The Scale Effect: A Comparative Industry-Level Analysis *

Keith E. Maskus (University of Colorado)
Carlos A. Cinquetti†(Sao Paulo State University - UNESP)

May 1, 2013

Abstract

We reassess, with industry-level data, the *scale effect* from trade protection, by means of a comprehensive fixed-cost variable, composing both technology coefficient and firms size, and a comparative (international) analysis. Evidence is based on Brazil's manufacturing industries during its import-substitution industrialization, comparatively to the USA. The panel-data analysis clearly shows a correlation between comparative increases in the number of firms with average costs, corroborating the *scale (entry) effect*.

*We thank Russell Hillberry and Carlos Martins Fo. for some topic and valuable suggestions, as well as data assistance from the staff of both IBGE and the Colorado University Library. Financial support from CAPES and CNPq are gratefully acknowledge.

†Corresponding author address: UNESP - Dep. Economics Araraquara, SP 14800-901. Brazil. Phone/Fax: 55 16 3301-6214/6258. E-mail: cinquett@fclar.unesp.br

1 Introduction

We reassess the "scale effect" from protectionism with industry-level data. The empirical framework relies on two key elements to trade theories, cost and international comparison.

More to the point, the analysis is built on a fixed-cost variable composing input coefficient and firms size, prying average cost, whose performance in a highly protected manufacturing industry, the Brazilian during the import-substitution industrialization (IS), is compared to a baseline economy, the USA.

Results of the exploratory statistical analysis show that comparative increases in industries' average cost are correlated with comparative entry (or firm's size).

The paper is thus structured. We revisit, in Section 2, the *elimination (industry) effect* by opposition to the *selection (firm) effect* with their corresponding empirical content, implementing the empirical analysis in Section 4 after briefly addressing data and variables in Section 3. Conclusions follow in Section 5.

2 Rivalry, Productivity and Technology

In an imperfectly competitive industry $i \in I$, with fixed cost F, equilibrium is determined by a return function on the number of firms, N_i

$$\pi_i(N_i^*) = V(N_i^*, \varphi, \theta) - F_i = 0, \tag{1}$$

where φ_i and θ_i stand for cost (technology) and demand variables respectively. Since variable profit$V(.)$ is non-increasing in N_i, $N_i^*$is such that $\pi(N_i^* + 1) < 0$, which holds good in oligopoly (, Pepall et al (2008)and monopolistic competition (Lancaster, 1984; Melitz and Ottaviano , 2008) as well, except with in that with constant elasticity of substitution by Dixit and Stigitz (1977) and Krugman (1980) – DSK henceforth.

In an international economy, marginal trade cost to (or into) country k, τ^k, shifts N_{it}^* through $V(N, \theta)$ for its associated increase (decrease) in markup over marginal cost, provided that international markets are integrated (see Markusen and Venables, 1988). This condition is unnecessary with the DSK monopolist competition, as well as in large and insulated (by geographic and policy barriers) countries, where $V(.)$ is mostly driven by domestic market. A fixed trade cost, F_{xi}, would similarly effect N_{it}^*.

Approaching the equilibrium through duality has the advantage that average cost may gather an ampler technology information. Since its variation goes through through opening (entry) and closing (exit) of plants, we should focus on plant fixed cost, which Brainard (1997) proxied by the input ratio of operative labor,[1] though expanding it with a term for average firm size, *i.e.*:

[1]While corporate fixed cost was proxied by the ratio of skilled to unskilled labor.

$$PLANT_{it}(N_{it}) = \frac{(l_{it}/y_{it})N_{it}}{\bar{G}_t} = \frac{l_{it}/\bar{x_{it}}}{\bar{G}_t}, \tag{2}$$

where l_{it} and y_{it} stand, respectively, for operative workers employment and output in each industry at time t – this extra dimension is explained below – whereas $\bar{x_{it}}$, is the mean size of firms. That $PLANT_{it}$ increases with N_{it} further shows its consistence as a measure of economies of scale. Normalization by $\bar{G}_t$, the mean value of the numerator, clears away business-cycle variations, as well the *home-market effect*.

Firm's conduct to more (or less) competitors underlines the mapping $\pi_{it}(N_{it})$, which is closely associated with the competition effect of international trade, while its $PLANT_{it}(N_{it})$ more incisively displays its efficiency, associated with the *scale (or elimination) effect* (Horstmann and Markusen, 1986; Feenstra, 1995).

Under a DSK market structure, θ_i is exogenous, or invariable to N_i, but variable profit subsists if firms are now heterogeneous in productivity, as in Melitz (2003), which shifts (1) to

$$\pi_{it}(\varphi^*_{it}) = V(\varphi_{ijt},) - F_{it} - F_{xit} = 0, \tag{3}$$

where φ_{ij} is the productivity of firm j. Here, not only defines simultaneously enter and a selection of which firms will export and which will not. More precisely, in a generic $g(\varphi_{it})$ distribution, $G(\varphi_{xi})$ is the threshold value for purely domestic firms, N^*_d, whereas $G(\varphi^*_{xi})$, stemming from F_{xit}, is the threshold value for exporter firms. Hence, albeit N_i is no longer a definite variable into $V(.)$, N^*_d and N^*_x are.

In such market structure, what best characterizes an international equilibrium is the distribution of firm's productivity:

$$PRODT_{ijt} = g\left(\frac{l_{ijt}/y_{ijt}}{\bar{Z}_{it}}\right), \tag{4}$$

where $\bar{Z}_{it}$ is the mean productivity value of i at t. From the first moment of this distribution (4) and from its skewness as well, we can infer the impact of trade upon the entry process and on industry's productivity. Melitz and Trefler (2012) show that, in Canada, trade openness reduced the number of firms with productivity below the median value, since domestic firms are selected out, corroborating the move in the threshold value $G(\varphi_{ijt})$ to $G(\varphi^*_{xi})$ and pushing up each industry's average productivity.

In the real world, the *firm selection* (3) does not excludes the *firm elimination* (1), unless we discharge the $\theta_i(N_i)$ relationship[2], as done by Feentra (2004, Ch. 5) to explain a contrary evidence on the latter effect. Yet, the former deals of a conduct relationship at industry-level, such as a trade policy pushing θ_i up and then accommodating a reduced $\bar{x}_i$. In this sense, it can be empirically assessed without firm-level data.

[2]As in Melitz (2003), though abandoned in Melitz and Ottaviano (2008)

3 Data and Variables

Rather than comparing performance before and after policy change, we analyze the *scale effect* through international comparison. Major trade-policy changes often come with a general policy change (see Trefler, 2001), making it more difficult to single out the former's effects in an inter-period statistic experiment than within-period international comparison. Accordingly, we compare the manufacturing industry in Brazil's ISI to a baseline country producing in the same analyzed industries, but rather closer to free trade.[3] Together with data availability, this led to the USA.

Four referential years of Brazil's ISI are considered: 1967, 1973, 1980, and 1987/88 – the latter average aims at smoothing extremely unstable years; smaller yet than 1986-87. Besides giving a better picture of this policy experiment, repeated observations compensate for the small number of industries (twenty-one), as compared to firm-level analyses. A mix of statistical and mathematical interpolation were applied for the 1987-88, given the interruption (in 1985-86) by IBGE (The Brazilian Institute of Geography and Statistics), and later resumption with historically incompatible series. Curious reader is referred to our paper ((Cinquetti and Marskus, 2012)).

Data on Brazil and the USA's output and employment come from both UNIDO database and some yearly *Industrial Statistics* as well, while on number of establishments comes, respectively, from PIA (Annual Survey of the Industry) and the County Business Patterns.

4. International Deviation from Scale Inefficiency

The attempted comparison between Brazil and the USA only makes sense in a quasi-Heckscher-Ohlin world Romalis (2004(@), which implies monopolistic competition. Accordingly, the scale effect can be singled out in a comparative-advantage model having a set X_{it} of control variables, encompassing marginal cost, corporate fixed cost, and market power, as done by Maskus & Cinquetti (2012). The authors run two regression:

$$E_{it} = \beta' \mathrm{X} + \mathrm{b} PLANT_{it} + \epsilon_{it}, \qquad E_{it} = \beta' X + \tilde{b} PLANT^*_{it} + \varepsilon_{it}, \tag{5}$$

where $PLANT^*_{it}$ is a counter-factual free-trade experiment against $PLANT_{it}$. A $b > \tilde{b}$ stands for weaker linkages to revealed comparative advantages, E_{it}, meaning that protection lowered the scale contribution to exports, which was verified by the authors – as well as evidence of market power upon E_{it}.

Here we scrutinize the plant fixed-cost variable, examining the correlation between N_{it}/N^*_{it}

[3] A small home market enforces a shift from oligopoly to monopoly, changing all analysis on trade policy (Pomfret , 1992).

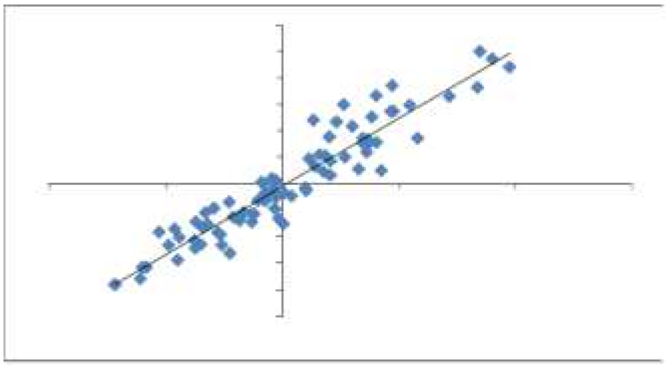

Figure 1: Number of Firms versus Plant Fixed cost

against $PLANT_{it}/PLANT^*_{it}$, following a tenet by Schmalensee (1989), that inter-industry studies with imperfect competition should rely first and foremost on good data and basic statistic tools, as in the elegant empirical analysis by Melitz & Trefler's (2012). The goal is analyzing the inefficient entry, or else the international deviation from scale inefficiency, since monopolistic competition rules out the maximum scale efficiency.

We must re-emphasize that the normalized $PLANT_{it}$ controls for *home-market effect* (i.e., or Hicks-neutral international technology differences) and add it is less plagued than corporate-fixed cost by activities (e.g., technology generation and technology transfers) that differs between developed and developing economies. In other words, $PLANT_{it}$ only holds good for examining change in firms size if its technology coefficient is internationally stable – in their ordering, at least.

In the below Figure 1, both $PLANT_{it}/PLANT^*_{it}$ and N_{it}/N^*_{it} were further transformed into log values to avoid large concentration of points in the [0,1] interval. As can be seen, N_{it}/N^*_{it} is positive and highly correlated with relative cost in the Brazilian manufacturing industries, confirming the *scale effect*. More to the point, for any industry i and time t, comparative increase in the number of firms, in the highly protected economy, is associated with relatively higher average cost.

There was no special legal barrier to entry in Brazil, except for one subsector in *metals* and *other sectors* each, which enables us attributing the above evidence to protectionism, which actually encaompassed a wide range of both trade and industrial-policy instruments. A messy arrangement that yielt unplanned negative effective ratio of protection to some industries, which may explain some points in the negative quadrant.

Inasmuch as $PLANT_{it}$ increases with the number of firms, the above correlation would only fail if higher N_{it}/N^*_{it} were associated with: (a) higher relative industry size, or (b) higher relative productivity. The latter can be referred to *firms selection*, while former to theeither comparative advantages or else to non-homothetic preferences. In fact, we expected firms' productivity to be loosely associated with comparative number of firms, when comparing countries with so different development levels and factor prices.

To reach a clearer view about the contribution of *firm scale* to the above relationship clearer, we can isolate $\bar{x}_{it}$ from $PLANT$. As can be seen in the below Figure 2, there is a strong negative correlation between N_{it}/N^*_{it} and $\bar{x}_{it}/\bar{x}^*_{it}$, showing that entry/exit greatly contributed to observed variation in the relative plant fixed cost. That the correlation is not as strong as the above one indirectly conveys the role of international technology difference, of the *selection effect*.

As to the evidence, our analysis departs from some previous empirical analyses of the *scale effect* (Head and Ries, 1999; Tybout et al., 1991) bot for the experience itself and for their inter-period comparison, while we resort to intra-period counterfactuals. As to the economics of production and technology, our working with cost – duality in production – enabled a composed variable encompassing both input and firm scale. Lastly, as to variable, their firm-level data, unlike (4), is not centered, turning it more to difficult to associate those firm-level variations with the cross-industry industry phenomenon at stake. Industry dummies capture only part of industry-based features. In sum, while our industry-level data only entitles analysing an industry-specific problem, theirs non-centered firm-level variable hardly entitle an inter-industry analysis.

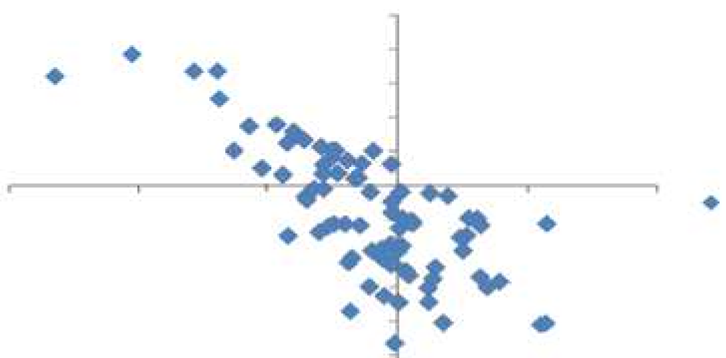

Figure 2: Number of Firms *versus* Firms Size

4 Conclusions

We examined the manufacturing industries in Brazil's ISI, comparatively to the USA, using a cost variable that composes both technology (input coefficient) and scale. Our exploratory panel-data analysis showed that higher comparative entry, in the high and pervasively protected economy, is correlated with comparative increase in average costs, with an additional analysis corroborating the entailed change in the mean firm size.

This evidence has no bearing on the *firm selection effect*; it only shows that industry matters when it comes to productivity and international trade.

References

Brainard, S. L., 1997. An Empirical Assessment of the Proximity-Concentration Trade-off Between Multinational Sales and Trade. *The American Economic Review* 87 (4), 520–544.

Cinquetti, Carlos .A., Maskus, Keith E. 2012. Number of firms in Brazil: a proposed compatible time series. Working papers.

Dixit, Avinash and Stiglitz, Joseph. 1977. Monopolistic competition and optimum product diversity. American Economic Review, 67, 297–308.

Feenstra, R. 1995. Estimating the effects of trade policy, In: G. Grossman and K. Rogoff (eds.), Handbook of International Trade. Amsterdam: Elsevier. Chapter 30.

Feenstra, R. 2004. Advanced International Trade. New Jersey: Princenton Univ. Press.

Head, Keith, Ries, John. 1999. Rationalization effects of tariff reductions. Journal of International Economics 47, 295-320.

Horstmann, I. J., Markusen, J. R., 1986. Up the Average Cost Curve: Inefficient Cntry and the New Protectionism. *Journal of International Economics* 20, 225–247.

Estatística Histórica do Brasil. Rio de Janeiro.

PIA (Annual Survey of the Industry). Rio de Janeiro. Several numbers.

Krugman, Paulo. 1980. Scale economies, product differentiation, and the pattern of trade. The American Economic Review, 70, 950–59.

Lancaster, K., 1984 Protection and Product Differentiation, In: KIERZKOWSKI, H. (ed), *Monopolistic competition and international trade*. Oxford: Claredon Press.

Markusen, James R, Venables, Anthony. 1988. Trade Policy with Increasing Returns and Imperfect Competition: Contradictory Results from Competing Assumptions. *Journal of International Economics*. 24, 299-316.

Melitz, M. J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica 71 (6), 1695–1725.

Melitz, Marc and Trefler, Daniel. 2012. Gains from trade when firms matter. *Journal of Economic Perspectives* 26 (2): 91–118.

Melitz, Marc and Ottaviano, Giancarlo. 2008. Market size, trade, and productivity. *Review of Economic Studies* 75 (1), 295-316.

Pepall, Lynne, Richards, Dan and Norman, George. 2008.

Pomfret, Richard. 1992. International Trade Policy with Imperfect Competition. *Special Papes in International Economics*, No. 17. Princeton University, New Jersey.

. Romalis, John. 2004. Factor proportions and the Structure of Commodity Trade. *The American Economic Review,* 94(1): 67–94.

Schmalensee, Richard. 1989. Inter-Industry Studies of Structure and Performance, in: Schmalensee, R. and Willig, R. D. (ed.), *Handbook of Industrial Organization*, Vol. II. Holland: Elsevier.

Trefler, Daniel. 1997. The Case of Missing Trade and Other Mysteries. *American Economic Review* 85 (5): 1029-1046.

Trefler, D. 2001. The long and short of the Canada-U.S. free trade agreement. NBER Working paper 8293.

Tybout, James, de Melo, Jamie and Corbo, Vittorio. 1991. The effects of trade reforms on scale and technical efficiency. Journal of International Economics, 31: 231–250.

UNIDO (United Nations Industrial Development Organization). *Industrial Statistics Database*.

United States Census Bureau. Several Years.