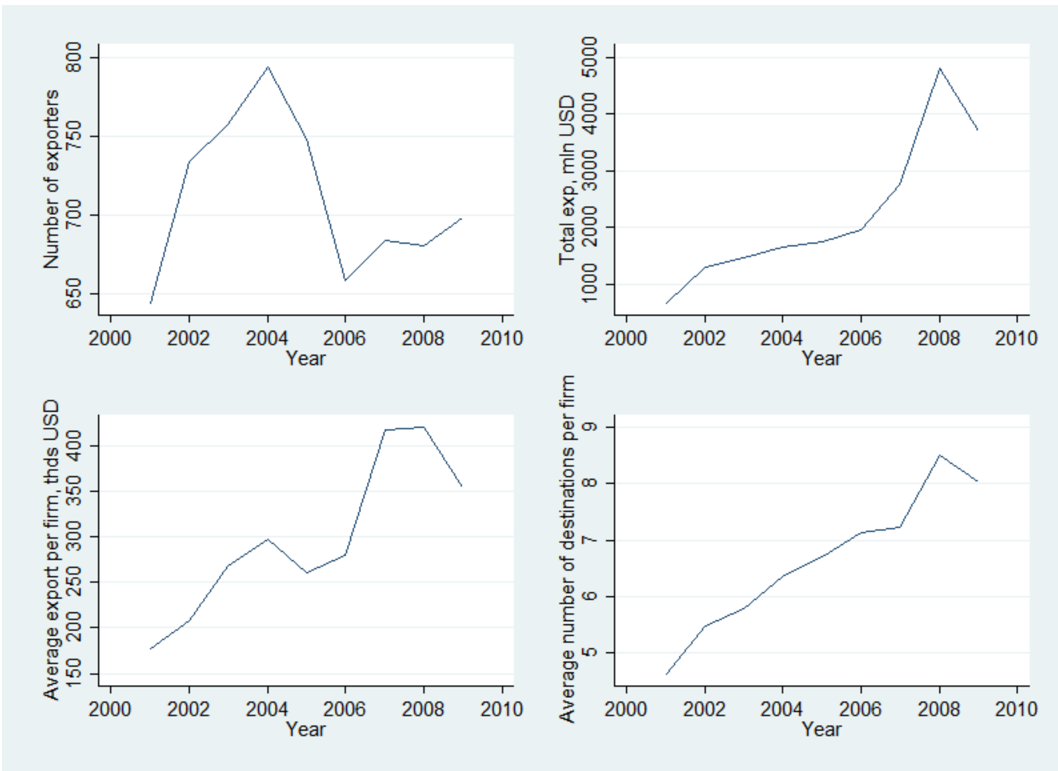

Figure 5: Exporters in food processing in Ukraine in 2001-2009

To evaluate the impact of NTMs on exports we estimate the following equation

$$\begin{aligned}\ln r_{it}^{cn} &= \delta_t^c + \delta^n + \delta_{i\in I} + \delta_\theta \ln\theta_{it} + \delta_l \ln l_{it} + \delta_{NTM}\ln(1+ave_t^n) + \\ &\quad \delta_{tariff}\ln(1+mfn_t^{nc}) + \delta_{inputNTM}\ln(1+inputNTM_{it}) + \\ &\quad \delta_{inputMFN}\ln(1+inputMFN_{it}) + \nu_{it}\end{aligned} \tag{19}$$

where r_{it}^{cn} is export of firm i at time t of good n to country c. Our main variables of interests are $\ln(1+ave_t^n)$ and $\ln(1+inputNTM_{it})$, forward and backward linkages effects of NTM barriers on the volume of export. We are also interested in the direct effect of tariffs on exports, measured by mfn_t^{nc}.[6] δ^n captures product-specific effects (mainly the expenditure share of good n). δ_t^c captures all characteristics of importing country, including market size and demand shocks. Index I captures industry specific technology effects, since we pool firms from different industries (defined at 3 digit NACE classification). l_{it} is firm size, measured in full-time units of labor. θ_{it} is productivity, measured as labor productivity (or TFP). ν_{it} is error term.

Table 4 presents our main results. In columns (1)-(3) the dependent variable is the natural logarithm of export sales in USD. Tariff and non-tariff barriers to trade have an impact on exports. Industry tariffs have a negative effect on the value of exports. NTMs are always positive and significant, which is consistent with the view that more stringent NTMs can play a role of a positive demand shifter. Higher tariffs and more non-tariff measures in upstream industries, on the other hand, have a negative effect on export. This is also an expected result because tougher trade

[6] We distinguish CIS and non-CIS exporters, which is indexed by c

	Dependent variable: log value of export			Dependent variable: log quantity of export		
	(1)	(2)	(3)	(4)	(5)	‘(6)
Productivity	-0.011	-0.034	0.082*	-0.025	-0.009	0.095*
	(0.034)	(0.030)	(0.039)	(0.038)	(0.031)	(0.041)
Industry Tariff	-2.147***	-0.487*	-0.499*	-0.885**	0.416	0.396
	(0.248)	(0.246)	(0.246)	(0.276)	(0.257)	(0.257)
Industry NTM	4.414***	0.562***	0.597***	7.209***	0.989***	1.021***
	(0.094)	(0.155)	(0.156)	(0.105)	(0.163)	(0.163)
CIS	0.657***	1.712	1.746	0.824***	2.545	2.563
	(0.040)	(2.288)	(2.284)	(0.045)	(2.393)	(2.389)
ln(empl)	-0.144**	-0.049	-0.067	-0.233***	0.032	0.027
	(0.048)	(0.043)	(0.045)	(0.053)	(0.045)	(0.047)
Input NTM	-2.514***	-1.400***	-1.411***	-2.145***	-1.006***	-0.993***
	(0.275)	(0.248)	(0.252)	(0.305)	(0.260)	(0.264)
Input Tariff	-2.846***	-0.347	-0.449	-1.648***	-0.446	-0.498
	(0.404)	(0.376)	(0.385)	(0.449)	(0.394)	(0.403)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Coutry-Year	No	Yes	Yes	No	Yes	Yes
Sub-Industry	No	No	Yes	No	No	Yes
N	47382	47382	47382	33601	33601	33601
R^2	0.086	0.372	0.376	0.143	0.477	0.480

Standard errors in parentheses. * p<0.05, ** p<0.01, *** p<0.001

Table 4: Gravity

barriers in the upstream industries narrow down the choices of inputs for a firm, which has a negative effect on technological efficiency of a firm.

Our results might be driven not by the effect of trade barriers on technological efficiency, but rather by variation in markups across different markets. In columns (4)-(6), the dependent variable is the natural logarithm of quantity of export in kilograms. It weakens the effect of tariffs on exports, which indicates that the tariff barriers affect exports primarily through prices. NTMs, on the other hand, work through the effect on technological efficiency, because results for NTMs remain significant, similar in magnitude, and of expected sign.

We also present results for aggregate firm-level exports and decompose them into probability of being exporter (equation (7)), total export per firm (equation (5)), average export per country, and number of destination countries. The results

Dependent variable	(1) Total Export	(2) Price	(3) Average export	(4) Number of countries	(5) Probability of export
TFP	0.425***	0.099***	0.314***	0.111***	0.313***
	(0.031)	(0.027)	(0.026)	(0.015)	(0.009)
Input Tariff	-1.381***	-1.045**	-0.969**	-0.413*	0.050
	(0.401)	(0.346)	(0.334)	(0.199)	(0.220)
Input NTM	-1.428***	-0.675*	-0.996***	-0.432**	-0.166
	(0.308)	(0.266)	(0.257)	(0.153)	(0.207)
ln(empl)	0.772***	0.075*	0.395***	0.377***	0.538***
	(0.043)	(0.037)	(0.036)	(0.022)	(0.007)
Firm FE	Yes	Yes	Yes	Yes	No
Year	No	No	No	No	Yes
Sub-industry	No	No	No	No	Yes
N	7353	7353	7353	7353	49227
R^2	0.083	0.006	0.047	0.060	

Robust standard errors clustered by firm in parentheses. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 5: Results of exporting along various margins

are presented in Table 5. Both tariff and non-tariff measures of protection in the upstream industries negatively effect exports along various margins. Productivity positively influence exports, and so does the firm size, measured as the number of workers. Probability of being an exporter, on the other hand, does not respond significantly to changes in trade barriers, the only variables that are significant in column (5) of the table are the technological efficiency and firm size.

8 Productivity: Estimation equation

The full estimated regression takes the following parametric form

$$\ln \theta_{it} = \gamma_0 + \delta_{inputNTM} \ln(1 + inputNTM_{it}) + \delta_{inputMFN} \ln(1 + inputMFN_{it}) + X_{it}\beta + T_t\mu + I_s\lambda + \epsilon_{it} \tag{20}$$

The dependent variable is the natural logarithm of TFP. The main variables of interest are $inputNTM_{it}$ and $inputMFN_{it}$.We control for firm-specific characteristics, including employment, export and import activities, and exit decision. T_t represents time fixed effect, whereas I_s represents 4-digit industry fixed effects. Errors are cluster-robust at the level of firm. Results are presented in Table 6. In columns (1)-(3) we look at contempraneous effects. In columns (4)-(6) all right hand side variables (except for fixed effects and exit decision) are lagged by one period. This partially removes endogeneity concerns about our input MFN and input NTM variables.For all regressions, both trade barriers have an expected negative effect on productivity, but the results are not robust once we control for year and industry fixed effects.

	(1)	(2)	(3)	(4)	(5)	(6)
Import Tariff	-1.594***	-1.021***	-0.125	-1.270***	-0.895***	-0.257*
	(0.211)	(0.159)	(0.135)	(0.168)	(0.141)	(0.126)
Import NTM	-1.089***	-1.207***	-0.207	-0.611***	-0.542***	-0.179
	(0.118)	(0.103)	(0.114)	(0.100)	(0.091)	(0.101)
ln(empl)	-0.057***	-0.035*	-0.019	-0.010	0.001	-0.003
	(0.015)	(0.014)	(0.014)	(0.012)	(0.011)	(0.011)
Export, Yes=1	0.193***	0.208***	0.203***	0.053**	0.059**	0.051**
	(0.020)	(0.019)	(0.019)	(0.019)	(0.018)	(0.018)
Import, Yes=1	0.082***	0.079***	0.093***	0.032	0.034*	0.045**
	(0.019)	(0.018)	(0.017)	(0.018)	(0.017)	(0.017)
Exit, Yes=1	-0.070	-0.052	-0.118**	-0.056	-0.042	-0.123**
	(0.042)	(0.040)	(0.040)	(0.046)	(0.044)	(0.045)
Year	No	No	Yes	No	No	Yes
Sub-industry	No	Yes	Yes	No	Yes	Yes
Firm	Yes	Yes	Yes	Yes	Yes	Yes
N	49510	49510	49510	41330	41330	41330
R^2	0.019	0.153	169	0.007	0.168	0.183

Cluster-robust standard errors in parentheses. * p<0.05, ** p<0.01, *** p<0.001

Table 6: Productivity, tariffs and NTM

9 Conclusions

In this paper we explored the effect of NTMs on firm's export and productivity. We have found that NTMs influence exports in two ways. First, more stringent health regulations in an industry play a role of positive demand shifter, because consumers in foreign countries are concerned about the quality and safety of food and, *ceteris paribus*, are more likely to buy products from a country with tougher standards. Second, NTMs are likely to increase costs and change composition of inputs in the upstream industries, which have a negative effect on export. NTMs in upstream industries lower total export, average export per country, and the number of destination countries where the firm exports. However, NTMs do not reduce a probability that a company becomes an exporter.

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About the Authors

Veronika Movchan is an Academic Director at the Institute for Economic Research and Policy Consulting - IER (Kyiv, Ukraine). Mrs. Movchan holds MA in Economics from the National University "Kyiv-Mohyla Academy" (Ukraine). Before joining the IER, she was a research fellow at Stanford University (USA) and worked as a consultant at the World Bank Resident Mission in Kyiv and the Harvard Institute for International Development (Ukraine). Her main research interests are in the sphere of trade policy, including WTO-related issues, regional integration, non-tariff measures, quantification of trade policy instruments, and modeling of policy changes, including the CGE modelling.

Volodymyr Vakhitov holds positions of Assistant professor at Kyiv School of Economics in Ukraine and of Senior Economist at the Center for Market Studies and Spatial Economics at Higher School of Economics in Russia. After graduating from the National University of Kyiv Mohyla Academy he obtained a PhD degree in Economics from the University of Kentucky, USA, in 2008. He was awarded with various grants and fellowships from the World Bank, Soros Foundation, and Global Development Network. Dr. Vakhitov's research interests are in agglomeration economies, urban and regional economics, and productivity analysis. Also, Dr. Vakhitov was invited to give lectures in Behavioral Economics both in Ukraine and abroad.

Oleksandr Shepotylo is a lecturer in the department of Economics at the University of Bradford, UK. Before that, he worked at Kyiv School of Economics (Ukraine) and Higher School of Economics (Russia). Oleksandr obtained PhD in Economics at the University of Maryland at College Park in 2006. He worked as a consultant at The World Bank's Development Research Group (DECRG) in 2003-2006. His main research interests are international trade, spatial econometrics, and applied industrial organization.

NUPI
Norwegian Institute of International Affairs
C.J. Hambros plass 2D
PO Box 8159 Dep. NO-0033 Oslo, Norway
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