Arbeitsbereich Ökonomie

IOS Working Papers

No. 387 May 2020

Market power, productivity and distribution of wages: theory and evidence with micro data

Oleksandr Shepotylo* and Volodymyr Vakhitov†

* Aston Universtiy, o.shepotylo@aston.ac.uk

† Kyiv School of Economics and Kyiv Economic Institute, vakhitov@kse.org.ua

Leibniz Institute for
EAST AND SOUTHEAST
EUROPEAN STUDIES

Landshuter Straße 4
D-93047 Regensburg

Telefon: (09 41) 943 54-10
Telefax: (09 41) 943 54-27
E-Mail: info@ios-regensburg.de
Internet: www.leibniz-ios.de

ISSN: 2199-9465

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Abstract

The declining labor share in national income and rising inequality over the last four decades raise questions about causes of these trends. In order to explain these trends, we develop a theoretical model that links intra-industry distribution of wages to variation in market power of firms. The model predicts that wages depend crucially on the demand side characteristics – they decline with market power if and only if demand elasticity is increasing with firm's output. Trade liberalization leads to expansion of more productive firms, which also increases their bargaining power, resulting in lower share of wage bill in total revenue.

The model predictions are tested on a sample of Ukrainian manufacturing firms in 2001–2007. We document that an increase in firm's size increases its bargaining power relative to workers. We measure firm level markups, and show that they increase with firm's output and market size. We find that wage rises with firm's productivity, but fall with its market power. The results are robust to various model specifications estimated at the firm and industry levels.

JEL-Classification: D43, F12, J31

Keywords: wage bargaining; wage inequality; heterogeneous firms; productivity; variable markups; international trade; monopolistic competition

We thank Philip Ushchev for invaluable contribution to the development of a theoretical model. We also thank C. d'Aspremont, K. Behrens, S. Cameron, R. Dos Santos, John Earle, D. Levando, N. Limao, P. Murrell, M. Parenti, D. Tarr, J.-F. Thisse, J. Wallis, Y. Gorodnichenko, and participants of conferences and seminars at ETSG, EERC, Royal Economic Society, George Mason University, University of Maryland, Higher School of Economics, New Economic School, Kyiv School of Economics, and SITE for valuable comments and suggestions. All remaining errors are ours.

1 Introduction

The rising inequality and declining labor share in income have been secular trends in the global economy for the last four decades. There is no consensus on what caused those changes. Dunne et al. (2004) connect increasing wage dispersion in US with development of IT technology. Goldberg and Pavcnik (2007) links it to globalization. There is even less consensus about the factors contributing to the declining labor share. One strand of the literature emphasizes the role of technology and technological change that leads to substitution of labor by capital or by increasingly more skilled labor (Karabarbounis and Neiman, 2014). Another strand stresses the impact of productivity slowdown Grossman et al. (2017). Yet, another stresses the role of market structure and demand conditions – factors that were profoundly changed by globalization and paved the way to the rise of "superstar firms" (Autor et al., 2017; De Loecker and Eeckhout, 2017).

Autor et al. (2017) points out that there are two reasons why larger firms may pay lower share of value added to workers – higher markups and lower share of fixed costs to value added. They focus on the second component, while this paper adds to the debates by showing that growing companies pay lower share of value added to workers due to higher markups. De Loecker and Eeckhout (2017) document 1 percent increase in markups over the last 35 years. They also demonstrate that growing markups can explain important trends in the data. Our paper provides theoretical explanation of growing markups stemming from rise of superstar firms, which is amplified by globalization. We show that the changes in markups depend on characterisitcs of demand.

We develop a model that accounts for both productivity shocks and changes in the market conditions within a unified framework that captures labor market rigidities, firm heterogeneity, and variable markups. To accomplish this goal, our point of departure is Helpman et al. (2010, hereafter HIR), who suggested a model that links the distribution of wages to the productivity distribution.[1] In the HIR framework, heterogeneous firms, facing a labor market with search and matching frictions, in equilibrium pay wages that increase with productivity. Wage inequality is driven by technological differences across firms. The model is based on identical

[1] See also Felbermayr et al. (2011); Egger and Kreickemeier (2012); Amiti and Davis (2012); Sethupathy (2013)

constant elasticity of substitution (CES) preferences across consumers, which precludes any effect of trade liberalization on firm's market power. It also follows that labor share in value added does not vary with the firm size. Such modeling features do not seem realistic as substantial variation of markups across firms and over time is well-known (De Loecker and Warzynski, 2012; De Loecker and Eeckhout, 2017).

We depart from the CES assumption as in Zhelobodko et al. (2012, hereafter ZKPT). As a result, in our model the bargaining power is variable. Firms with different productivity operate at different points of their demand schedules. Since our model allows variable demand elasticities, this leads to the effect of demand on labor share. Because the demand side effects in our model operate through the variable markups, distribution of market power across firms impacts wage distribution. This has an important policy implication that inequality concerns can be addressed through competition policy directed towards firms with high market power. This important conclusion is missing in the models that emphasize the technological differences across firms as the main reason for differences in wages. We provide a micro foundation for this channel, which stems from the fact that the outcome of the bargaining game crucially depends on the demand side characteristics.

Our main results may be summarized as follows. First, we derive the wage-productivity equation, which describes the link between firm-level productivity, markups, and wages. This equation states that more productive firms pay higher wages. Moreover, firms with higher market power set lower (higher) wages if and only if the aggregate demand elasticity is an increasing (decreasing) function of output. Trade liberalization reallocates market shares towards firms with higher productivity, which tend to increase their market power (Melitz and Ottaviano, 2008) and, conditional on productivity, lower wages.

Second, we document that an increase in the firm size increases its bargaining power relative to workers. The share of revenues that is attributed to the firm increases from 0.75 for small firms to 0.82 for large companies. Moreover, we find that markups increase with output and market size. These results are consistent with our model predictions when the inverse demand elasticity is increasing with output. We also find that demand for labor is not robustly determined by firm's productivity, which is also consistent with our theoretical model.

Third, we estimate the log-linearized version of the wage-productivity equation, focusing mainly on the sign of the markup coefficient, because the elasticity of wage with respect to the markup summarizes all the relevant features of the demand structure of the model. We exploit variation in trade costs and demand characteristics at the firm level and the regulatory changes in trade policy as a source of exogenous variation to identify the effects of productivity and markups on wages. We find an important negative (for workers) effect of market power in the wage bargaining process, which is comparable in absolute value to the positive effect of firm's productivity on wages. An increase in productivity leads to an increase in the average wage: the elasticity of wage with respect to productivity is 0.151 in the baseline IV specification. An increase in the markup, on the other hand, results in the lower average wage with elasticity –0.145. The effect is robust to various model specifications. Our results hold when we look at wages within manufacturing industries. Wages increase with growth in productivity, but decline with growth in market power. At the same time, wages have greater variability with an increase in variability of both productivity and markups. Moreover, the effect of variability in markups is found to be statistically significant, while the effect of variability in productivity is not.

The rest of the paper proceeds as follows. Section 2 develops a theoretical model and derives the wage-productivity equation. Section 3 describes the data. Section 4 presents results. Section 5 concludes.

2 Model

Our main goal is to derive a theoretically grounded wage equation that captures demand and supply motives and reflects division of bargaining power between a firm and a worker. We also introduce international trade into the model, because it allows us to exploit trade liberalization shocks when we empirically study the relationships between wages, productivity, and market power. We consider a two-country model with costly trade. Markets are monopolistically competitive. Firms are heterogeneous in productivity, and workers are heterogeneous in ability. Labor market has two sources of imperfections. First, firms do not directly observe workers' abilities, hence they bear the screening costs. Second, the search process for job candidates is costly. Unlike HIR, we do not impose any parametric specifications of preferences. Instead, in the spirit of ZKPT, we assume non-specified additive preferences, which implies that firms face non-isoelastic demands on both home and foreign markets. In addition, we do not restrict the model to a specific parametrization of the distribution of abilities.

2.1 Consumers

Each of the two countries is populated by a unit mass of consumers. Consumers share the same additive preferences given by

$$\mathcal{U} \equiv \int_0^N u\,(q_i)\mathrm{d}i + \int_0^{N^*} u\,(q_j^*)\mathrm{d}j \tag{1}$$

where q_i is consumption of domestic variety i and q_j^* is consumption of foreign variety j. Each consumer maximizes (1) subject to the budget constraint

$$\int_0^N p_i\, q_i \mathrm{d}i + \int_0^{N^*} p_j^*\, q_j^* \mathrm{d}j \leq w \tag{2}$$

The individual inverse demand for variety i is given by

$$p_i = \frac{u'(q_i)}{\lambda} \tag{3}$$

where λ is the Lagrange multiplier of the program (1)–(2), which shows marginal utility of income.

It is worth noting that consumers are heterogeneous in income, because workers with different levels of ability may earn different wages. As a consequence, the values of λ may also vary across consumers. We denote the distribution of λ's at home and foreign countries as $\mathbf{\Lambda}$ and $\mathbf{\Lambda}^*$, respectively.

2.2 Firms

Each country accommodates a continuum of firms. We assume that firms are non-atomic, which means that the impact of firm's behavior on market aggregates is negligible. In other words, unlike in oligopoly models, firms are not involved into strategic interactions. However, they are involved into *weak interactions*, which occur through the impact of collective firms' behavior on the market aggregates. Firms are heterogeneous in productivity θ drawn from a distribution $\Gamma(\theta)$, which is common for both countries. Each firm produces at most one variety, and each variety is produced by at most one firm. In other words, there are no scope economies.

Equation (3) implies that the aggregate demand faced by domestic firm i at the domestic market is given by

$$y_i = D(p_i; \mathbf{\Lambda}) \equiv \int_0^\infty (u')^{-1}(\lambda p_i)\mathrm{d}\mathbf{\Lambda}(\lambda) \tag{4}$$

It follows from (4) that if a firm chooses to sell y_d units of its product at the home market, then it receives revenue

$$R(y_d; \mathbf{\Lambda}) \equiv y_d \Delta(y_d; \mathbf{\Lambda}), \tag{5}$$

where $\Delta(y; \mathbf{\Lambda}) = D^{-1}(y; \mathbf{\Lambda})$ is the inverse aggregate demand. Similarly, selling y_x units at the foreign market yields revenue $R(y_x/\tau; \mathbf{\Lambda}^*)$, where τ is the iceberg transportation cost.

To export or not to export?

Consider exporting behavior of a firm. We assume that if a firm chooses to export it faces a fixed cost of exporting $f_e > 0$. Firm's total revenue $\mathcal{R}$ as a function of its total output y is given by

$$\mathcal{R}(y) \equiv (1 - I_x)R(y; \mathbf{\Lambda}) + I_x R_e(y; \mathbf{\Lambda}, \mathbf{\Lambda}^*), \tag{6}$$

where $I_x \in \{0,1\}$ is the indicator of the firm's exporting behavior ($I_x = 1$ if and only if firm exports), while R_e stands for the revenue of an exporting firm and is given by

$$R_e(y; \mathbf{\Lambda}, \mathbf{\Lambda}^*) \equiv \max_{y_d + y_x \leq y} \left[R(y_d; \mathbf{\Lambda}) + R\left(\frac{y_x}{\tau}; \mathbf{\Lambda}^*\right) \right]. \tag{7}$$

A firm chooses to export if and only if

$$R_e(y; \mathbf{\Lambda}, \mathbf{\Lambda}^*) - R(y; \mathbf{\Lambda}) \geq f_e. \tag{8}$$

It can be shown that the left-hand side of (8) increases with y, hence there exists a threshold value of output $\tilde{y} > 0$ such that the firm chooses to export if and only if $y > \tilde{y}$.

Production Technology

Following Helpman et al. (2010), we define firm's production function as follows

$$y = \theta \bar{a} h^\gamma, \; \gamma \in (0,1), \tag{9}$$

where θ is firm's productivity, h is the mass of workers hired by the firm, $\bar{a}$ is the average ability of workers hired, and γ captures the degree of diminishing marginal returns to labor.

Combining (9) with (6), we redefine firm's revenue as follows

$$R(h, \theta, \bar{a}) \equiv \mathcal{R}(\theta \bar{a} h^\gamma) \tag{10}$$

Following the duality principle, we define a variable production cost as follows

$$C(y;\, \bar{a}, \theta, w) \equiv w \left(\frac{y}{\theta \bar{a}}\right)^{1/\gamma} \tag{11}$$

For a non-exporting firm, the markup is given by

$$m \equiv \frac{p - \partial C / \partial y}{p}$$

For an exporting firm, the markups are

$$m_d \equiv \frac{p_d - \partial C / \partial y}{p_d}, \quad m_x \equiv \frac{p_x - \partial C / \partial y}{p_x}$$

Note that the firm can charge different markups at home and foreign markets.

2.3 Labor market

A worker is endowed with a specific level of ability a drawn from a distribution $G(a)$. Firms do not observe a, but know $G(\cdot)$. In contrast to Helpman et al. (2010) we do not assume any parametric specification of G.

Each firm chooses the mass n of workers to be interviewed. Search requires a constant cost $b > 0$ to interview an additional worker. Even though a is not observable, the firm can set up a screening process that allows to find out whether the worker's ability exceeds a *screening threshold* a_c chosen by the firm. The firm bears screening costs $S(a_c)$, which are assumed to satisfy $S'(a_c) > 0,\ S''(a_c) \geq 0$, and hires a worker if and only if $a > a_c$. Thus, the mass of hired workers is determined as $h = [1 - G(a_c)]n$, while the average ability of workers within the firm is the mean of distribution G, truncated at the level a_c.

Wage bargaining process

We now come to the wage determination process. We assume that, given n and a_c (hence h and $\bar{a}$), each firm is involved in a bargaining game with its potential workers. To describe the bargaining process, we use the approach proposed by (Stole and Zwiebel, 1996).[2] This approach takes into account that a firm internalizes potential gains or losses from re-negotiation, which arise when the number of workers changes (e.g. if an applicant leaves without achieving an agreement on the wage). As a consequence, it must be that, given θ and $\bar{a}$, the negotiated wage $w_{\text{neg}}(h, \theta, \bar{a})$ satisfies the following equation (Helpman et al., 2010):

$$\frac{\partial R}{\partial h} = w + \frac{\partial (wh)}{\partial h} \quad \text{forall } h > 0. \tag{12}$$

Equation (12) brings together two ideas. First, the wage-setting game results in firm's marginal benefits $\partial R / \partial h$ of hiring an extra worker being equal to marginal hiring costs. Second, firms internalize re-negotiation effects captured by the second term of the right-hand side of (12): in addition to the wage w paid to an extra worker, marginal hiring cost includes a change in the total wage bill $\partial (wh) / \partial h$.

[2] It develops a non-cooperative bargaining game framework to look at the bargaining process between employees and the firm if contracts are non-binding. It has a unique equilibrium that in its simlest form can be characterized either as the simple average of the neoclassical (i.e., non-bargaining) firm's profits or as the Shapley value of the corresponding cooperative game.

Solving (12), we find that the total wage bill is given by

$$hw_{\text{neg}}(h,\theta,\bar{a}) = R(h,\theta,\bar{a}) - \frac{1}{h}\int_0^h R\,(\xi,\theta,\bar{a})\mathrm{d}\xi \tag{13}$$

Claim. The negotiated wage decreases with h if and only if $R(h,\theta,\bar{a})$ is concave in h.

See Appendix 1 for deriving (13), as well as for the proof of the Claim.

Denote through $\beta(h,\theta,\bar{a})$ the *bargaining power* of firm θ, measured as the share of revenue attributed to firm θ:[3]

$$\beta(h,\theta,\bar{a}) \equiv \frac{R(h,\theta,\bar{a}) - hw_{neg}(h,\theta,\bar{a})}{R(h,\theta,\bar{a})}. \tag{14}$$

Unlike in HIR, firms' bargaining power is no longer constant, it now varies with h. Indeed, combining (13) with (14), we obtain

$$\beta(h) = \frac{\int_0^h R\,(\xi,\theta,\bar{a})d\xi}{hR(h,\theta,\bar{a})}. \tag{15}$$

Do larger (in terms of h) firms always enjoy higher bargaining power in the wage setting process than the smaller ones? We show in Appendix 1 that the elasticity of β with respect to h is given by

$$\mathcal{E}_h(\beta) \equiv \frac{\partial\beta}{\partial h}\frac{h}{\beta} = \frac{\int_0^h R\,(\xi,\theta,\bar{a})\left[\mathcal{E}_\xi(R) - \mathcal{E}_h(R)\right]d\xi}{\int_0^h R\,(\xi,\theta,\bar{a})d\xi}. \tag{16}$$

Inspecting (16), we come to a proposition.

Proposition 1. *Given θ and $\bar{a}$, firms' bargaining power increases (decreases) with the number of workers if the elasticity of revenue $\mathcal{E}_h(R)$ is a decreasing (increasing) function of h.*

Recall that

$$R(h,\theta,\bar{a}) = \theta\bar{a}h^\gamma\Delta(\theta\bar{a}h^\gamma).$$

Hence, we have $\mathcal{E}_h(R) = \gamma[1-\eta(y)]$, which implies the following corollary of Proposition 1.

[3] Our definition of bargaining power is outcome-based and can be directly measured. Moreover, $1-\beta$ measures the labor share in firm's revenue.

Corollary. *Given θ and $\bar{a}$, firms' bargaining power increases (decreases) with the number of workers if the inverse demand elasticity $\eta(y)$ is an increasing (decreasing) function of y.*

This result clearly shows that it is the demand side which is crucial for the wage bargaining outcome. Using this result, it is straightforward to test the property of the inverse elasticity of demand using firm level data. Revenue and total wage bill, which are required to compute the bargaining power of a firm, are readily available in most firm-level data sets. The same is true about the size of the labor force. We perform the test further in the paper.

2.4 Profit maximization

To maximize profit, each firm chooses how many workers to interview n, how many workers to hire h, the screening threshold a_c, and the decision whether to export I_x

$$\pi = R(h, \theta, \bar{a}) - wh - bn - S(a_c) - f_d - f_e I_x$$

Using $h = [1 - G(a_c)]n$, (20), as well as (12), the firm's problem may be reformulated as follows

$$\max_{a_c, h, I_x} \left[R(h, \theta, \bar{a}) - wh - \frac{bh}{1 - G(a_c)} - S(a_c) - f_d - f_e I_x \right] \tag{17}$$

The first order condition $\partial\pi/\partial h = 0$ yields

$$w = \frac{b}{1 - G(a_c)} \tag{18}$$

The intuition behind (18) is as follows. According to Stole and Zweibel bargaining procedure, the firm's marginal benefit of losing one worker is equal to w. On the other hand, given the screening threshold a_c, $b/(1 - G(a_c))$ is a marginal replacement cost. Thus, (18) states that at the optimal level of employment, the firm equates the marginal cost and marginal benefit of hiring a worker. It also implies that the profit maximizing level of the total wage bill is equal to the total search cost. Another important message sent by (18) is that firms making tougher requirements typically pay higher wages – there is an increasing relationship between w and a_c, independent from other endogenous variables. As a consequence, wage is uniquely pinned down by the screening threshold, regardless of the other decisions of the firm on production and exporting.

The condition $\partial\pi/\partial a_c = 0$ yields

$$\frac{g(a_c)}{1-G(a_c)}\left[\left(1-\frac{a_c}{\bar{a}}\right)\frac{1}{\gamma}-1\right]\frac{w}{S'(a_c)} = \left(\frac{\theta}{y}\right)^{1/\gamma}, \tag{19}$$

while the average within-firm ability of workers is given by

$$\bar{a} = \frac{\int_{a_c}^{\infty} a\, dG(a)}{1-G(a_c)}. \tag{20}$$

Equation (20) defines a one-to-one relationship between a_c and $\bar{a}$. Combining (20) with (19) and (18), we may restate (19) as follows

$$\frac{\theta}{y} = \phi(w) \tag{21}$$

where

$$\phi(w) = \left[\frac{g(a_c(w))}{1-G(a_c(w))}\left(\left(1-\frac{a_c(w)}{\bar{a}(a_c(w))}\right)\frac{1}{\gamma}-1\right)\frac{w}{S'(a_c(w))}\right]^{\gamma}$$

If $\phi'(w) > 0$, output and wages are negatively related for firms with the same productivity level.[4] Combining (21) with production function equation (9), we derive a downward-sloping demand for labor

$$h^{*}(w) = \left(\frac{1}{\bar{a}(a_c(w))\phi(w)}\right)^{1/\gamma} \tag{22}$$

It is worth-noting that this demand is the same for all firms, because it is independent of θ. However, this property depends crucially on the power specification of production function. We test properties of the firm-level demand for labor conditional on productivity level in the empirical part of the paper.

2.5 Wage-productivity equation

Equation (21) can be rewritten as follows

$$\ln\, w = \Psi(\ln\, \theta - \ln\, y) \tag{23}$$

[4] It can be shown that $\phi'(w) > 0$ when (i) G is Pareto, while S is power function or (ii) G is exponential, while S is linear.

Furthermore, it can be shown that the profit-maximizing markups for a non-exporting firm satisfy the standard monopoly pricing rule

$$m = \eta(y), \tag{24}$$

where $\eta(y)$ is the *inverse aggregate demand elasticity*:

$$\eta(y) \equiv -\frac{\partial \Delta}{\partial y}\frac{y}{\Delta} \tag{25}$$

Using (24) and a linear Taylor approximation of (23), we obtain

$$\ln\ w \approx \ln\ \bar{w} + \delta_\theta(\ln\ \theta - \ln\ \bar{\theta}) + \delta_m(\ln\ m - \ln\ \bar{m}) \tag{26}$$

where

$$\delta_\theta = \Psi'(\ln\ \bar{\theta} - \ln\ \bar{y}), \quad \delta_m = -\delta_\theta \frac{\eta(\bar{y})}{\bar{y}\eta'(\bar{y})}. \tag{27}$$

Notice that $\frac{\delta_m}{\delta_\theta} = -\frac{\bar{y}\eta'(\bar{y})}{\eta(\bar{y})}$ is the superelasticity of inverse aggregate demand as defined by Klenow and Willis (2006). Thus, our model suggests a natural estimator of superelasticity, different from the one used by Nakamura and Zerom (2010).

Equation (26) can be estimated using a log-linear regression. Moreover, it follows immediately from (27) that (i) $\delta_\theta > 0$, (ii) $\delta_m < 0$ if and only if $\eta(y)$ is an increasing function of y, (iii) $\delta_\theta + \delta_m = 0$ if and only if $\frac{\bar{y}\eta'(\bar{y})}{\eta(\bar{y})} = 1$. The last condition holds regardless of a specific value of $\bar{y}$ if and only if η is linear in y, which is equivalent to $\Delta(y) = A\exp(-\kappa y)$. In other words, inverse aggregate demand varies with y as if it was generated by a representative consumer with CARA utility: $u(q) = 1 - \exp(-\kappa q)$. (see Behrens and Murata (2007) for details).

For exporting firms, domestic and exporting markups are given by

$$m_d = \eta(y_d), \quad m_x = \eta\left(\frac{y_x}{\tau}\right). \tag{28}$$

Linearizing (23), we obtain

$$\ln\ w \approx c + \delta_\theta \ln\ \theta + \delta_M \ln\ M \tag{29}$$

where

$$M = m_d^{\frac{\alpha}{\alpha+\beta}} m_x^{\tau\frac{\beta}{\alpha+\beta}} \tag{30}$$

is a composite markup and

$$\delta_\theta = \Psi'(\ln\ \bar{\theta} - \ln\ \bar{y}), \quad \delta_M = -\delta_\theta(\alpha+\beta) \tag{31}$$

$$\alpha = \frac{\eta(\bar{y}_d)}{\bar{y}_d\eta'(\bar{y}_d)}\frac{\bar{y}_d}{\bar{y}}, \quad \beta = \frac{\eta(\bar{y}_x)}{\bar{y}_x\eta'(\bar{y}_x)}\frac{\bar{y}_x}{\bar{y}}$$

It is clear that markups are endogenously determined within the model. First, they depend on exogenous trade costs τ. Second, note that aggregate demand elasticity η also depends on Λ and Λ^*. This justifies including observable trade costs measures and market aggregates statistics, such as aggregate demand and income inequality, as instruments that generate exogenous variability in the markups across firms.

3 Data

To explore links between wages, productivity, and markups, we look at the Ukrainian firm-level data in 2001–2007 from the State Statistics Service of Ukraine (UKRSTAT). We restrict our sample to manufacturing firms (NACE Revision 1.1 Section "D", codes 15–37) with 20 or more workers.[5]

As a measure of output (y), we use "Net sales after indirect taxes" from the Financial Results Statement. The Balance Sheet Statement is the source of the capital measure (k), for which we use "End-of-year value of tangible assets". Employment (h), material costs (mat), wage cost (wc), and investment (i) come from the Enterprise Performance Statement. Employment is measured as the "Year-averaged number of enlisted employees", which is very similar to a full-time equivalent used elsewhere. For investment, we use "Investments in tangible assets."

Our measure of the firm-level average wage is

$$w = \widetilde{wc}/h,$$

where $\widetilde{wc} = wc/CPI$ is real wage cost and CPI is consumer price index.

Output is deflated by an industry-specific price index. Capital, investment, and material costs are deflated by a producer price index (PPI). We exclude observations with zero or negative output, capital stock or employment. We also exclude outliers based on top and bottom 1 percentile of output, capital, employment, and material costs. Based on the files accompanying the Enterprise Performance Statement and the Balance Sheet Statement, we create a comprehensive profile for every firm, which includes the territory code and the four-digit sub-industry code, fully compatible with the NACE classification.

To control for selection and attrition factors, we generate entry and exit indicator variables, marking an entry as the first year when a firm appears in the sample, and an exit as the last year when a firm appeared in the sample. In year 2007, the value of the exit variable is assumed to

[5] We combine industries 15 (Manufacture of food products and beverages) and 16 (Manufacture of tobacco products) into one industry (15+16) due to a small number of firms in industry 16. This gives us 22 manufacturing industries.

Our results for all manufacturing firms do not differ neither in statistical significance nor in size of the coefficient point estimates. Results are available upon request.

be zero, to be consistent with Olley and Pakes (1996). Similarly, the entry variable is assumed to be zero for all firms in 2001.

A comprehensive transaction-level database of foreign trade in goods collected by Ukrainian Customs Service is used for measuring firm's exports and imports. It contains information about export and import value in USD, country of origin for imports and country of destination for exports, and a four-digit product classification code, defined by the Harmonized System (HS-4).english We use these data to define export-to-sales and import-to-sales shares, which are better measures of the firm level exposure to international trade than binary indicators. We also use these data to construct instruments for markups and for productivity variables.

The descriptive statistics are presented in Table 1. The full dataset contains over 18,000 manufacturing firms with average employment of 215 employees. 11 percent of sales go abroad and 8 percent of inputs are imported. About 8 percent of firms are foreign, which is defined as 10 percent or more assets owned by foreigners. On average, 2 percent of firms exit and 4 percent of firms enter manufacturing annually. 71 percent of firms are located in urban areas, 93 percent of firms are privately owned, and 96 percent firms have only one plant, which considerably reduces a concern about establishment level vs firm level data.

However, only approximately 10,000 manufacturing firms (in 2007, this number fell down to 2,700 firms due to the change in the sample composition), that we call the IV sample, report the Annual Sectoral Expenditures Statement with detailed firm's expenditures on purchases from 22 manufacturing industries and 15 service sub-sectors. These data are essential for our identification strategy, allowing us to construct instruments for productivity. The IV sample descriptive statistics are presented in the right panel of the table. Firms in this sample are bigger, pay higher wages, export and import more, more often are foreign or state owned. The average employment of reporting manufacturing firms in the IV sample is 333 workers. These firms also produced over 75% of the annual manufacturing output of Ukraine in the sample period.

Table 1: Summary statistics

	Full sample			IV sample		
	N	Mean	S.d.	N	Mean	S.d.
Wage per worker (w), thsd UAH 2001	71,422	4.66	3.65	40,557	5.06	3.93
Output (y), mln. UAH 2001	71,430	16.21	145.86	40,557	26.18	190.38
Employment (h), workers	71,430	214.84	1116.34	40,557	332.54	1449.78
Capital (k), mln. UAH 2001	71,430	5.50	40.18	40,557	9.03	52.62
Material cost (mat), mln. UAH 2001	71,430	10.07	111.55	40,557	16.49	146.59
Investment (i), mln. UAH 2001	48,803	1.81	18.42	32,371	2.47	22.32
$\ln(w)$	71,422	1.31	0.70	40,557	1.40	0.68
$\ln(M)$	71,430	–0.85	0.45	40,557	–0.91	0.44
$\ln(TFP)$	69,028	1.08	1.39	40,557	1.07	1.35
$\ln(LP)$	69,444	2.36	1.25	39,236	2.48	1.28
Export share	71,430	0.11	0.25	40,557	0.13	0.26
Import share	71,430	0.09	0.24	40,557	0.11	0.26
Foreign	71,430	0.08	0.27	40,557	0.10	0.29
Exit	71,430	0.02	0.15	40,557	0.02	0.14
Entry	71,430	0.04	0.20	40,557	0.02	0.13
Urban	71,430	0.71	0.45	40,557	0.69	0.46
Private	71,430	0.93	0.26	40,557	0.90	0.31
Single plant	71,430	0.96	0.21	40,557	0.93	0.26
Input tariff	41,272	4.91	3.16	40,557	4.92	3.15
Service lib.				40,557	0.35	0.53

3.1 Productivity

In our empirical analysis we use two measures of productivity, labor productivity (LP) and total factor productivity (TFP). Labor productivity is computed as the value added deflated by the industry price deflator divided by the number of workers. TFP is estimated under assumption of the Cobb-Douglas production function.

TFP estimation

To recover TFP, we estimate a production function for each manufacturing industry (2-digit NACE classification). We use the Olley-Pakes procedure (Olley and Pakes, 1996), controlling for sub-industry (4-digit NACE classification) specific demand shocks as in De Loecker (2011).

We identify demand shocks by exploiting variation in the sub-industry output at time t and by controlling for sub-industry and time fixed effects. As a new result, we extend De Loecker methodology to the case of non-CES preferences. The estimation details, derivations, and estimated coefficients are presented in the appendix.

3.2 Markups

We calculate firm-specific markups following De Loecker and Warzynski (2012). The method does not impose any demand side or market structure restrictions. It relies on a cost-minimizing producer, variable input into production (i.e. material costs), and continuous, twice-differentiable production function.

We denote the price to marginal cost ratio as $\widehat{m} = p/(\partial C/\partial y)$ and compute it according to the following formula

$$\widehat{m}_{it} = \frac{\beta_{mat}}{mat_{it}/p_{it}y_{it}}. \tag{32}$$

In other words, $\widehat{m}_{it}$ equals to the ratio of the material cost's output elasticity to its revenue share. We then calculate a markup as $M_{it} = \frac{p-\partial C/\partial y}{p} = 1 - 1/\widehat{m}_{it}$.

3.3 Summary statistics

Summary statistics of the natural logs of labor productivity, TFP, markups, and wages in 2001–2007 are presented in Table 2. The left panel of the table presents statistics for the full sample. Over the investigated period, labor productivity and TFP increased by 115 percent and 54 percent respectively. Dispersion of labor productivity and TFP remained relatively stable, but showed some signs of reduction. Similarly, markups increased by roughly 15 percent with a downward trend in volatility. An increase in the markups during the trade and services liberalization episode is consistent with findings of De Loecker et al. (2012): during the trade liberalization episode in India, marginal costs decreased by 40 percent, while prices fell by only 16.8 percent, leading to higher markups. Average firm-level wages during the same period increased by 80 percent and became more equal, which is consistent with lower volatility in productivity and markups.

For the IV sample, which is presented in the right panel of the table, growth in productivity and wages was even stronger. TFP increased by 82 percent, whereas wages grew by 182 percent. At the same time there was a relatively small increase in markups: 10 percent increase in 2001–2006 followed by a small decline in 2007. We attribute the last fact to a considerable reduction of firms that reported their use of inputs in 2007, which substantially reduced the sample size.

Table 2: Productivity, markups, and wages

	Full sample				IV sample			
	LP	TFP	$\ln M$	$\ln w$	LP	TFP	$\ln M$	$\ln w$
2001								
Mean	1.75	0.81	–0.96	0.83	1.77	0.79	–0.99	0.91
S.d.	1.40	1.40	0.50	0.74	1.40	1.37	0.49	0.72
2002								
Mean	1.98	0.91	–0.90	1.05	2.05	0.89	–0.95	1.15
S.d.	1.23	1.39	0.48	0.68	1.27	1.33	0.46	0.65
2003								
Mean	2.14	0.98	–0.89	1.17	2.26	0.97	–0.96	1.29
S.d.	1.21	1.38	0.48	0.66	1.22	1.32	0.46	0.61
2004								
Mean	2.43	1.11	–0.83	1.31	2.58	1.11	–0.88	1.42
S.d.	1.15	1.38	0.44	0.62	1.14	1.31	0.42	0.57
2005								
Mean	2.60	1.18	–0.82	1.49	2.74	1.18	–0.86	1.61
S.d.	1.08	1.36	0.42	0.59	1.07	1.31	0.40	0.55
2006								
Mean	2.75	1.25	–0.79	1.62	3.03	1.32	–0.85	1.77
S.d.	1.08	1.37	0.42	0.58	1.05	1.36	0.40	0.54
2007								
Mean	2.90	1.35	–0.75	1.71	3.59	1.61	–0.87	2.06
S.d.	1.11	1.34	0.40	0.56	1.03	1.24	0.35	0.53
Total								
Mean	2.36	1.08	–0.85	1.31	2.46	1.07	–0.91	1.39
S.d.	1.25	1.39	0.45	0.70	1.29	1.35	0.44	0.69

This table reports means and standard deviations of the natural logs of labour productivity (LP), total factor productivity (TFP), markup (M), and average wage (w) in 2001–2007 for full and IV samples.

4 Results

4.1 Bargaining power and the firm size

We first establish the relationship between firm's bargaining power and the size of its labor force. Given productivity and average worker's ability, *firm's bargaining power, measured as* $\beta(h) = (R - wh)/R$, *increases with the number of workers if the elasticity of revenue* $\mathcal{E}_h(R)$ *is a decreasing function of h. It also means that the inverse demand elasticity* $\eta(y)$ *is an increasing function of* y. Importantly, under CES demand, firms bargaining power is a constant $\beta(h) = \beta_{CES}$ that does not depend on the firm size. Therefore, testing for the relationship between β and h allows us to answer the question whether CES utility is a good approximation of underlying preferences.

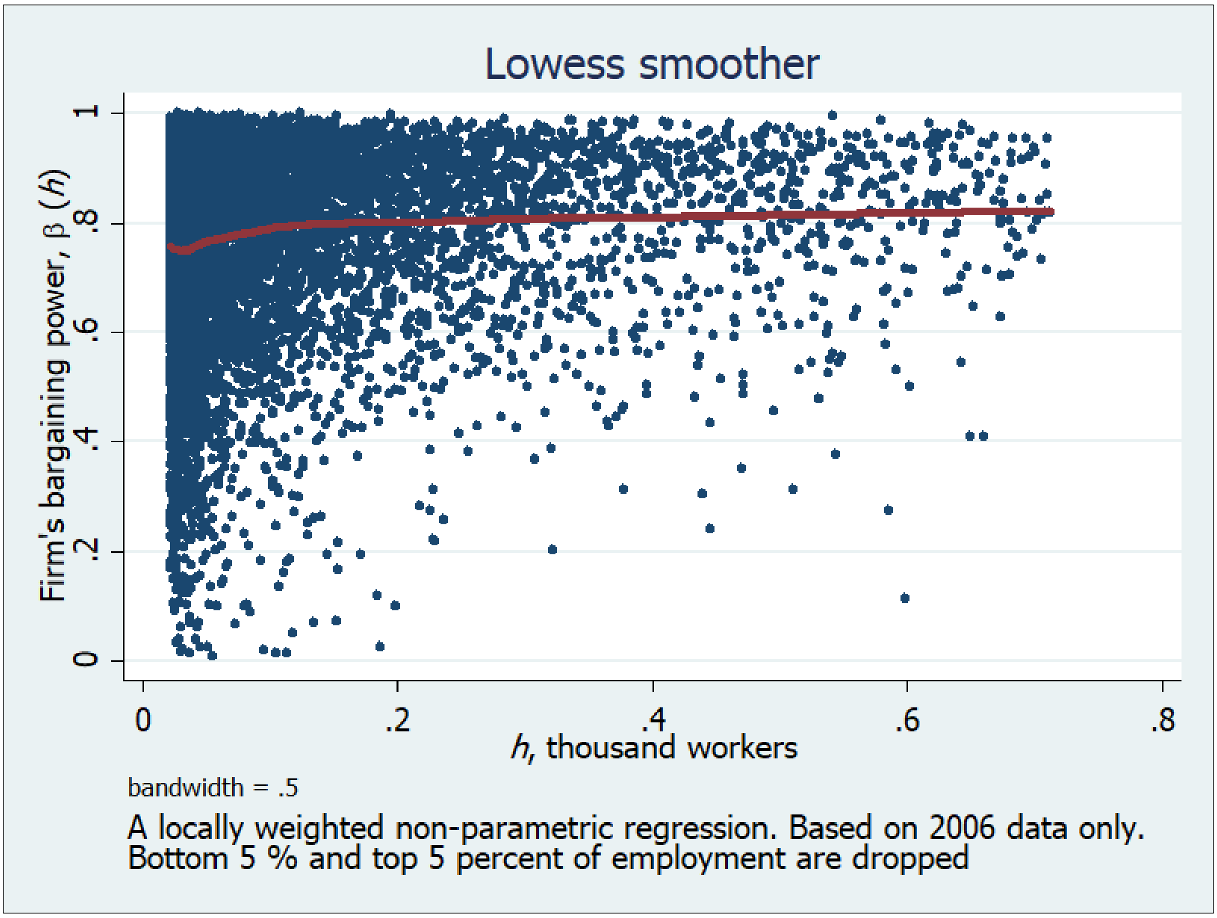

Figure 1: Firms bargaining power and employment

Figure 1 presents a scatter plot of the relationship between firm's bargaining power and its size. The solid line is bargaining power predicted using a non-parametric, locally-weighted regression of $\beta(h)$ on h. It shows an increase in the bargaining power from 0.75 for small firms to 0.82 for large companies. This result is consistent with the model's prediction that inverse demand elasticity increases with output. To formally test for this effect, we estimate the following equation

$$\beta_{it} = \bar{a}_i + \gamma_h h_{it} + \gamma_\theta \theta_{it} + \varepsilon_{it},$$

where we assume that average worker's ability $\bar{a}_i$ does not vary over the investigated period and is captured by the firm's fixed effect, θ_{it} is firm's productivity, h_{it} is number of workers, and ε_{it} is an error term.

Table 3: Bargaining power and firm size

Dependent variable: Firm's bargaining power $\beta(h)$						
	(1)	(2)	(3)	(4)	(5)	(6)
Employment (h), thds. workers	$.011^{*}$	$.013^{*}$	$.0060^{*}$	$.0089^{*}$		
	(.005)	(.005)	(.003)	(.004)		
TFP	$.00015^{*}$		$.00018^{*}$			
	(.000)		(.000)			
LP		$.00021^{**}$		$.00025^{**}$		
		(.000)		(.000)		
$\ln(h)$					$.0095^{**}$	$.0085^{**}$
					(.001)	(.001)
$\ln(TFP)$					$.062^{**}$	
					(.001)	
$\ln(LP)$						$.039^{**}$
						(.002)
Year FE	No	No	Yes	Yes	Yes	Yes
Region FE	No	No	Yes	Yes	Yes	Yes
Industry FE	No	No	Yes	Yes	Yes	Yes
Observations	67993	70304	67993	70304	67993	68585
R^2	.002	.009	.042	.050	.180	.215

Robust standard errors clustered at firm level in parentheses. All models have firm fixed effects. In models (1)–(4) the dependent variable is β. In models (5) and (6), the dependent variable is $\ln(1+\beta)$

The results are presented in Table 3. In columns (1)–(4) we look at a linear model specification, using two different measures of productivity and different sets of fixed effects. Columns (5) and (6) of the table present estimates of the double log functional form. All models have firm fixed effects. In columns (3)–(6) we also control for industry, year, and region fixed effects to capture technological differences, aggregate shocks, and regional differences in demographic, institutional, and labor market conditions.

The coefficient on the number of workers is positive and significant in all specifications. Increasing a number of workers by a thousand is associated with an increase in firm's bargaining power by 0.6–1.3 percentage points. This result is consistent with the fact that firms that produce more output also charge higher markups (Melitz and Ottaviano, 2008). The double log model yields similar conclusions. An increase in the average size of a firm by one standard deviation is associated with 1.8 percentage points increase in bargaining power. The log-log model also has a better fit, which suggests that the relationship between the bargaining power and labor force size is non-linear.

4.2 Labor demand

Following our theoretical results, we further estimate demand for labor and test whether it is independent of productivity. The labor demand equation is specified similarly to (Hamermesh, 1993):

$$\ln\, h_{it} = \xi_0 + \xi_1 \ln\, h_{it-1} + \xi_2 \ln\, w_{it} + \xi_3 \ln\, TFP_{it} + X_{it}\Xi + \omega_{it}.$$

where h is the number of workers, w is firm-level wage, TFP is total factor productivity, and X includes firm specific characteristics, such as export status, ownership type, single- or multi-plant firm, and exit.

Table 4 presents estimates of the labor demand equation. Model (1) is estimated as a fixed effect model. Models (2)–(5) are estimated by Arellano-Bover/Blundell-Bond linear dynamic panel-data method (Blundell and Bond, 1998), with the firm-level wage as an endogenous variable and a lagged value of the dependent variable as one of the controls. According to our preferred method (column (5)), wage elasticity of demand is approximately -0.14, which is close to the upper bound for similar studies (Navaretti et al., 2003; Lichter et al., 2015). Importantly, productivity is not a robustly significant determinant of the demand for labor, as our theoretical model suggests. Capital is negatively associated with the demand for labor, which is consistent with our assumptions about the production function. Exporters demand 8.6 percent more labor, which is consistent with Helpman et al. (2010) model and also confirmed empirically in other studies (i.e. Amiti and Davis, 2012). Exiting firms demand 22.4 percent less labor. We also find that single-plant firms demand 3 percent less labor relative to multi-plant firms. Interestingly, foreign ownership does not play any significant role in explaining the demand for labor.

Table 4: Labor Demand

Dependent variable: ln (h)					
	(1)	(2)	(3)	(4)	(5)
ln (w)	-0.030**	-0.143**	-0.143**	-0.142**	-0.142**
	(0.011)	(0.028)	(0.028)	(0.028)	(0.028)
ln (TFP)	0.018**	–0.013	–0.013	–0.013	–0.013
	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
ln (k)	0.099**	-0.051**	-0.051**	-0.050**	-0.049**
	(0.004)	(0.015)	(0.015)	(0.015)	(0.015)
Export share	0.113**	0.086**	0.086**	0.086**	0.086**
	(0.017)	(0.016)	(0.016)	(0.016)	(0.016)
Exit	-0.228**	-0.244**	-0.244**	-0.244**	-0.243**
	(0.020)	(0.021)	(0.021)	(0.021)	(0.021)
Private	0.032	0.018			0.017
	(0.023)	(0.029)			(0.029)
Foreign	0.013		0.015		0.014
	(0.013)		(0.014)		(0.014)
Single plant	-0.056**			-0.033*	-0.032*
	(0.013)			(0.013)	(0.013)
L.ln (h)	0.503**	0.578**	0.577**	0.577**	0.577**
	(0.010)	(0.017)	(0.017)	(0.017)	(0.017)
Observations	51809	51809	51809	51809	51809
R^2	0.411				
χ^2		4035	4019	4000	4046

Robust standard errors clusterd at firm level reported in parentheses. Each estimation includes region, year-industry, and firm fixed effects. Labor demand equation is defined as in Hamermesh (1993) and Barba Navaretti et al. (2003) Model (1) includes firm fixed effects. Models (2)–(5) are estimated as Arellano-Bover/Blundell-Bond linear dynamic panel-data models with the average wage as an endogenous variable and a lagged value of the dependent varaibles as one of the controls. Blundell and Bond (1998) developed a system estimator that uses additional moment conditions; Stata command xtdpdsys implements this estimator, which is reported in this table.

4.3 Markups, size, and transportation costs

To understand how markups respond to trade costs and demand side shocks, given (30), we estimate the following equation

$$\ln\ M_{it} = \gamma_d \ln\ y_{dit} + \gamma_x \ln\ y_{xit} - \gamma_\tau \widehat{\tau_{it}} + \gamma_{MP} \widehat{MP_{it}} + \nu_{it}$$

and present results in Table 5. We do not observe domestic and export quantities, so we proxy those by domestic and export revenues. In column (1), we regress markups on total revenues. Higher revenues are associated with higher markups. It corresponds well with the fact that the bargaining power of firms is increasing with size. In column (2), we split revenues into domestic and export revenues. Markups increase with both domestic and export sales, which is consistent with the fact that the inverse elasticity of demand is increasing with output of a firm. We also can not reject the hypothesis that the markup elasticities of local and foreign sales are equal for the majority of our results.

Table 5: Markups

Dependent variable: ln (M)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln (y)	$.061^{**}$								
	(.004)								
ln (y_d)		$.061^{**}$	$.061^{**}$	$.043^{**}$	$.043^{**}$	$.042^{**}$			
		(.004)	(.004)	(.004)	(.004)	(.004)			
ln (y_x)		$.060^{**}$	$.066^{**}$	$.050^{**}$	$.050^{**}$	$.050^{**}$			
		(.004)	(.005)	(.005)	(.005)	(.005)			
Transport cost			$-.050^{**}$	$-.187^{**}$	$-.186^{**}$	$-.187^{**}$	$-.153^{**}$	$-.151^{**}$	$-.075^{**}$
			(.019)	(.022)	(.022)	(.022)	(.016)	(.016)	(.011)
Market size				$.111^{**}$	$.108^{**}$	$.109^{**}$	$.118^{**}$	$.117^{**}$	$.029^{**}$
				(.006)	(.006)	(.006)	(.006)	(.006)	(.003)
ln (h)								$-.011^{+}$	
								(.006)	
ln (TFP)									$.484^{**}$
									(.006)
Region FE	No	No	No	No	No	Yes	Yes	Yes	Yes
Industry FE	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Observations	71430	71430	71430	71430	71430	71430	71430	71430	69028
R^2	.015	.015	.015	.051	.067	.068	.060	.060	.423
$H_0\colon \beta_{\ln(y_d)} = \beta_{\ln(y_x)}$		.432	.132	.043	.025	.023			

Robust standard errors clustered at firm level in parentheses. Each estimation includes firm fixed effects. The last row in the table present p-values of the test for equality of the domestic and foreign output elastisities of markup.

In column (3), we add transport costs. Firms that sell in remote markets have lower markups, which contradicts findings in Hummels and Skiba (2004). In column (4), we control for the market size. Markups increase with the market size, which indicates that the self-selection of more productive firms into tougher markets dominates the competition effect. In columns (5)–(6) we consequently add industry and region fixed effects to account for unobserved variation in prices across industries and regions. In column (7) we drop outputs from estimation because of endogeneity and measurement error concerns and report only the effects of market potential and trade costs. In columns (8) and (9) we use employment and TFP as additional controls to account for firm size. In all specifications that include the market size and trade costs we have a positive effect of the market size on markups and a negative effect of trade costs on markups, which are statistically significant at 5 percent level. We use this result in Section 4.5 when we instrument markups with our measures of the market size and trade costs.

4.4 Wages, productivity and markups: OLS

The empirical counterpart of equation (29) is

$$\ln\ w_{it} = \alpha_i + \delta_\theta \ln\ \theta_{it} + \delta_M \ln\ M_{it} + \delta_{exp} \times export_{it} + \delta_{\theta exp} \times export_{it} \ln\ \theta_{it} + X_{it}\gamma + D_{st}s + D_r r + \epsilon_{it} \tag{33}$$

where w_{it} is firm $i's$ average wage at time t. θ_{it} is firm $i's$ measured productivity at time t. M_{it} is firm $i's$ average markup, $export_{it}$ is the export-to-sales share. D_{st} are industry-year fixed effects, and D_r are region fixed effects. X represents a vector of additional controls, including firm size, import intensity, ownership, exit indicator, and location.

Based on the theory developed in Section 2, we expect $\delta_\theta > 0$, which reflects a well-documented stylized fact that more productive firms pay higher wages (Amiti and Davis, 2012). However, the behavior of δ_m is more versatile. It is positive (negative) if and only if inverse demand elasticity is a decreasing (increasing) function of y, i.e. when larger firms charge lower (higher) markups.

Table 6: OLS: Wage, productivity, and markups

Dependent variable: ln (w)										
	Labor productivity					TFP				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ln (LP)	.271**		.272**	.201**	.278**					
	(.008)		(.008)	(.017)	(.008)					
ln (TFP)						.349**		.378**	.306**	.286**
						(.007)		(.008)	(.009)	(.009)
ln (M)		.132**	−.015^{+}	−.230**	−.390**		.132**	−.101**	−.185**	−.166**
		(.008)	(.009)	(.023)	(.015)		(.008)	(.009)	(.009)	(.009)
LP × Markup					.070**					
					(.011)					
TFP × Markup										−.026**
										(.004)
ln (h)	.119**	.161**	.118**	.028**	.029**	.141**	.161**	.136**	.024**	.023**
	(.003)	(.004)	(.003)	(.007)	(.007)	(.004)	(.004)	(.004)	(.007)	(.007)
Export share	.086**	.092**	.086**	.051**	.046**	.065**	.092**	.065**	.056**	.057**
	(.016)	(.019)	(.016)	(.015)	(.015)	(.018)	(.019)	(.018)	(.015)	(.015)
Import share	.042*	.257**	.043*	.015	–.001	.117**	.257**	.116**	.007	.011
	(.017)	(.019)	(.017)	(.012)	(.012)	(.017)	(.019)	(.017)	(.013)	(.012)
Foreign	.124**	.241**	.123**	.023	.021	.192**	.241**	.184**	.044**	.043**
	(.013)	(.017)	(.013)	(.014)	(.014)	(.015)	(.017)	(.015)	(.015)	(.015)
Exit	−.072**	−.226**	−.071**	−.028^{+}	–.024	−.152**	−.226**	−.147**	−.067**	−.066**
	(.016)	(.017)	(.016)	(.015)	(.015)	(.017)	(.017)	(.017)	(.016)	(.016)
Urban	.078**	.152**	.078**	–.009	–.008	.104**	.152**	.103**	.008	.007
	(.008)	(.009)	(.008)	(.023)	(.022)	(.009)	(.009)	(.009)	(.023)	(.023)
Industry × Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	69437	71422	69437	69437	69437	69020	71422	69020	69020	69020
R^2	.567	.418	.568	.526	.532	.503	.418	.506	.503	.504

Robust standard errors clustered at firm level are in parentheses. Dependent variable is a natural log of the firm's wage cost divided bythe number of workers. Models (1)–(3) and (6)–(8) are estimated by OLS. Models (4), (5), (9) and (10) include firm fixed effects.

We control for the structural changes in the economy by industry-time specific effects. The errors are corrected for heteroskedasticity at the firm level. The results are presented in Table 34. First, we regress ln w_{it} on the measured labor productivity and other controls, ignoring the variation in markups. Column (1) of Table 6 shows that a 10 percent increase in labor productivity is associated with 2.7 percent increase in wage. We include the markup variable and exclude our productivity measure in column (2) in which case the markup coefficient has a positive sign and is significant. However, when we include both productivity and the markup in column (3), the markup coefficient becomes negative and significant. Both productivity and markup are potentially endogenous variables. Inclusion of firm-specific effects in columns (4) and (5) of the table alleviates the endogeneity problem, resulting in a smaller coefficient on labor productivity (consistent with our prior discussion about a positive bias), but the coefficient on the markup becomes more negative and significant.

According to our results in column (4), firms that increase export to sales ratio by a standard deviation pay a wage premium of 1.5 percent, which is well in agreement with the theoretical predictions. Adding an interaction between markups and productivity, $\ln M_{it} \times \ln \theta_{it}$, in column (5), demonstrates that for more productive firms an increase in the markup is associated with higher wages. Foreign firms pay 2 percent higher wages than domestic once, but the result is not significant. This result may be explained by the fact, that only large firms are in the sample. Exiting firms pay 2–3 percent lower wages. We also find a positive scale effect, measured by total employment, even after controlling for productivity, market power, and export status, which is in line with findings in literature that looks at the firm size and wage relationship (Brown and Medoff, 1989). Columns (6)–(10) of Table 6 show results of the regression of ln w_{it} on TFP and other controls. The results are quite similar to the results for labor productivity. It gives us more confidence in our results, because they are robust to different ways of measuring productivity.

4.5 Wages, productivity and markups: IV results

This section reports results of the estimation of the equation (33) by IV GMM method. The equation is estimated in the first differences in order to account for firms' fixed effects. We use a set of four instruments. Two of them, the services liberalization index and the input tariff liberalization measure, are instruments for productivity. The other two, the trade cost measure and the market potential variable, are instruments for markups. Construction of the instruments is described in the appendix 3. The errors are corrected for heteroskedasticity at the firm level. All regressions control for industry-time and region specific trends.

The results for the LP measure of productivity are presented in columns (1)–(6) of Table 7, and results for the TFP measure of productivity are in columns (7)–(12) of the table. The estimation is performed on the restricted IV sample. Column (1) of Table 7 presents the benchmark OLS result estimated on the restricted IV sample. Columns (2)–(6) present point estimates of the coefficients estimated by the instrumental variables GMM method. Overall, the results are not too different from the OLS estimates. Most importantly, while productivity is positively related to wages, markups are negatively related to wages. In light of the rise of the superstar firms and increase in the markups over the last decades, it sends an important message that those secular trend had a negative impact on wages and generate more inequality between workers and firms' owners.

There is a number of other interesting results. Wage is an increasing function of the export to sales ratio: Increasing the exports to sales ratio by a standard deviation increases the average wage by 1.4 percent. Firms that start importing their inputs pay 2.1 percent higher wages. Firms that switch to foreign ownership start paying slightly higher wages, but the effect, again, is not significant.

In column (3) we control for privately owned vs state owned firms. It should be noted that private firms in Ukraine pay a part of the salary in cash and do not report it as the wage bill to evade the social security tax, which ranges from 32.6 to 49.7 percent of the wage bill. State-owned companies do not have this incentive, reporting all labor-related expenses in wage bills. This feature of the tax system might lead to under-reporting of wages by the private companies and can bias our results. Despite that, private firms report paying 8 percent higher wages.

Table 7: IV: Productivity and markups

Dependent variable: $D.\ln(w)$	Labor productivity						TFP					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
D.ln (LP)	$.163^{**}$	$.151^{**}$	$.151^{**}$	$.151^{**}$	$.148^{**}$	$.148^{**}$						
	(.006)	(.035)	(.035)	(.035)	(.036)	(.036)						
D.ln (TFP)							$.169^{**}$	$.426^{**}$	$.425^{**}$	$.426^{**}$	$.420^{**}$	$.419^{**}$
							(.010)	(.100)	(.100)	(.100)	(.101)	(.101)
D.ln (M)	$-.251^{**}$	$-.145^{**}$	$-.146^{**}$	$-.145^{**}$	$-.148^{**}$	$-.148^{**}$	$-.108^{**}$	$-.348^{**}$	$-.347^{**}$	$-.347^{**}$	$-.345^{**}$	$-.345^{**}$
	(.012)	(.039)	(.039)	(.039)	(.039)	(.039)	(.010)	(.067)	(.067)	(.067)	(.067)	(.067)
D.ln (h)	–.008	$-.019^{+}$	$-.019^{+}$	$-.019^{+}$	$-.024^{*}$	$-.024^{*}$	$-.024^{*}$	$-.024^{*}$	$-.024^{*}$	$-.024^{*}$	$-.028^{**}$	$-.027^{**}$
	(.009)	(.011)	(.011)	(.011)	(.012)	(.012)	(.010)	(.010)	(.010)	(.010)	(.010)	(.010)
D.Export share	$.054^{**}$	$.051^{**}$	$.050^{**}$	$.051^{**}$	$.050^{**}$	$.050^{**}$	$.070^{**}$	.029	.029	.029	.030	.029
	(.015)	(.016)	(.016)	(.016)	(.016)	(.016)	(.015)	(.019)	(.019)	(.019)	(.019)	(.019)
D.Import share	$.029^{*}$	.016	.016	.016	.018	.017	$.021^{+}$	$.023^{+}$	.023	$.023^{+}$	$.024^{+}$	$.023^{+}$
	(.011)	(.014)	(.014)	(.014)	(.014)	(.014)	(.012)	(.014)	(.014)	(.014)	(.014)	(.014)
D.Foreign	$.028^{+}$	.012	.012	.012	.012	.012	$.038^{*}$	.012	.012	.012	.012	.012
	(.015)	(.011)	(.011)	(.011)	(.011)	(.011)	(.015)	(.012)	(.012)	(.012)	(.012)	(.012)
D.Exit	$-.037^{*}$	$-.045^{*}$	$-.045^{*}$	$-.045^{*}$	$-.047^{*}$	$-.047^{*}$	$-.093^{**}$	$-.069^{**}$	$-.069^{**}$	$-.069^{**}$	$-.070^{**}$	$-.070^{**}$
	(.018)	(.020)	(.020)	(.020)	(.020)	(.020)	(.019)	(.021)	(.021)	(.021)	(.021)	(.021)
D.Urban	.019	.021	.021	.021	.021	.021	.024	.006	.005	.006	.006	.006
	(.019)	(.016)	(.016)	(.016)	(.016)	(.016)	(.020)	(.020)	(.020)	(.020)	(.020)	(.020)
D.Private			$.080^{*}$			$.080^{*}$			.059			.059
			(.031)			(.031)			(.046)			(.046)
D.Single plant				.008		.007				$.019^{+}$		$.018^{+}$
				(.008)		(.008)				(.010)		(.010)
D.Entry					$-.058^{**}$	$-.059^{**}$					$-.046^{**}$	$-.046^{**}$
					(.019)	(.019)					(.018)	(.018)
Industry × Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	31224	29019	29019	29019	29019	29019	32298	30040	30040	30040	30040	30040
Hansen J statistics		4.532	4.600	4.573	4.408	4.514		9.200	9.197	9.377	9.130	9.300
p-value		.209	.204	.206	.221	.211		.027	.027	.025	.028	.026
R^2		.300	.300	.300	.302	.302		.155	.156	.155	.160	.161

Robust standard errors clustered by firms are in parentheses. Column (1) and (7) presents the estimates of the OLS regression. The rest of the results are estimated by IV method in first differences. Dependent variable is $D.ln(w)$. Productivity and markup are instrumented by EBRD index of services liberalization, index of trade liberalization, weighted average of distances to five major destination countries weighted by export shares,the number of destination countries per exporting firm, and market access computed as GDP of trading partners weighted by distance.

Literature emphasizes distinction between multi-plant and single-plant firms. Related to this, distinction between multi-product and single-product firms is important when modeling firm's reaction to trade liberalization (Bernard et al., 2011). We control for single- vs. multi-plant firms in column (4), which has no impact on our conclusions regarding the effect of markups on wages. This fact is due to a very low share of multi-plant firms in the sample, 4 to 5 percent only. In column (5) we control for new entrants, which on average pay 5.8 percent lower wages than incumbents. Finally, in column (6) we include all additional controls, which also does not alter our main results.

Our identification strategy would fail if exclusion restrictions were not valid. For instance, trade and services liberalization can have a general equilibrium effect on wages which influences more firms that use imported goods and liberalized services more intensively. In that case our excluded variables influence wages not only through productivity, but also directly. We are quite confident that our estimation is valid for several reasons. First, we control for the industry-time specific trends directly, so the identification comes from variation within an industry at a certain time. Second, the overidentification test does not reject validity of our instruments.

To summarize, we find a robust negative effect of market power on wages, with the absolute value of elasticity in the range 0.145 to 0.148. The labor productivity, on the other hand, positively contributes to wages, with the elasticity in the range 14.8–15.1. This finding corresponds well with Amiti and Davis (2012), who found 0.2 elasticity of wages with respect to revenue for Indonesia.

As a robustness check, columns (7)–(12) of Table 7 reports IV results with productivity measured by TFP. In general, results are very similar in the direction of effects of productivity and markups to the results discussed for labor productivity. However, the size of the elasticities is roughly twice as large in absolute values.

4.6 Wage inequality, productivity and markups: industry level results

We further present industry level results. We aggregate our data to the level of NACE 4 digit sub-industries computing simple means and standard deviations of our key variables: wages, productivity, and markups. In addition, we use simple means and standard deviations of our control variables. We estimate the following regressions

$$\ln \bar{w}_{jt} = \alpha_j + \delta_\theta \ln \bar{\theta}_{jt} + \delta_M \overline{\ln M_{jt}} + \delta_{exp} \times \overline{export}_{jt} + \bar{X}_{jt}\gamma + u_{jt} \quad (34)$$

and

$$\sigma(\ln w)_{jt} = \beta_j + \beta_\theta \sigma(\ln \theta)_{jt} + \beta_M \sigma(\ln M)_{jt} + \beta_{exp} \times \sigma(export)_{jt} + \sigma(X)_{jt}\beta + v_{jt} \quad (35)$$

where $\bar{x}$ denotes a simple average of a variable x and $\sigma(x)$ stands for a standard deviation of x, and those values are computed for each sub-industry j and time t. We estimate equations (34) and (35) with sub-industry fixed effects and standard errors clustered by sub-industries.

The results, presented in columns (1)–(6) of Table 8, indicate that the average wage within sub-industry is positively linked to average productivity and negatively related to the average markup, which is consistent with our findings at the firm level. Columns (7)–(12) of the table show that higher variation of wages within an industry is positively linked to both variation of productivity and variation of markups. However, the variation of wages within an industry is mostly explained by the variation in markups, because the coefficient on the variation of productivity becomes insignificant, while the coefficient on the variation of markups is positive and significant.

Table 8: Industry level wages, productivity, and markups

Dependentvariable: $\ln(w)$												
	Average wage						Standard deviation of wage					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\ln(TFP)$	0.838^{**}		0.995^{**}	0.995^{**}	0.967^{**}	0.908^{**}						
	(0.045)		(0.069)	(0.068)	(0.068)	(0.073)						
$\ln(M)$		0.695^{**}	-0.405^{**}	-0.400^{**}	-0.399^{**}	-0.384^{**}						
		(0.115)	(0.099)	(0.099)	(0.098)	(0.103)						
$\ln(h)$				0.029	–0.011	–0.027						
				(0.046)	(0.045)	(0.040)						
Exporter					0.593^{**}	0.548^{**}						
					(0.175)	(0.178)						
Importer						0.309						
						(0.189)						
Private						0.291^{+}						
						(0.163)						
Single plant						-0.633^{**}						
						(0.137)						
$\sigma(\ln TFP)$							0.132^{*}		0.078	0.079	0.080	0.074
							(0.054)		(0.059)	(0.059)	(0.060)	(0.059)
$\sigma(\ln M)$								0.214^{**}	0.160^{**}	0.159^{**}	0.159^{**}	0.145^{*}
								(0.051)	(0.060)	(0.061)	(0.060)	(0.060)
$\sigma(\ln h)$										0.070	0.061	0.057
										(0.043)	(0.044)	(0.045)
σ(Export share)											0.167^{*}	0.146
											(0.084)	(0.089)
σ(Import share)												0.015
												(0.069)
σ(Private)												0.159^{*}
												(0.063)
σ(Single plant)												-0.155^{**}
												(0.042)
Observations	1618	1626	1618	1618	1618	1618	1558	1561	1558	1558	1558	1558
R^2	0.697	0.501	0.709	0.709	0.716	0.726	0.516	0.521	0.525	0.528	0.531	0.542

Robust standard errors clustered at industry level are in parentheses. Dependent variable in columns (1)–(6) is an industry average natural log of the firm's wage. Dependent variable in columns(7)–(12) is an industry standard deviation of the natural log of the firm's wage. Industries are defined as NACE 4 digit industries All models include industry fixed effects.

5 Conclusion

This paper studied the impact of a firm's technological efficiency and market power on its average wage. Our analysis was based on a new theoretical model that brings together labor market imperfections, firms' heterogeneity, and variable markups. We demonstrated that the relationship between wages and markups crucially depends on demand side characteristics. We found that the markup channel plays an important role in shaping the wage distribution within manufacturing industries. Firms with higher market power pay lower wages – the elasticity of wage with respect to productivity is 0.151, while the elasticity of wage with respect to markup is –0.145 in the baseline IV specification for the labor productivity measure of productivity. The negative sign of the markup coefficient indicates that the elasticity of aggregate demand is an increasing function of output. This result is robust to the different measures of productivity, estimation methods, and to additional controls.

This finding allows to consider an important channel of rising inequality and reduced the labor share in income through the effect of trade liberalization on markups and the rise of the superstar firms. As more productive firms expand their market share and gain market power through the pro-competitive effect, it allows them to lower wages by gaining more bargaining power in their negotiation of wages with its employees. On the other hand, an increase in competition from foreign firms reduces their market power and has a positive effect on wages (keeping the technological efficiency constant). The overall effect of trade liberalization is ambiguous and requires additional research. This has an important policy implication: inequality concerns can be addressed through competition policy directed towards firms with high market power.

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Appendix

Appendix 1: Mathematical proofs

Derivation of (13).

Multiplying both sides of (12) by h yields

$$h\frac{\partial R}{\partial h} = 2wh + \frac{\partial w}{\partial h}h^2 = \frac{\partial}{\partial h}(wh^2).$$

Integrating across $[0, h]$ and applying integration by parts, we obtain

$$w = \frac{1}{h^2}\int_0^h \frac{\partial R}{\partial \xi}\xi \mathrm{d}\xi = \frac{R(h,\theta,\bar{a})}{h} - \frac{1}{h^2}\int_0^h R\,(\xi,\theta,\bar{a})\mathrm{d}\xi. \quad (36)$$

Multiplying both sides by h, we come to (13). Q.E.D.

Proof of Claim 1. Differentiating (36) in h, we get

$$\frac{\partial w}{\partial h} = \frac{1}{h^2}\left[h\frac{\partial R}{\partial h} - 2R(h,\theta,\bar{a}) + \frac{2}{h}\int_0^h R\,(\xi,\theta,\bar{a})\mathrm{d}\xi\right] = \frac{\partial^2}{\partial h^2}\left[\frac{1}{h}\int_0^h R\,(\xi,\theta,\bar{a})\mathrm{d}\xi\right]. \quad (37)$$

It remains to prove that revenue $R(h,\theta,\bar{a})$ is concave in h if and only if $\frac{1}{h}\int_0^h R\,(\xi,\theta,\bar{a})\mathrm{d}\xi$ is concave in h.

To prove the "if" part, we assume that $R(h,\theta,\bar{a})$ is concave in h. Then, by Jensen's inequality, for any $\alpha \in [0,1]$ and for any $h_1, h_2 > 0$ we have

$$\frac{1}{m}\sum_{j=1}^{m} R\left(\frac{j}{m}(\alpha h_1 + (1-\alpha)h_2),\theta,\bar{a}\right) \geq \frac{\alpha}{m}\sum_{j=1}^{m} R\left(\frac{jh_1}{m},\theta,\bar{a}\right) + \frac{1-\alpha}{m}\sum_{j=1}^{m} R\left(\frac{jh_2}{m},\theta,\bar{a}\right). \quad (38)$$

Under $m \to \infty$, (38) becomes

$$\frac{1}{\alpha h_1 + (1-\alpha)h_2}\int_0^{\alpha h_1+(1-\alpha)h_2} R\,(\xi,\theta,\bar{a})\mathrm{d}\xi \geq \frac{\alpha}{h_1}\int_0^{h_1} R\,(\xi,\theta,\bar{a})\mathrm{d}\xi + \frac{1-\alpha}{h_2}\int_0^{h_2} R\,(\xi,\theta,\bar{a})hrmd\xi,$$

which means that $\frac{1}{h}\int_0^h R\,(\xi,\theta,\bar{a})\mathrm{d}\xi$ is concave. This completes the proof of the "if" part.

As for the "only if" part, we prove it by reductio ad absurdum. Namely, assume that $\frac{1}{h}\int_0^h R(\xi,\theta,\bar{a})\mathrm{d}\xi$ is concave in h, while $R(h,\theta,\bar{a})$ is not. Then, it must be that $R(h,\theta,\bar{a})$ is strictly convex in h over some non-degenerate segment $[\underline{h},\overline{h}]$. This implies that if we choose $h_1, h_2 \in [\underline{h},\overline{h}]$, the opposite of (38) holds. Consequently, when $m \to \infty$, we have

$$\frac{1}{\alpha h_1 + (1-\alpha)h_2}\int_0^{\alpha h_1+(1-\alpha)h_2} R(\xi,\theta,\bar{a})\mathrm{d}\xi < \frac{\alpha}{h_1}\int_0^{h_1} R(\xi,\theta,\bar{a})\mathrm{d}\xi + \frac{1-\alpha}{h_2}\int_0^{h_2} R(\xi,\theta,\bar{a})\mathrm{d}\xi.$$

This, however, violates the assumption that $\frac{1}{h}\int_0^h R(\xi,\theta,\bar{a})\mathrm{d}\xi$ is concave. Thus, we come to a contradiction, and the "only if" part is proven.

Using (37), we conclude that $\partial w/\partial h$ has the same sign as $\partial^2 R/\partial h^2$, which implies Claim 1. Q.E.D.

Derivation of (16). Differentiating (15) with respect to h yields

$$\frac{\partial\beta}{\partial h} = \frac{\int_0^h R(\xi,\theta,\bar{a})d\xi}{h^2 R(h,\theta,\bar{a})}\left[\frac{hR(h,\theta,\bar{a}) - \int_0^h R(\xi,\theta,\bar{a})d\xi}{\int_0^h R(\xi,\theta,\bar{a})d\xi} - \frac{artialR(h,\theta,\bar{a})}{\partial h}\frac{h}{R(h,\theta,\bar{a})}\right].$$

Combining this with (15) and using integration by parts, we obtain

$$\mathcal{E}_h(\beta) = \frac{hR(h,\theta,\bar{a}) - \int_0^h R(\xi,\theta,\bar{a})d\xi}{\int_0^h R(\xi,\theta,\bar{a})d\xi} - \mathcal{E}_h(R) = \frac{\int_0^h \xi\cdot[\partial R(\xi,\theta,\bar{a})/\partial\xi right]d\xi}{\int_0^h R(\xi,\theta,\bar{a})d\xi} - \mathcal{E}_h(R).$$

Since $\xi\cdot[\partial R(\xi,\theta,\bar{a})/\partial\xi] = \mathcal{E}_\xi(R)R(\xi,\theta,\bar{a})$, we come to (16). Q.E.D.

Appendix 2: TFP estimation

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

$$y_{it} = h_{it}^{\alpha_h} k_{it}^{\alpha_k} mat_{it}^{\alpha_{mat}} \exp(\tilde{\omega}_{it} + \tilde{u}_{it}), \tag{39}$$

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 the firm-specific productivity that captures both technical efficiency and workers' average ability, unobservable by an econometrician, but known to the firm before it chooses variable inputs. $\tilde{u}_{it}$ is an idiosyncratic shock to production that also captures the 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. Therefore, use of R_{it} as the dependent variable in estimation of the 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.

We account for demand shocks incorporating the following inverse demand relationship from our model:

$$p_{it} = \frac{u_s'(y_{it})}{\lambda_{st}} \exp(\tilde{\xi}_{it}), \quad i \in I_s \tag{40}$$

where I_s is the set of firms in industry s, y_{it} is the output of firm $i \in I_s$ in 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.

Setting $R_{it} \equiv y_{it}p_{it}$ yields

$$\ln R_{it} = \ln y_{it}\, u_s'(y_{it}) - \ln \lambda_{st} + \tilde{\xi}_{it} \tag{41}$$

and after log-linearization we obtain

$$\ln(R_{it}/P_{st}) \approx \text{const} + (1 + \eta(\bar{Y}_s)) \ln y_{it} - \eta(\bar{Y}_s) \ln(Y_{st}/P_{st}) + \tilde{\xi}_{it}, \tag{42}$$

where $\bar{Y}_s$ is output of industry s, 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 (42) with the production function (39), we come to

$$r_{it} = \beta_h \ln h_{it} + \beta_k \ln k_{it} + \beta_m \ln mat_{it} + \beta_s \ln Y_{st} + \omega_{it} + \xi_{it} + u_{it}, \tag{43}$$

where $r_{it} = \ln(R_{it}/P_{st})$ is a natural log of revenue deflated by a corresponding industry 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.

We estimate equation (43) separately, for each manufacturing industry, using the Olley-Pakes methodology (Olley and Pakes, 1996) and accounting for demand shocks as outlined above. Instead of using the 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

$$\xi_{it} = \xi_t + \xi_g + \tilde{\chi}_{it}, \qquad (44)$$

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 $\tilde{\chi}_{it}$ is an idiosyncratic shock. Plugging in (44) in (43), we obtain the following equation

$$r_{it} = \beta_h \ln\, h_{it} + \beta_k \ln\, k_{it} + \beta_m \ln\, mat_{it} + \beta_s \ln\, Y_{gt} + \delta_t D_t + \delta_g D_g + \omega_{it} + \varepsilon_{it} \qquad (45)$$

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

Total factor productivity net of price and demand effects is recovered as

$$\ln\, \hat{\theta}_{it} = (r_{it} - \beta_h \ln\, h_{it} - \beta_k \ln\, k_{it} - \beta_m \ln mat_{it} - \beta_s \ln\, Y_{gt})\frac{\sigma_s}{\sigma_s + 1}. \qquad (46)$$

Appendix 3: Instruments for productivity and markups

Instruments for productivity

To estimate the relationship between wages and productivity consistently, a source of exogenous variation in productivity is needed. We propose a well-established link from services and trade liberalization to productivity as the source of variation. Recent studies of services and trade liberalization (Amiti and Konings, 2007; Arnold et al., 2011; Fernandes and Paunov, 2011; Khandelwal and Topalova, 2011) find positive effect of liberalization on productivity of manufacturing firms. The size of the effect varies across firms because of differences in intensity, with which firms use liberalized inputs and services.

We use the episode of the Ukrainian trade and services liberalization in 2001–2007, isolated from other major deregulatory changes and driven by political pressure imposed by Ukraine's trading partners as the precondition for the Ukrainian WTO accession. Concerning services, the government developed new laws and amended existing ones that regulated activities of TV and broadcasting, information agencies, banks and banking activities, insurance, telecommunications, and business services. It led to differentiated but positive effect on productivity in the downstream manufacturing firms (Shepotylo and Vakhitov, 2015). The results indicate that a standard deviation increase in services liberalization is associated with a 9.2 percent increase in TFP. In parallel with the services liberalization, the WTO negotiations also led to further liberalization of trade in goods, which also had a positive effect on productivity.

In what follows we describe construction of instruments related to endogeneity of the productivity measure. The first instrument is an index of services liberalization. The index is firm-specific, reflecting the variation in firm-level intensity of usage of various services inputs. Similarly to Arnold et al. (2011), but using firm level data, the index is computed according to the following formula

$$serv\,lib_{it} = \sum_{j} a_{it}^{j} \times index_{t}^{j} \qquad (47)$$

where a_{it}^{j} is the share of input sourced from the services sub-sector j in the total input for a firm i at time t, and $index_{t}^{j}$ is the measure of liberalization in the service sector j at time t. We proxy for $index_{t}^{j}$ by the structural change indicators provided by the European Bank for Reconstruction and Development (EBRD).[6]

The second instrument is an index of trade liberalization. We compute the firm-specific index of input tariff liberalization, $input\,tariff_{it}$, following Amiti and Konings (2007):

$$input\,tariff_{it} = \sum_{s} b_{it}^{s} \times tariff_{t}^{s} \qquad (48)$$

where b_{it}^{s} is the share of input sourced from industry s in the total input for firm i at time t, and $tariff_{t}^{s}$ is the trade-weighted average MFN import tariff in industry s at time t.

[6] EBRD structural change indicators are available at http://www.ebrd.com/pages/research/economics/data/macro.shtml. The mapping from the structural change indicators to sub-sectors of services is explained in the appendix 4.

Instruments for markups

According to equation (28), $\ln M = \frac{\alpha}{\alpha+\beta} \ln m_d + \tau \frac{\beta}{\alpha+\beta} \ln m_x$, where domestic and foreign markups depend on domestic and foreign market sizes. M for exporting firms also depend on transportation costs. Using firm-level export statistics, we construct two instruments. First, we construct a proxy for the transport costs as a weighted average of the local distance within Ukraine and the export-weighted average distances to destination markets

$$\widehat{\tau_{it}} = y_{d,it}/y_{it} \times \ln dist_{UKR} + y_{x,it}/y_{it} \times \sum_j \frac{exp_{ijt}}{exp_{it}} \ln dist_j \tag{49}$$

where $y_{d,it}/y_{it}$ and $y_{x,it}/y_{it}$ are domestic and export shares of sales, exp_{ijt} is export of firm i to country j at time t, $exp_{it} = \sum_j exp_{ijt}$ is the total export of firm i at time t, $dist_{UKR}$ is internal distance within Ukraine (equals to 438 kilometers – a radius of a circle with the area equals to the area of Ukraine), and $dist_j$ is the distance from Ukraine to country j. Second, we construct a proxy for the market size as

$$\widehat{MP_{it}} = y_{d,it}/y_{it} \times \ln GDP_{UKR,t} + y_{x,it}/y_{it} \times \sum_j \frac{exp_{ijt}}{exp_{it}} \ln GDP_{jt} \tag{50}$$

where GDP_{jt} is gross domestic product of country j at time t. We expect that, ceteris paribus, higher transportation costs lower markups due to the incomplete pass-through effect. At the same time, it is plausible americanto have a positive relationship between markups and transportation costs as in Hummels and Skiba (2004). The effect of the market size on markups is also ambiguous. As Melitz and Ottaviano (2008) pointed out, large markets have tougher competition, but also attract more productive firms. While tougher competition has a negative effect on markups, the positive selection bias tend to increase markups.

Appendix 4: Mapping EBRD indices to services sub-sectors

For four services sub-sectors – Transport, Telecom, Finance, and Other business-related services (hotels and restaurants, real estate, rent, IT, R&D, agencies) – we map the sub-sector with EBRD indices of reforms as follows:

I: Transportation 1/2 (rail + roads)

I1: Telecom (telecom)

J: Finance 1/2 (banking + financial)

H+K: Other business-related services (hotels and restaurants, real estate, rent, IT, R&D, agencies) 1/5 (small scale privatization + price liberalization + trade liberalization+ competition reform+ financial reform)