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Productivity Spreads, Market Power Spreads and Trade

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Abstract
Much of recent Trade theory focuses on heterogeneity of firms and the differential impact trade policy might have on firms with different levels of productivity. A common problem is that most firm level dataset do not contain information on output prices of firms which makes it difficult to distinguish between productivity differences and differences in market power between firms. This paper develops a new econometric framework that allows estimating both firm specific productivity and market power in a semi-parametric way based on a control function approach. The framework is applied to Chilean firm level data from the early 1980, shortly after the country underwent wide ranging trade reforms. The finding is that in all sectors of the economy market power declined and productivity increased. In sectors with higher import penetration productivity particularly at the bottom end of the distribution increased faster. At the same time market power declined particularly so at the top end of the market power distribution. We also show, that ignoring the effect on market power leads to an underestimation of the positive effects of increased import penetration on productivity.

JEL classification: C81, D24, L11, L25
Keywords: Trade policy, productivity measurement, imperfect competition, productivity dispersion, productivity spread

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1 Introduction

Much of recent Trade theory focuses on heterogeneity of firms and the implication this has for trade policy (Melitz and Ottaviano 2008, Melitz 2003) Increasingly such models stress not only interactions between trade policy and the distribution of firm level productivity but also with the distribution of market power across firms. This poses a challenge for measurement when using firm level production datasets. Common methods to analyse firm level productivity require assuming perfectly competitive market structures. Almost all of the limited number of studies that go beyond that (Klette and Griliches 1996, Melitz 2003, Martin 2008, Dobbelaere and Mairesse 2008, de Loecker and Warzynski 2009) rely on a Dixit Stiglitz market structure which implicitly assumes that all firms in an industry or a pre-defined group of firms[1] have

[1] For example de Loecker and Warzynski (2009) allow for different markups for the group of exporters as opposed to non-exporting firms. Although, in a more recent version of their study they take up the idea used in this study and originally proposed in Martin (2008) of using factor shares to control for potentially firm and time specific markups without prior grouping.

the same degree of market power. This is measured by the degree of markup they can charge over their marginal costs. [2] This is clearly restrictive as it would not allow that for example a trade reform reduces the market power of some firms whereas it increases that of others. The contribution of this paper is to introduce a new framework for productivity estimation that allows recovering an index of the distribution of markups across firms in addition to productivity estimates. We achieve this by expanding on the control function approach originally introduced by Olley and Pakes (1996) to deal with factor endogeneity in production function regressions. The control function approach exploits assumptions about firm behaviour to recover a control function for un-observed heterogeneity that potentially biases production function estimates. The standard control function approach is only concerned with one type of heterogeneity: a single index capturing Hicks neutral shifts in technical efficiency between firms. We allow in addition that market power as measured by markups can vary arbitrarily between firms. To control for that we introduce a second control index based on mild structural assumptions about firm behaviour. Importantly, this requires no further assumptions about the distribution of the parameters in the population and can therefore be used to compute the complete distribution of market power for all firms at all points in time.

The basic idea is most easily grasped in a simple Cobb-Douglas setting with a log-linear demand function; i.e. output quantity Q_i is

$$Q_i = A_i K_i^{\gamma-\alpha_L-\alpha_M} L_i^{\alpha_L} M_i^{\alpha_M} \tag{1}$$

where γ measures the returns to scale and demand is

$$Q_i = P_i^{-\eta_i} \tag{2}$$

although it can easily be extended to a very general class of production functions and demand functions. Consider a production factor that is perfectly flexible in the short run such as materials, $M_i$where i indexes a firm. In the perfect competition case ($\eta_i = \infty$) it is a familiar results that short run profit maximisation implies

$$\alpha_M = \frac{W^M M_i}{Q_i} = s_i^M$$

i.e. the production function parameter is equal to materials share in output. With imperfect competition this equation becomes

$$\frac{\alpha_M}{\mu_i} = \frac{W^M M_i}{R_i} = s_i^M \tag{3}$$

where $\mu_i = \frac{1}{1-\frac{1}{\eta_i}}$ captures the (potentially) firm specific markup parameter and output quantity $Q_i$is replaced by revenue R_i, which is all that we can observe in this case at the firm level. Note that the left hand side becomes smaller compared to the perfect competition case (recall that $\mu_i > 1$). Intuitively this is because it measures the marginal benefit of increasing usage of materials. With imperfect competition this is smaller ceteris paribus as now an increase in materials not only increases output but also lowers the price that can be charged for this output.

[2] One exception is Klette (1999) who proposes a Random Coefficients Specification. A random effect specification would not allow to separately identify both: firm specific market power and productivity shocks. Another exeption is Katayama et al. (2003). Their framework requires however that all firms face constant marginal costs, thus ruling out increasing returns to scale or adjustment costs which make some factors fixed in the short run.

Note that 3 suggests a simple way to control for unobserved variation in μ_i. Simply use the inverse revenue share as a proxy:

$$\mu_i = \psi\left(s_i^M\right) = \frac{\alpha_M}{s_i^M}$$

How can this be used in a regression setting? Using production and demand function in equations 1 and 2 we can write (log) revenue as

$$\ln R_i = \frac{1}{\mu_i}\left(\alpha_M \ln M_i + \alpha_L \ln L_i + (\gamma - \alpha_L - \alpha_M)\ln K_i + a_i\right)$$

which we can re-write as

$$\frac{\ln R_i - s_i^M\left(\ln M_i - \ln K_i\right) - s_i^L\left(\ln L_i - \ln K_i\right)}{s_i^M} = \frac{\gamma}{\alpha_M}k_i + \frac{a_i}{\alpha_M} \tag{4}$$

Note that the LHS of equation can be computed directly from standard firm level productivity data. To conduct a regression we need to take into account endogeneity from the TFP shock a_i affecting k_i. This can be done by one of the standard control function approaches.[3] With an estimate of $\frac{\gamma}{\alpha_M}$ we can derive a TFP estimate as $LHS_i - \frac{\hat{\gamma}}{\alpha_M}$ and use $\frac{\hat{\alpha}}{\gamma}s_i^{-1}$as an index for μ_i. The following section will show how this can be generalised to a general production and demand function where $\alpha_M$is not necessarily constant. The two key assumptions required are that the demand curve is downward sloping and that the production function is homothetic. A downward sloping demand curve is a natural assumption implied by a variety of settings. Large parts of the literature equally assume homothetic production functions even though it is potentially a very restrictive assumption. In the current context, for example, it would rule out that some firms adjust to trade liberalisation by outsourcing part of their production thereby becoming more intermediate intensive. However, in appendix B we develop a way of assessing if such concerns are important for a dataset at hand.

Another way of looking at the idea proposed in this paper is as follows: a common approach to measure market power is to look at price margins. With constant unit costs, price costs margins are proportional to factor shares in revenue; i.e. we can measure market power trough factor shares. What we show in the following is then how to use price cost margins as a control even if unit costs are not constant because the production technology is not constant returns or because not all factors are fully flexible.

We apply this new framework to Chilean data. This is of interest for two reasons. Firstly, Chile was subject to fundamental trade reforms in the 1970s and therefore has attracted interest in the Trade Literature before (Pavcnik 2002). Secondly, because firm level micro data for Chile has been relatively freely available previous studies on firm level productivity measurement have used the country as a test case (Levinsohn and Petrin 2003).

Using the new method proposed in this paper we compute firm specific (Total Factor) Productivity and market power for Chilean manufacturing firms. We find that across manufacturing, productivity (TFP) increased and market power declined over the sample period which is from 1979 to 1986. Comparing sectors with high import penetration to those with lower import penetration we find that, productivity increased whereas market power declined by more than in sectors with low import penetration. The productivity effect appears stronger at the bottom of the productivity distribution whereas the increase in market power is more pronounced at the top of the market power distribution. Ignoring the market power effect thus leads to an under-estimation of the productivity effects of higher import penetration.

[3] Using s_i^M as additional state variable in the proxy function, that is.

The remainder of this paper is organised as follows: Section 2 introduces the new framework for firm level market power and productivity estimation. Section 3 contains a basic description of the dataset used, Section 4 reports results, Section 5 concludes.

2 An augmented control function approach

Suppose there is a representative consumer deriving utility from m differentiated products

$$U = U\left(\tilde{\mathbf{Q}}, Y\right) \tag{5}$$

where $\tilde{\mathbf{Q}}$ is a $m \times 1$ vector of effective units of the goods consumed, Y is income and $U(\cdot, Y)$is a differentiable, non convex function.

$$\tilde{Q}_i = \Lambda_i Q_i$$

i.e. Λ_i is a specific utility shock derived from consumption of good i.
Further suppose that each of the m products is produced by a single producer. Caplin and Nalebuff (1991) derive conditions under which this leads to downward sloping demand curves for a specific producer i conditional on the actions of the other producers. They show that this is the case under a wide variety of market structures.

$$Q_i = D_i\left(P_i, \Lambda_i\right) \tag{6}$$

For a production factor X that can be adjusted instantly in response to demand or supply shocks, short run profit maximisation implies[4]

$$\frac{\partial lnF_i}{\partial lnX_i}\frac{1}{\mu_i} = s_{xi} \tag{7}$$

where $F_i$is a homogeneous of degree γ production function,

$$F_i = A_i\left[f\left(\mathbf{X}_i\right)\right]^{\gamma}$$

s_x is the revenue share of expenditure on factor X and $\mu_i = \frac{1}{1-\frac{1}{\eta_i}}$ with $\eta_i = -\frac{\partial lnD(P_i)}{\partial lnP_i}$ measuring elasticity of demand for producer i with. Producers revenue can be written as a function of inputs demand and supply shocks (as well as non firm specific variables which we suppress)

$$R_i = P_i\left(Q_i\left(\mathbf{X_i}, A_i\right), \Lambda_i\right)Q_i$$

Letting x_i the log deviation of a variable X_i from a reference firm M[5] - i.e. $x_i = lnX_i - lnX_M$- we can invoke the mean value theorem (Baily et al. 1992, Klette 1996, Martin 2008)

$$r_i = \sum_X \bar{\rho}_i^x x_i + \bar{\rho}_i^{\Lambda}\lambda + \bar{\rho}_i^A a_i + \eta_i \tag{8}$$

[4]i.e. $\max_{X\neq K}\left\{Q_iP_i - \sum_{X\neq K} X_iW^X\right\}$ implies the following first order condition $\frac{\partial Q_i}{\partial X_i}P_i + \frac{\partial P_i}{\partial M_i}Q_i = W^X$ which we can re-write as $\frac{\partial Q_i}{\partial X_i}P_i\left(1 + \frac{\partial P_i}{\partial Q_i}\frac{Q_i}{P}\right) = W^X$. Because 6 is downward sloping and therefore invertible we get $\frac{\partial P_i}{\partial Q_i}\frac{Q_i}{P} = -\frac{1}{\eta_i}$ with $\eta_i = -\frac{\partial lnD(P_i)}{\partial lnP_i}$ the price elasticity of demand. Multiplying the first order conditions by $\frac{X_i}{Q_i}$ we then get $\frac{\partial Q_i}{\partial X_i}\frac{X_i}{Q_i}\left(1 - \frac{1}{\eta_i}\right) = \frac{W^X X_i}{P_iQ_i}$ which is the condition in equation 7.

[5]e.g. the median firm in terms of some variable.

where $\rho_i^X = \frac{\partial lnR_i}{\partial lnX_i}$ and $\bar{\rho}_i^X \approx \frac{\rho_i^X + \rho_M^X}{2}$; i.e. the mean value theorem suggest that $8\bar{\rho}_i^X \in \left[\rho_i^X,\, \rho_M^X\right]$. We follow common practice by approximating this by averaging across the derivative at firms i and M. We introduce an iid shock η_i allowing for the fact that the mean value theorem and our way of approximating might only hold approximately.

Note that $\frac{\partial lnR_i}{\partial lnX_i} = \frac{\partial lnF_i}{\partial lnX_i}\left(\frac{\partial lnP_i}{\partial lnQ_i} + 1\right) = \frac{\partial lnF_i}{\partial lnX_i}\frac{1}{\mu_i} = s_{xi}$ for flexible factors. Similarly $\frac{\partial lnR_i}{\partial lnA_i} = \frac{1}{\mu_i}$. Assume there is one fixed factor K. Then

$$\frac{\partial lnR_i}{\partial lnK_i} = \frac{\gamma}{\mu_i} - \sum_{x \neq K} s_{Xi}$$

Finally, because $D\left(\cdot\right)$ is monotone in P and demand shocks are "consumption augmenting" we get that[6]

$$\frac{\partial lnR_i}{\partial ln\lambda_i} = \frac{1}{\mu_i} \tag{9}$$

Consequently we can write

$$r_i - \sum_{X \neq K} \bar{s}_{Xi}\left(x_i - k_i\right) = \tilde{r}_i = \gamma\overline{\frac{1}{\mu_i}}k_i + \overline{\frac{1}{\mu_i}}\left(\lambda_i + a_i\right) + \tilde{\eta}_i \tag{10}$$

Now, from Equation 7 we see that

$$\frac{1}{\mu_i} = s_{xi}\left(\frac{\partial lnF_i}{\partial lnX_i}\right)^{-1} = s_{xi}\Psi\left(\mathbf{X}_i\right) \tag{11}$$

i.e. because the productivity shock is Hicks neutral, the (inverse of) firm level markups can be expressed as the product of factor shares and a function of observable factor inputs only. While $\Psi\left(\cdot\right)$ is not known we can specify a general functional form and let it be determined by the data. We can combine this with the usual strategy of a proxy variable for TFP[7] (Olley and Pakes 1996, Levinsohn and Petrin 2003, Bond and Söderbom 2005, Martin 2008). Martin (2008) shows that conditional on markups TFP can be expressed as a function of net revenue and capital. Now, the factor share of a variable factor becomes an additional argument in this function to control for varying degrees of market power between firms. Thus in terms of deviation from a reference firm we can write

$$\omega_{it} = \phi_\omega\left(k_{it}, k_M, ln\Pi_{it}, ln\Pi_M, s_{xi}, s_{xM}\right)$$

Finally assume that ω is driven by a Markov Process[8] so that

$$\omega_{it} = g\left(\omega_{it-1}, \underline{\omega}_{it-1}\right) + \nu_{it}$$

where $g\left(\cdot\right) = E_{t-1}\left\{\omega_{it}\right\}$ and $\omega_{it} = \lambda_{it} + a_{it}$. Further, $\underline{\omega}_{it-1}$ is a threshold value that summarises the firm's rule regarding exiting.

We can now specify a 3 stage regression procedure similar to Olley and Pakes (1996), Levinsohn and Petrin (2003), Bond and Söderbom (2005), Martin (2008). First, to control for exit we conduct a probit regression on a dummy indicating if a firm exits the following period:

[6] See appendix A for more details.

[7] In the remainder I refer to the sum of technology and demand shock - $\omega = a + \lambda$ -as TFP for simplicity. See Martin (2008) for an depth discussion of this.

[8] This follows the common assumption in the literature but is not a necessary assumption here.

$$P_{it} = P\left(ln\mathbf{X}_{it-1}, ln\mathbf{X}_{Mt-1,}s_{xit-1}, s_{xMt-1}, ln\Pi_{it-1}, ln\Pi_{Mt-1}, t\right)$$

This yields an predicted exit probability $\hat{P}_{it}$ which we can use in subsequent stages to control for the un-observed exit threshold, $\underline{\omega}_{it-1}$. Next to smooth the shock $\tilde{\eta}_i$ in Equation 10 we can run the following regression

$$\tilde{r}_{it} = \phi_r\left(ln\mathbf{X}_{it}, ln\mathbf{X}_{Mt,}s_{xit}, s_{xMt}, ln\Pi_{it}, ln\Pi_{Mt}\right) + \tilde{\eta}_{it} \tag{12}$$

where $\phi_r(\cdot)$ is an arbitrary function approximated by a polynomial.

Finally, we can devise a number of moment conditions to recover $\Psi(\cdot)$ and in turn indices of relative productivity and relative markups. For that purpose notice that conditional on trial values for the parameters that define $\Psi(\cdot)$ we can compute an estimate of ω_{it} over γ as

$$\frac{\hat{\omega}_{it}}{\gamma} = \frac{\hat{\phi}_{rit}}{g_\mu\left(ln\mathbf{X}_{it}, ln\mathbf{X}_{M0,}s_{xit}, s_{xM0}\right)} - k_{it} \tag{13}$$

where $\hat{\phi}_{rit}$ is an estimate of $\phi_r(\cdot)$ derived from the second stage in Equation 12 and

$$g_\mu\left(ln\mathbf{X}_{it}, ln\mathbf{X}_{Mt,}s_{xit}, s_{xM0}\right) = \frac{\gamma}{2}\left[s_{xit}\Psi\left(ln\mathbf{X}_{it}\right) + s_{xM0}\Psi\left(ln\mathbf{X}_{M0}\right)\right] \tag{14}$$

Using the estimates of ω_{it} we can recover estimates of the shocks ν_{it} using a regression of the following equation:

$$\frac{\hat{\omega}_{it}}{\gamma} = \tilde{g}\left(\frac{\hat{\omega}_{it-1}}{\gamma}, \hat{P}_{it}\right) + \nu_{it} \tag{15}$$

where $\tilde{g}(\cdot)$ is version of $g(\cdot)$ accounting for the fact that we re-scaled ω_{it} using the constant scale parameter γ.

The shock ν_{it} are independent of all variables determined before period t. We assume that this includes k_{it} ; i.e. capital that is productive in period t has been determined before ν_{it} realises.[9] We can then use the following moment restrictions involving ν_{it} to identify all remaining parameters:

$$E\left\{\left[\quad X_{it-1} \times k_{it} \quad\right]' \nu_{it}\right\} = 0 \tag{16}$$

i.e. to identify $\Psi(\cdot)$ we use the zero moment conditions from the interaction of current levels of capital with lagged levels of all production factors. Note that we cannot use conditions on lagged production factor variables without interaction, as these have already been exploited in the regression implied by Equation 15.

Finally, recall that the focus of this estimation framework is to derive firm specific TFP and markup estimates. We get those by evaluating equations 14 and 13 at the parameter values that solve 16.

[9] Again this is a common assumption in the literature.

3 Data

We are using a dataset that been used in a series of papers before (Pavcnik 2002, Levinsohn and Petrin 2003). The reader should refer to those papers for a more in depth description of the dataset. Interest in this data is sparked both because Chile has been subject to fundamental trade reforms in the 1970s[10] and because data from the Chilean Census of Businesses has been relatively freely available. Clearly, it would be good to compare outcomes from before to those from after these trade reforms were implemented. Unfortunately such data is not available at the micro level. Similar to Pavcnik (2002) we therefore look at trends over the sample period. Table 2 reports descriptive statistics by year. We see that using various measures of size - revenue, employment or capital - the size of the average firm increased over the sample period. Equally, labour productivity - measured as value added per employee increased dramatically

4 Results for Chile

4.1 The distribution of markups and TFP

Figures 1 and 2 shows density estimates of markups and TFP - $\lambda + a$ - relative to the median firm in terms of revenue per employee in 1979.

$$\tilde{\mu} = \ln \mu_{it} - \ln \mu_M \tag{17}$$

Density estimates are reported separately for sectors with high and low rates of import penetration as well as for the earlier and later years of the sample period. Following Pavcnik (2002) we code a (3 digit) sector with an import penetration of more than 15% as being highly exposed to foreign imports. We can see that for both, sectors with high and low import penetration the density curve shifts to the left in the later period in Figure 1. Contrarily, for TFP in Figure 2 we see that both distributions shift to the right suggesting that TFP increases. To examine if these shifts are significant we run quantile regressions for both variables on a set of dummy variables that distinguish between the various cases reported in Figures 1 and 2. That is we run regressions of the following form:

$$y_{it} = \beta_{>83}\mathbf{I}\{t > 1983\} + \beta_{High}High_{S(i)} + \varepsilon_{it} \tag{18}$$

where $y_{it} \in \{\tilde{\mu}_{it}, \omega_{it}\}$ and $High_{S(i)} = 1$ if the three digit sector firm i belongs to has an import penetration of 15% or more. The first panel of Table 3 reports results for market power. We see that at various points in the distribution the coefficients of the interaction between the post 83 indicator and the "High" dummy are negative, implying that in sectors with high import penetration the decline in market power is stronger. The difference is larger and statistically more significant at higher points in the distribution. In the second panel of Table 3 we report the same quantile regressions for TFP. Again we find that there is a significant difference between sectors with high and low import penetration in the later years. Firm level productivity in sectors with high import penetration increases significantly more. The effect appears slightly stronger at the bottom of the distribution.

If market power and thus output prices decline while TFP increases, measuring TFP with revenue based output measures should lead to an underestimate of the TFP increase. We can confirm this by conducting the same analysis as above, yet imposing a constant markup. Table 4reports the results. We see that at various points in the distribution TFP still increases by

[10]Reforms which have been brought about by a highly repressive and un-democratic regime.

more in sectors with high import penetration. However, the effects are much smaller than in Table 3. For example at the median (p50) we find an increase of 11.3 percentage points in Table 3 whereas the same value is 4.3 percentage points in Table 4.

We might also ask if the reduction in market power could have been detected more simply. For that purpose, Figure 3 reports similar density plots as before for the price cost margin estimated as revenue over variable costs. As in Equation 17 we report the log deviation from the the median firm in the base year. As discussed in the introduction, this is an index of firm level market power under the assumption that the production technology is Cobb-Douglas. The density plot makes apparent that rather than a decline in market power - as found in before - this would suggest that market power increased. An implication of this is, which we can derive from Equation 7, is that the marginal productivity of the variable factors must have declined.[11] Potentially, this could be explained by a reduction in capital stocks.

4.2 The relationship between markups and TFP

Figure 4 explores the relationship between TFP and markups in a scatter plot. Fitting a regression line confirms that the relationship is significantly positive; i.e. firms with higher TFP charge higher markups. Notice however that the fitted regression line is rather flat compared to the 45 degree line. This suggests that on average the TFP gain is higher than the increase in markups so that we would expect that firms with higher TFP charge lower prices dispite having higher markups. In other words: they pass on most but not all of their higher productivity increase to consumers.

In the scatter plot, straight crosses indicate the earlier (79-83) period whereas diagonal crosses represent the later (84-86) period. It is striking that in the earlier period there are a number of firms with relatively low TFP but high market power. Over time this case seems to disappear, which is consistent with our understanding of the impact of trade reforms.

Figure 5 as well as Table 5 explore the impact on prices further by looking at the impact of trade reform on prices. Thus, we compute the percentage deviation from the median firm in terms of markups minus the percentage deviation in terms of TFP to derive an index of the firm level price relative to the median firm. As before we report density plots as well as quantile regressions. We find that sectors with higher import penetration had a stronger price decline.

5 Conclusion

This paper develops a new structural approach to production function estimation that can recover both, estimates of firm specific TFP as well as market power. While structural, the assumptions needed are very mild compared to what is often assumed in the literature. The method is of interest in any situation where firm level productivity is estimated with revenue rather than quantity information which is almost always the case. In this paper we apply it to study the impact of trade reforms in Chile in the 1970s. We find that in sectors with higher import penetration market power decreased and productivity increased. Importantly, the increase in productivity is under-estimated if the market power effects are ignored.

[11] Recall that the factor share is the inverse of the price cost margin measure used in Figure 3

A The response of prices to quality shocks

This section works out the response of prices and revenue to quality shocks Λ_i; i.e. it proves the result stated in equation 9 implying that quality shocks affect revenue in the same way as Hick's neutral TFP shocks. This allows us to combine TFP and quality shocks and separate them from firms specific demand factors affecting markups.

Suppose consumers maximise a general differentiable utility function subject to budget M :

$$\max_{Q}\left\{U\left(\tilde{Q}\right)-\kappa\left(\sum_{i}Q_iP_i-M\right)\right\}$$

where κ is a Lagrange multiplier and $\tilde{Q}$ is a vector of elements Λ_iQ_i. The first order conditions of this problem imply

$$\frac{\partial U}{\partial\tilde{Q}_i}\frac{\partial\tilde{Q}_i}{\partial Q_i}=\frac{\partial U}{\partial\tilde{Q}_i}\Lambda_i=\kappa P_i$$

Taking logs implies

$$\ln\frac{\partial U}{\partial\tilde{Q}_i}+\lambda_i=\ln\kappa+\ln P_i \tag{19}$$

Solving all these conditions will give us demand functions for all products including that of firm i. Even if we knew the exact form of $U(\cdot)$ this might be tricky to work out. Notice, however what 19 tells us about the shape of demand function. Differentiating w.r.t to $\ln Q_i$ yields

$$\frac{\partial lnP_i}{\partial lnQ_i}=-\frac{1}{\eta_i}=\frac{\partial\ln\frac{\partial U}{\partial\tilde{Q}_i}}{\partial ln\tilde{Q}_i}\frac{\partial ln\tilde{Q}_i}{\partial lnQ_i}=\frac{\partial\ln\frac{\partial U}{\partial\tilde{Q}_i}}{\partial ln\tilde{Q}_i}$$

Similarly we find that

$$\frac{\partial lnP_i}{\partial\lambda_i}=\frac{\partial\ln\frac{\partial U}{\partial\tilde{Q}_i}}{\partial ln\tilde{Q}_i}\frac{\partial ln\tilde{Q}_i}{\partial\lambda_i}+1=\frac{\partial\ln\frac{\partial U}{\partial\tilde{Q}_i}}{\partial ln\tilde{Q}_i}+1$$

i.e. the elasticity of prices with respect to output quantity differs from the elasticity of prices w.r.t to the quality shock by one. Moreover, because of the demand function is invertible we get

$$\frac{\partial lnP_i}{\partial\lambda_i}=1-\frac{1}{\eta_i}=\frac{1}{\mu_i}$$

B Testing the validity of the homogeneity assumption

As discussed in the main text, homogeneity of the production function is a key assumption of the proposed estimation approach. While this is an explicit or implicit assumption widely made in the literature this does not necessarily mean it is reasonable. An example of why it might

Table 1: R2 across 3 digit sectors

			Percentiles			
Sample	mean	min	p5	p10	p20	p40
Across firms	0.90	0.71	0.75	0.78	0.86	0.92
Across Sectors	0.89	0.71	0.75	0.76	0.81	0.88

Notes: The table shows statistics of R^2 of regressions of equation 20 at each 3 digit sector. The statistics in in row 1 are weighted by the number of firms in a sector whereas row 2 reports unweighted statistics across 3 digit sectors.

no hold is the following: suppose that after a change in trade policy some firms respond by out-sourcing parts of their production. Therefore, to examine its validity of the homogeneity assumption we propose the following. Above we derived that under homogeneity factor shares of variable factors are equal to a function of observable production factors divided by markups. We can therefore model deviations from this assumption by writing e.g. for materials

$$s_{mi} = \frac{\Psi_m\left(\mathbf{X}_i\right)}{\mu_i}\Xi_{mi}$$

where Ξ_{Mi} measures firm specific deviations from this assumption. If we have at least one other variable factor - labour say - we can write

$$\ln s_{mi} - \ln s_{li} = \ln \Psi_m\left(\mathbf{X}_i\right) - \ln \Psi_L\left(\mathbf{X}_i\right) + \xi_{mi} - \xi_{li} \tag{20}$$

where $\xi_{Xi} = \ln \Xi_{Xi}$. Hence the log difference in factor share of two variable factors becomes a function of observable variables and any homogeneity destroying shocks. Hence, to examine the validity of the homogeneity assumption we can run regressions of equation 20. If homogeneity is a reasonable assumption, most of the variation in the share difference should be explained by the function of observables.[12] In other words, we can look at the R^2 statistic which should be rather high. Table 1 reports statistics of R^2 computed for each 3 digit sector after regressing equation 20 with the Chilean data.[13] Row 1 of the table reports statistics weighted with the number of firms in a sector whereas row 2 reports unweighted statistics. We see that no sector has an R^2 lower than 71%. The majority of firms in the sample are in a sector with R^2 larger than 90%.

C Tables and Figures

[12]Although we should note that this a necessary although not sufficient condition. Our test would bear no power if ξ_m and ξ_l are perfectly negatively correlated.

[13]We used a simple non-linear least squares approach. A more sophisticated appraoch would consider various assumption about the dynamics and correlation of the the ξ shocks with the observed explanatory variables.

Table 2: Descriptive Statistics by year

variable	year	mean	sd	p10	p50	p90	count
Revenue	79	66515	293998	4070	13056	133586	2958
	80	89484	377169	5554	17915	176633	3146
	81	114000 *	421073	6635	22480	233638	3069
	82	116632 *	553747	6035	21259	229204	2709
	83	164288 ***	743369	8448	28628	341316	2476
	84	233704 ***	1082926	11005	40297	479047	2390
	85	353063 ***	1599479	16557	59780	734565	2346
	86	503219 ***	2150605	22173	84936	1067461	2133
Employment	79	53	100	12	23	108	2958
	80	54	105	12	23	113	3146
	81	56	108	12	24	122	3069
	82	51	97	11	23	107	2709
	83	53	99	11	24	113	2476
	84	58 *	104	12	26	126	2390
	85	63 ***	111	12	28	138	2346
	86	71 ***	119	13	30	167	2133
Capital	79	36657	178514	977	4364	56753	2958
	80	37412	198003	1015	4230	54298	3146
	81	41972	211392	1053	4299	59745	3069
	82	47967 *	236453	1089	4455	68924	2709
	83	48960 **	255152	1058	4491	68980	2476
	84	51063 **	252865	1077	4427	77310	2390
	85	52088 **	253663	1078	4542	78762	2346
	86	53813 ***	245613	1079	4511	89680	2133
Value added per employee	79	375	424	97	247	784	2958
	80	531 ***	613	130	351	1097	3146
	81	672 ***	775	170	441	1419	3069
	82	734 ***	945	180	451	1537	2709
	83	910 ***	1145	199	532	1980	2476
	84	1120 ***	1514	237	641	2456	2390
	85	1541 ***	2111	319	853	3406	2346
	86	1970 ***	2832	396	1068	4265	2133
Price Cost Margins (Revenue over Material and Labour Costs)	79	1.66	0.56	1.13	1.52	2.36	2958
	80	1.67	0.53	1.14	1.54	2.39	3146
	81	1.64	0.51	1.12	1.51	2.37	3069
	82	1.64	0.51	1.13	1.51	2.32	2709
	83	1.6 ***	0.52	1.11	1.47	2.24	2476
	84	1.57 ***	0.48	1.13	1.45	2.18	2390
	85	1.58 ***	0.47	1.13	1.46	2.18	2346
	86	1.57 ***	0.49	1.13	1.44	2.19	2133

Notes: Stars indicate if the mean for a specific year is significantly different from that for the first year. *,**,***=significant at 10, 5, 1%.

Table 3: Quantile Regressions of Markups and Productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Percentile:	*5*	*10*	*25*	*50*	*75*	*90*	*95*
				Markup ln(μ(i)-μ(Median))			
Post 83 Dummy	-0.004	0.004	-0.003	-0.020***	-0.034***	-0.041***	-0.030***
	(0.008)	(0.007)	(0.005)	(0.005)	(0.005)	(0.006)	(0.007)
Post 83 X High Import Penetration	-0.000	-0.003	-0.014*	-0.010	-0.026***	-0.021**	-0.025**
	(0.012)	(0.011)	(0.008)	(0.008)	(0.008)	(0.010)	(0.011)
				Combined TFP and demand shock ω			
Post 83 Dummy	0.040**	0.054***	0.040***	0.018	0.015	-0.011	-0.016
	(0.020)	(0.014)	(0.013)	(0.011)	(0.014)	(0.017)	(0.022)
Post 83 X High Import Penetration	0.137***	0.119***	0.127***	0.113***	0.109***	0.107***	0.085**
	(0.032)	(0.023)	(0.021)	(0.018)	(0.022)	(0.028)	(0.034)
Observations	16362	16362	16362	16362	16362	16362	16362

Notes: The table reports results from quantile regressions as described in Equation 18.

Table 4: Quantile Regressions of Productivity imposing constant markups

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Percentile:	*5*	*10*	*25*	*50*	*75*	*90*	*95*
				Combined TFP and demand shock ω			
Post 83 Dummy	0.043***	0.044***	0.046***	0.039***	0.045***	0.043***	0.016
	(0.012)	(0.010)	(0.011)	(0.009)	(0.011)	(0.015)	(0.018)
Post 83 X High Import Penetration	-0.007	0.008	0.038**	0.043***	0.041**	0.039	0.079***
	(0.018)	(0.016)	(0.017)	(0.014)	(0.017)	(0.024)	(0.029)
Observations	16362	16362	16362	16362	16362	16362	16362

Notes: The table reports results from quantile regressions as described in Equation 18. The dependant variable is a TFP measure obtained with a control function approach where markups are restricted to be constant.

Table 5: Quantile Regressions of the net effect on prices

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Percentile:	*5*	*10*	*25*	*50*	*75*	*90*	*95*
				Prices ln(μ(i)-μ(Median))-ω			
Post 83 Dummy	-0.007	0.012	-0.028**	-0.039***	-0.058***	-0.059***	-0.073***
	(0.020)	(0.017)	(0.013)	(0.010)	(0.010)	(0.016)	(0.025)
Post 83 X High Import Penetration	-0.092***	-0.123***	-0.109***	-0.118***	-0.149***	-0.174***	-0.148***
	(0.031)	(0.027)	(0.021)	(0.016)	(0.016)	(0.025)	(0.040)
Observations	16364	16364	16364	16364	16364	16364	16364

Notes: The table reports results from quantile regressions as described in Equation 18. The dependant variable is an index of the output price computed as the sum of (log) markup minus TFP, all relative to the reference firm.

Table 6: Transitions in the market power distribution

	(1)	(2)	(3)	(4)
Dep. Variable	High Markup Indicator (above median) in t+4			
Incumbent Firm (Established before 1980)	0.040	-0.033	-0.019	-0.021
	(0.041)	(0.039)	(0.039)	(0.040)
High Import Penetration (above 15%)	0.101	-0.091	-0.152**	-0.116
	(0.069)	(0.070)	(0.070)	(0.075)
Incumbent Firm X High Import Penetration	-0.105	-0.005	-0.018	-0.015
	(0.072)	(0.071)	(0.072)	(0.072)
High Markup (above median)		0.511***	0.523***	0.631***
		(0.020)	(0.020)	(0.030)
High Markup X High Import Penetration		0.164***	0.142***	0.037
		(0.043)	(0.044)	(0.063)
High TFP (above median)			-0.107***	0.009
			(0.025)	(0.037)
High TFP X High Import Penetration			0.146***	0.113*
			(0.042)	(0.064)
High TFP X High Markup				-0.218***
				(0.049)
High TFP X High Markup X High Import Penet.				0.099
				(0.085)
Year dummies	yes	yes	yes	yes
Sample	1980-82	1980-82	1980-82	1980-82
Observations	4336	4336	4336	4336

Notes: The table reports probit regressions on the event that a firm is in the upper half of the market power distribution after 1983. The explanatory variables include dummies regarding the state of a firm 4 years earlier.

Table 7: Transitions in the TFP distribution

	(1)	(2)	(3)	(4)
Dep. Variable	High TFP Indicator (above median) in t+4			
Incumbent Firm (Established before 1980)	0.007	0.017	-0.042	-0.041
	(0.039)	(0.040)	(0.039)	(0.039)
High Import Penetration (above 15%)	-0.244***	-0.349***	-0.340***	-0.402***
	(0.065)	(0.064)	(0.068)	(0.067)
Incumbent Firm X High Import Penetration	-0.009	-0.010	0.045	0.047
	(0.071)	(0.071)	(0.073)	(0.073)
High Markup (above median)		-0.079***	-0.147***	-0.217***
		(0.025)	(0.025)	(0.039)
High Markup X High Import Penetration		0.199***	0.199***	0.322***
		(0.037)	(0.037)	(0.046)
High TFP (above median)			0.418***	0.368***
			(0.022)	(0.031)
High TFP X High Import Penetration			0.102**	0.253***
			(0.040)	(0.051)
High TFP X High Markup				0.114**
				(0.048)
High TFP X High Markup X High Import Penet.				-0.297***
				(0.070)
Year dummies	yes	yes	yes	yes
Sample	1980-82	1980-82	1980-82	1980-82
Observations	4336	4336	4336	4336

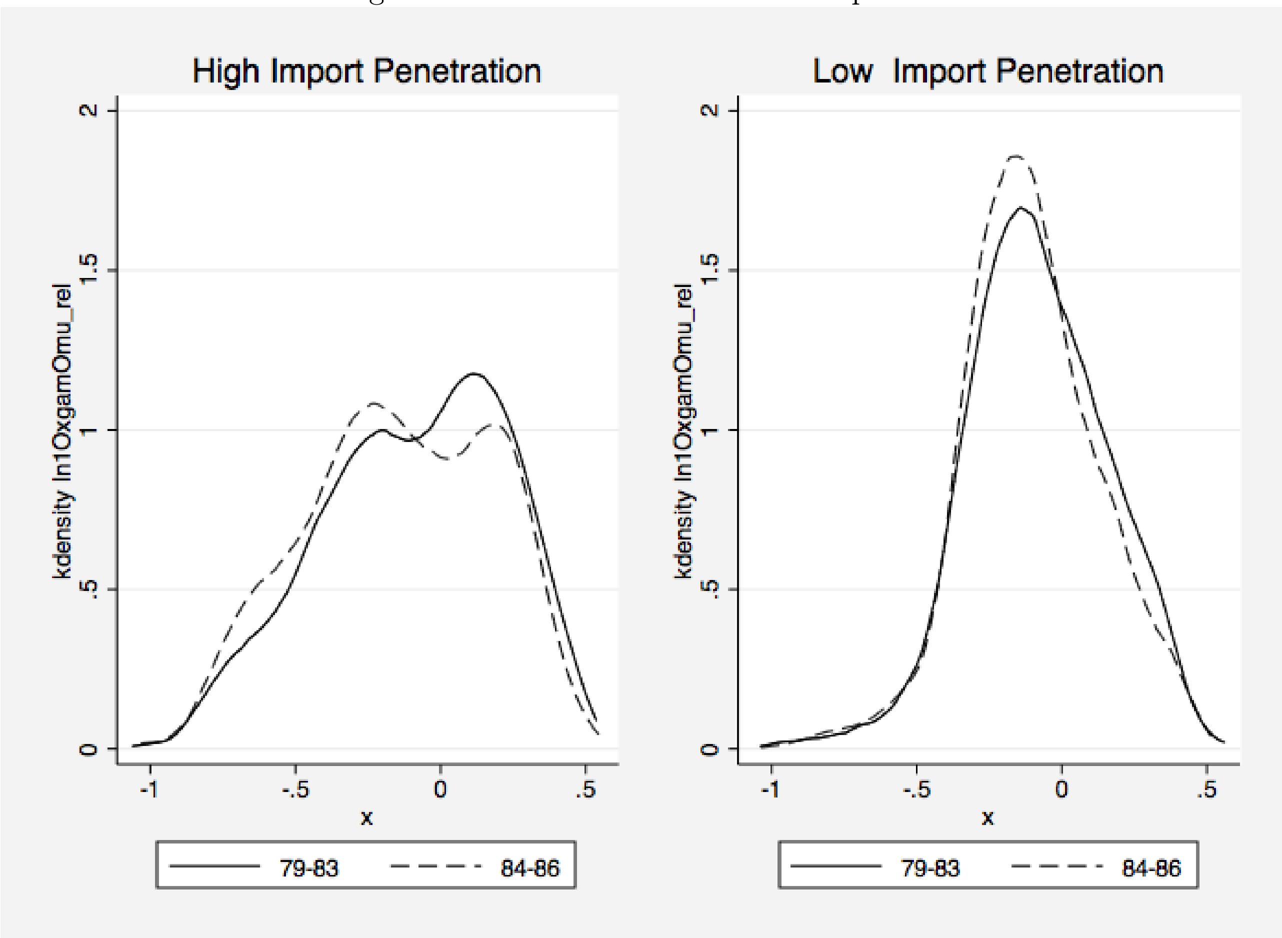
Notes: The table reports probit regressions on the event that a firm is in the upper half of the TFP distribution after 1983. The explanatory variables include dummies regarding the state of a firm 4 years earlier.

Table 8: Exit regressions

	(1)	(2)	(3)	(4)
Dep. Variable	Exit Indicator in t+4			
Incumbent Firm (Established before 1980)	-0.169***	-0.168***	-0.152***	-0.153***
	(0.030)	(0.030)	(0.030)	(0.030)
High Import Penetration (above 15%)	0.099**	0.082*	0.038	0.038
	(0.043)	(0.046)	(0.048)	(0.050)
Incumbent Firm X High Import Penetration	-0.055	-0.055	-0.070	-0.067
	(0.046)	(0.046)	(0.046)	(0.046)
High Markup (above median)		-0.013	-0.003	0.066**
		(0.019)	(0.019)	(0.030)
High Markup X High Import Penetration		0.033	0.027	0.016
		(0.031)	(0.031)	(0.042)
High TFP (above median)			-0.124***	-0.067**
			(0.019)	(0.027)
High TFP X High Import Penetration			0.084***	0.123***
			(0.032)	(0.047)
High TFP X High Markup				-0.113***
				(0.035)
High TFP X High Markup X High Import Penet.				-0.051
				(0.057)
Year dummies	yes	yes	yes	yes
Sample	1980-82	1980-82	1980-82	1980-82
Observations	4336	4336	4336	4336

Notes: The table reports probit regressions on the event that a firm exits within 4 years. The explanatory variables include dummies regarding the state of a firm 4 years earlier.

Figure 1: The distribution of market power



Notes: The figure shows kernel density plots of the distribution of market power, separately for import intensive and non import intensive sectors as well as for the earlier and later sample period.

Figure 2: The distribution of Productivity

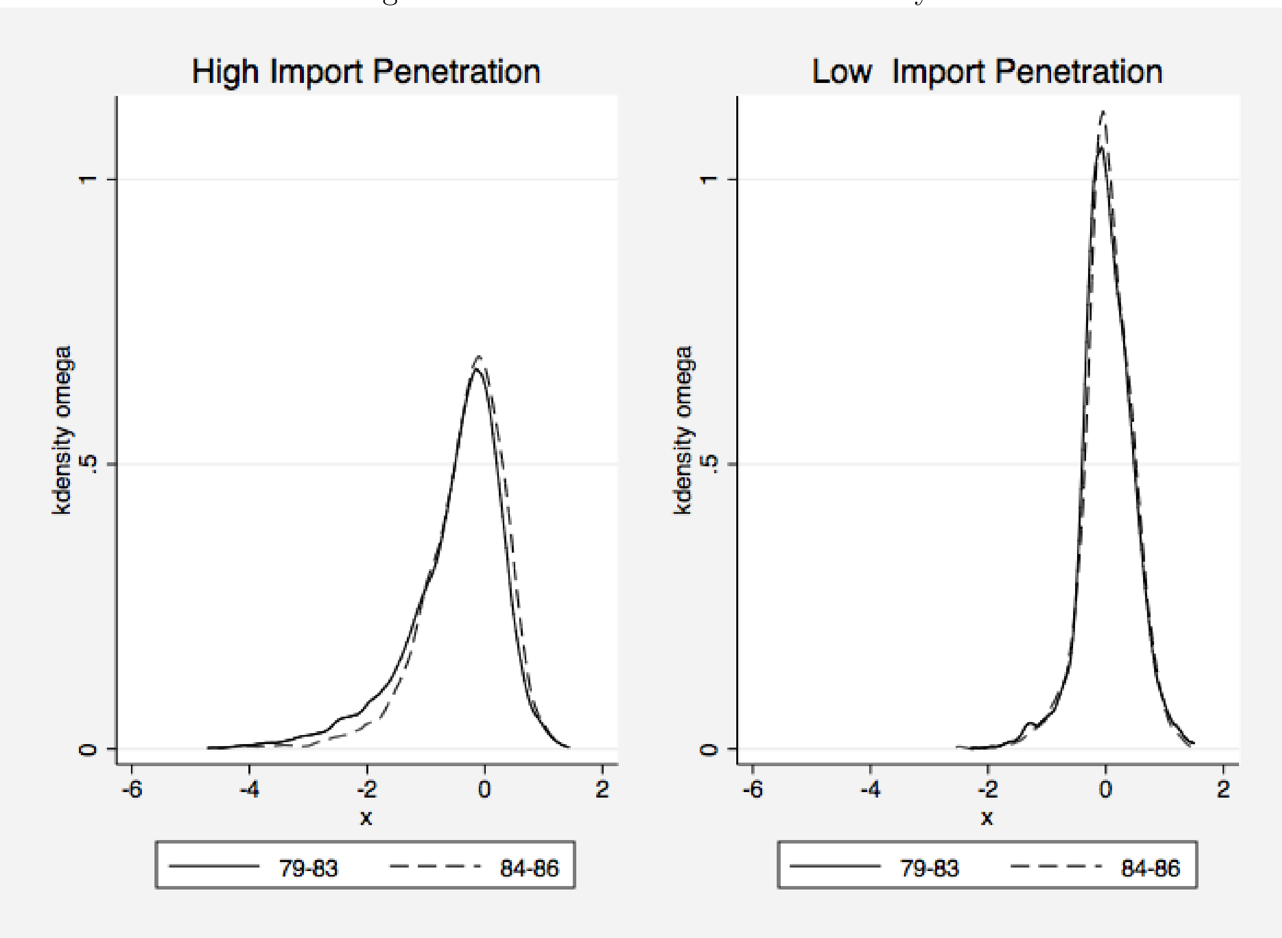


Figure 3: Revenue over variable costs

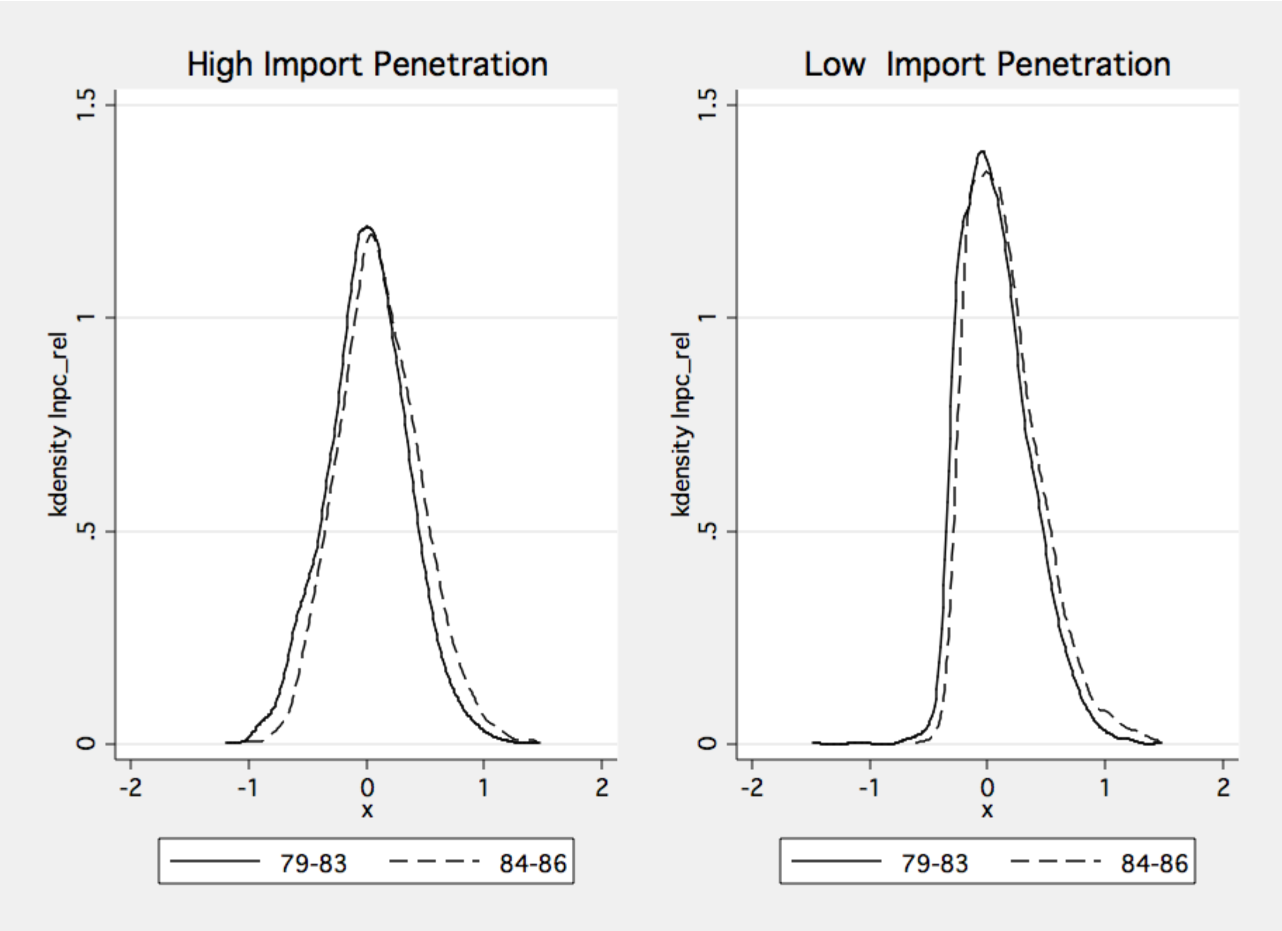
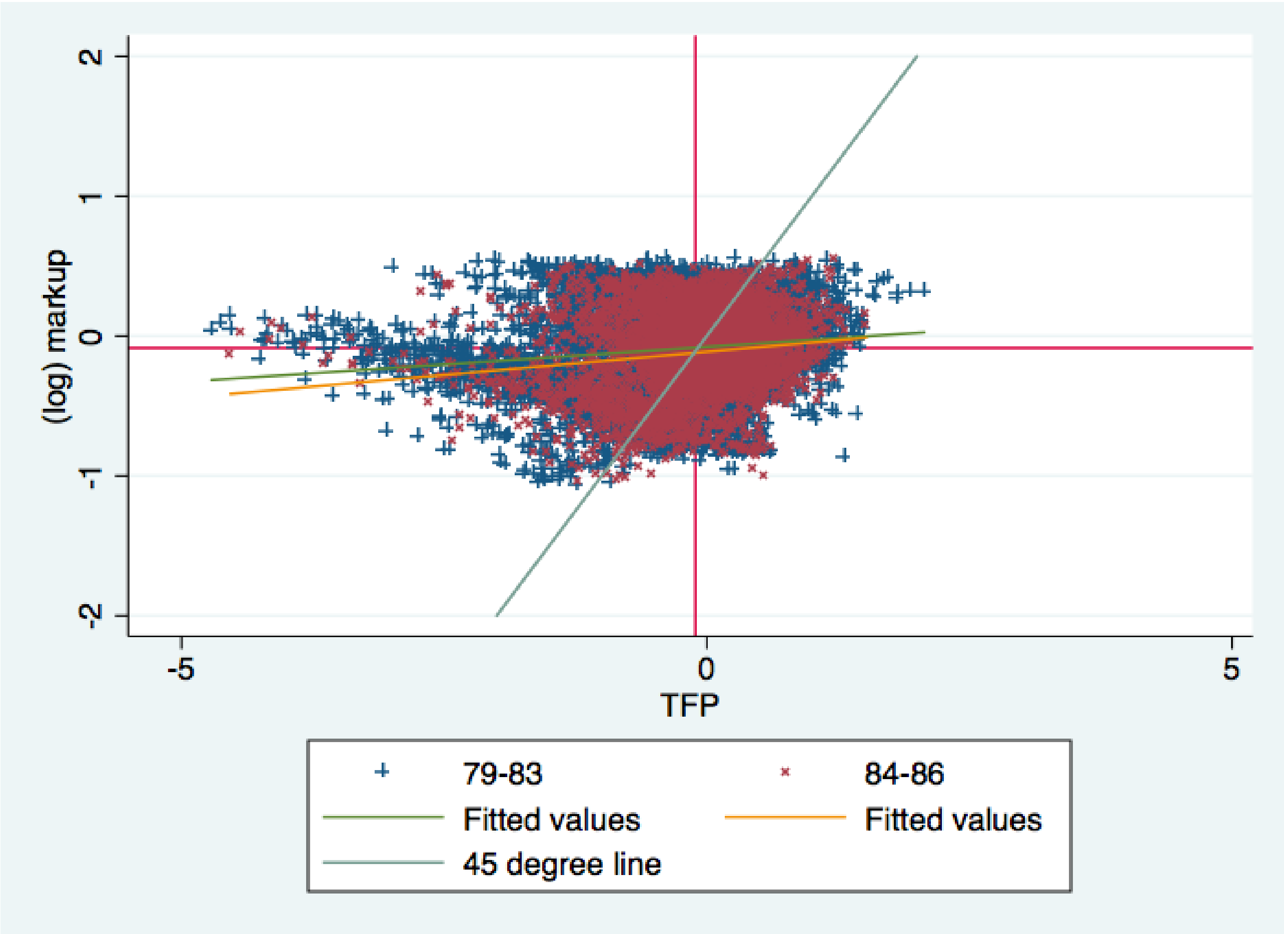
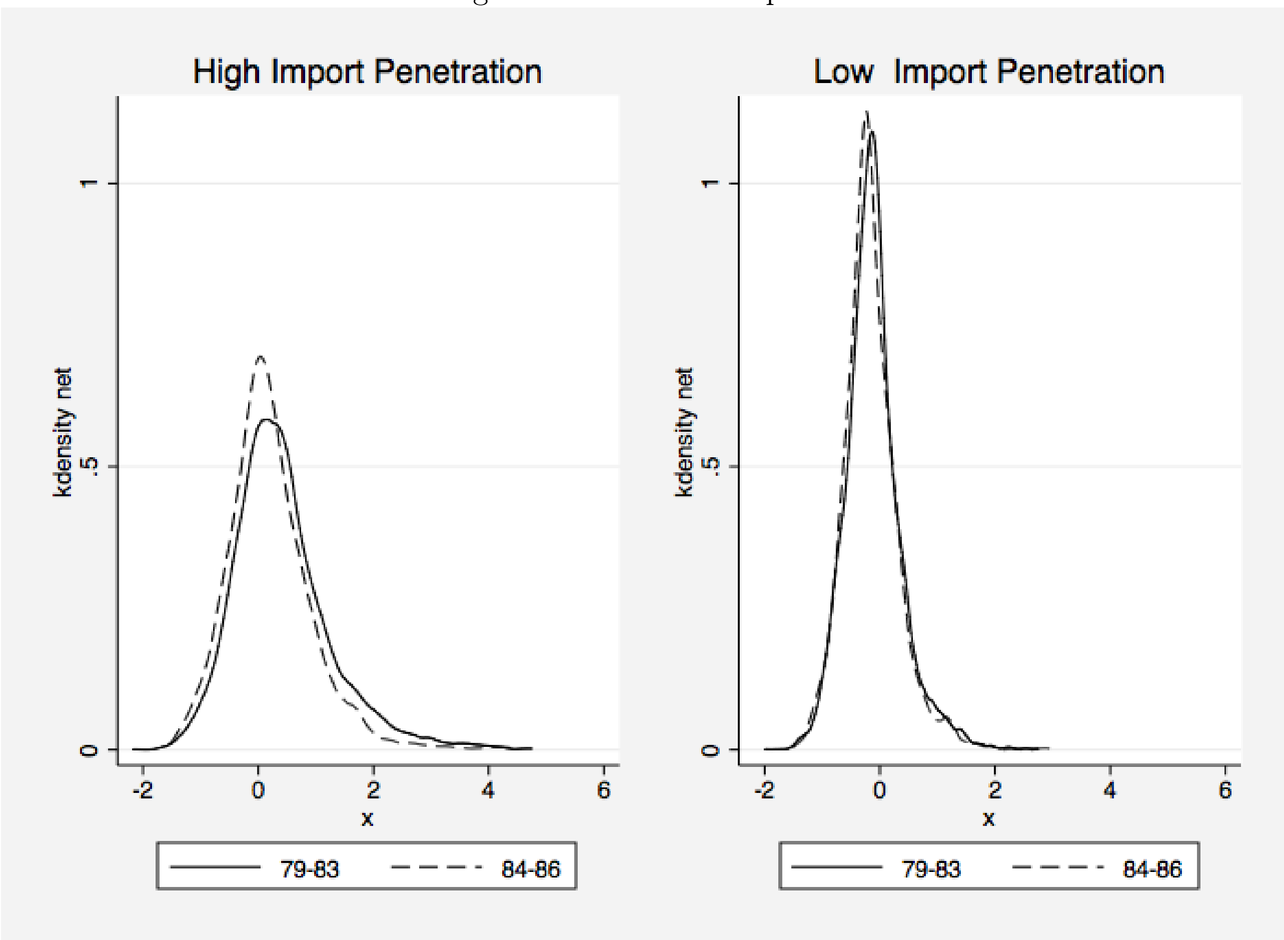


Figure 4: Markups vs TFP



Notes: The figures shows a scatter plot of firm level markups on firm level TFP. Earlier values are represented by blue crosses, later values by red x's. The red vertical and horizontal lines indicate the median. The graph also contains linear regressions lines separately for the earlier and later period. This suggest that the positive relationship between markups and TFP become stronger over time.

Figure 5: Net effect on prices



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