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Protection, Openness and Factor Adjustment: Evidence from the manufacturing sector in Uruguay

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Resumen

En este trabajo se analiza los procesos de ajuste en el uso de capital, obreros y empleados, usando un panel de empresas uruguayas. Nuestros resultados confirman la naturaleza discreta de los ajustes en el uso de los factores, la relevancia de los aspectos no lineales y la interdependencia entre los ajustes de los diferentes factores de producción. Se estima una brecha anual promedio en el producto debida a los costos de ajuste de 2% entre 1982 y 1995. Se encuentra que la apertura comercial afectó los procesos de ajuste de los tres factores. Sectores altamente protegidos ajustan menos cuando se trata de crear empleos que los sectores con protección baja, lo que puede reflejar desconfianza respecto a la reversión de las políticas en el caso de sectores con alta protección. Los sectores con alta protección ajustan más fácilmente comparados con los de baja protección al destruir empleos, especialmente en caso de puestos de trabajo de obreros. Ello sugiere que la protección puede contribuir a la destrucción de empleos dentro de las industrias, dado que las empresas en sectores más protegidos son más reacias a contratar y más dispuestas a despedir que aquellas en sectores con protección baja. Los resultados para el capital son cualitativamente similares aunque de magnitud inferior. En general, los impactos de la exposición internacional son mayores para los obreros que para los empleados.

Abstract

Using a panel of Uruguayan manufacturing firms we analyze the adjustment process in capital, blue collar and white collar employment. Our results confirm the lumpy nature of factor adjustment, the relevance of nonlinearities and the interdependence between factor shortages. The average annual estimated output gap due to adjustment cost for1982-1995 was 2%. Trade openness affected the adjustment functions of all three factors. Highly protected sectors adjust less when creating jobs (reducing labor shortages) than sectors with low protection. This may be due to fears of policy reversal in highly protected sectors. Also, highly protected sectors adjust more easily (than low protection sectors) when destroying jobs (reducing labor surpluses), especially in the case of blue collar labor. This suggests that trade protection may in fact destroy rather than create jobs within industries, as firms in highly protected sectors are more reluctant to hire and more ready to fire than firms in sectors with low protection. The results for capital are qualitatively similar but quantitatively smaller. Overall the impact of higher international exposure is larger for blue collar workers than white collar workers.

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Keywords: Adjustment costs, Adjustment functions, Openness
Palabras clave: Costos de ajuste, Funciones de ajuste, Apertura

1. Introduction

The traditional microeconomic textbook model assumes that the level of employment and capital used by firms is optimal at any point in time. But since adjusting employment and capital is costly to firms, they often deviate from what would be optimal in the absence of frictions. In this paper we analyze such adjustment process and how it may be affected by changes in trade policy.

There is a relatively large literature on adjustment costs in factor demand[1], however most of it focuses in only one factor of production. Those few studies that jointly consider the adjustment of capital and labor do not differentiate types of workers and in general assume convex adjustment technologies and do not use firm level data. Hall (2004) is a recent example of this trend in the literature. He analyzes a long panel 1948-2001 at the two-digit level of aggregation for the US. Our approach departs from this tradition at least in three aspects. First, it allows for non-convex adjustment, second each factor adjustment may depend on the shortage of the other factors of production and third it uses firm level data.

The objective of this paper is to provide an assessment of the impact that trade liberalization as a source of competition for Uruguayan manufacturing firms had on the factor adjustment of blue and white collar workers, as well as capital. Are sectors exposed to more foreign competition subject to larger adjustment costs? Are adjustment costs more important in the presence of surpluses, when the firm needs to reduce its current level of employment, or in the presence of shortages, when the firms needs to increase its current level of employment? How does the impact of the higher international exposure differ for the adjustment of blue and white collar workers and capital? The answer to these questions will provide some light to whether more attention needs to be paid to facilitating factor adjustment as exposure to foreign competition increases, and whether the focus should be on hiring versus firing costs, capital versus labor, skilled versus unskilled workers, etc.

The literature on trade and adjustment costs generally focuses on what are called social adjustment costs measured by the impact of trade reforms on factor unemployment. Magee (1972) and Baldwin et al. (1980) measure the number of workers falling in unemployment after a trade reform in the US, as well as the duration of their unemployment to provide estimates of the adjustments cost associated with the unemployment spell. Their estimates suggest that social adjustment costs represent only 4 to 12 percent of the welfare gains associated with the reforms. Matusz and Tarr (1999) in a review of the literature confirmed that the measured net labor employment effect of trade reforms is generally small.

It is tempting to extrapolate these conclusions to the case of the Uruguayan manufacturing sector facing rising competition from higher international exposure. But there are two problems with this. First, most of the existing literature reviewed by Matusz and Tarr (1999) focuses on adjustment costs in the labor markets of developed countries. Regulation of factor markets in Uruguay can be significantly more stringent than in the average OECD country. According to World Bank (2006), Uruguay ranks 111th out of 155 countries in terms of easiness for starting a

[1] See Hammermesh and Pfann (1996) for a literature review.

business, and 85th in terms of overall business climate. Second, and more importantly, by focusing on the impact on unemployment (or employment levels) to capture factor adjustment costs, the literature assumes that firms are always at their desired levels of employment. If this is not the case, the small measured impact of trade opening on unemployment does not necessarily imply that adjustment costs are small, but rather that firms may be reluctant to fire or hire when subject to trade shocks, due precisely to the presence of very large factor adjustment costs faced by firms (hiring and firing costs, training, loss of firm specific human or physical capital, etc.). Putting it differently, one should expect trade reforms to have little impact on unemployment levels in the presence of large factor adjustment costs faced by firms (or private adjustment costs in Matusz and Tarr, 1999 terminology). In the extreme case where adjustment costs are infinite, there would be no impact of trade on employment, and the earlier literature would have concluded that there are no (social) adjustment costs. True, but there are very large opportunity costs in terms of production efficiency (and probably employment) due to the fact that firms face infinite factor adjustment costs.

Although we do not specifically test the channel from trade to adjustment costs there is more than one way to think about them. Melitz (2003) presents a dynamic industry equilibrium model with heterogeneous firms. In this model, more productive firms become exporters and in order to profit from their higher productivity increase their labor demand. The increased demand in the labor market produces changes in factor prices that some firm can not afford at their current employment level and have therefore to downsize or exit. Thus, in a model with heterogeneous firms trade liberalization is likely to induce reallocation of factors of production that necessarily imply adjustment costs. Some of these adjustment costs have to do with changes in the usage of inputs of production and others have to do with changes in the identity of the particular employee or machine. As an example of the former we could think of disruptions to the production provoked by rearrangement of workers assignments due to changes in total labor or capital use. As examples of the latter there are search costs, training costs and severance payments.

Another channel is related to the changes in relative prices between tradeables and nontradables. In general, trade liberalization process implies that capital goods become cheaper and more widely available (what Muendler 2002 calls the foreign input push). Even if the total level of employment is not altered, an increase in the level of capital comes in hand with reassignment and restructure of blue and white collar tasks. These adjustment costs are even higher when we consider the time necessary for the delivery, installation of the machinery and training of personnel. The irreversibility of investment stressed for instance in Bertola and Caballero (2004) makes firms reluctant to alter the capital level in the phase of uncertainty about future policies generating then adjustment costs that at least from this perspective may be higher for capital than employment.

Either of the channels mentioned affects both capital and employment in a way that is likely to make the adjustment of one factor to be affected by the adjustment needed in the other. Also both channels suggest that the adjustment cost may vary with the task performed by workers. Moreover, in their literature review Hamermesh and Pfann (1996) mention that there is evidence that the average cost of adjustment is larger for skilled than unskilled workers. Therefore it is important to allow the adjustment process of each factor to be affected by shortages of the others and to differentiate between white and blue-collar workers.

The closest reference to our paper is Eslava *et al* (2005) that provides a novel approach to estimating adjustment functions that overcomes many of the drawbacks of the previous literature. Our work is clearly in the same research line but there are several dimensions in which our paper is different from theirs. First, we extend the analysis to three factors of production, allowing the separate study of blue-collar labor and white-collar labor, rather than simply employment. Second, we have a specific emphasis in trade policy shifts. Besides the interest on the effects of international exposure on adjustment costs per se, trade policy has variation in the time and firm (sector) dimension and is therefore better for identification of the effect that policy measures with variation only through time. Eslava *et al* (2005) look at the overall effect of policy reforms and therefore reflect aggregate policy changes with no industry variation. The lack of industry variation weakens their results that could be attributed to other contemporaneous changes. Third, as a broad measure of welfare costs we estimate the output gap produced by these adjustment costs.

The next two differences relate to the techniques applied to estimate several parameters that are needed to apply this methodology. Forth our estimation of total factor of productivity is better shaped to take care of the simultaneity and selection bias problems common in this type of estimations. Fifth, for the demand shock instead of estimating the inverse demand function by two stage least squares we estimate a system of supply and demand using three stage least squares.

Finally, instead of Colombian we use Uruguayan data. While in the 1990s in Colombia there were important reforms in factor markets, in Uruguay the most important policy and institutional changes relate to the country insertion into world trade. The Uruguayan economy evolved from inward looking, based on state interventionism and import substitution protectionist policies, towards an outward looking orientation, with more reliance on markets as resource allocation mechanisms and exports as the growth engine. A first phase of trade reform took place in the 1970s, accompanied by a quick financial liberalization process. Later, in the 1990s there was a process of trade liberalization (with simultaneous real exchange rate appreciation), combining a gradual unilateral tariff reduction with the creation of Mercosur, an imperfect customs union between Argentina, Brazil, Paraguay and Uruguay. As a result, flows from and to these countries increased their share in Uruguay's trade. Figure 1 shows the relative convergence to lower tariffs of most sectors of activity. A by-product of the trade liberalization process in Uruguay was that manufacturing firms switched to more capital intensive technologies as reported in Casacuberta, Fachola and Gandelman (2004, 2006).

Our main results confirm the lumpy and asymmetric nature of firms' adjustment process. Large shortages of one factor lead to less responsiveness in adjustment in the creation side of other factors but larger adjustment in the destruction side. Everything else equal it is easier to adjust in the presence of shortages (when the desired level is larger than the actual level): hiring adjustment costs are smaller than firing costs. Adjustment costs reduce the volatility of factor usage but on average they implied an annual gap between desired and observed output of 2%.

Less protected sectors adjust a larger fraction of the gap in the creation side (reducing shortages, i.e. hiring employees or investing) but a lower fraction in the destruction side (reducing surpluses, i.e. firing employees, scrapping or letting capital depreciate). The reluctancy of more protected sectors to adjust in the creation side may be due to fears of policy reversal. The results on the adjustment on the creation and destruction side suggests that trade protection may in fact destroy rather than create jobs within industries, as firms in highly protected sectors are more reluctant to hire and more ready to fire than firms in sectors with low protection.

The paper proceeds as follows. Section 2 presents the policy experiments and the basic definitions of factor growth rates, factor shortages and adjustment functions. Shortages are defined with respect to some targeted desired levels. Section 3 details the methodology to obtain these desired levels. Readers not interested in the technicalities of this procedure may skip this section. Section 4 introduces the data and Section 5 presents the results and analyzes the effects of policy changes in the adjustment process of firms and finally section 6 concludes.

2. Estimating labor and capital adjustment functions

In the traditional model without adjustment costs, the employment (capital) choice of the firms depends only on current shocks and future expectations. In the presence of adjustment costs, it also depends on past employment (capital) decisions and in the gap between the actual level of employment (capital) and the "desired" level. We will use the notation B^*, W^* and K^* and B, W and K for the desired and actual levels of blue collar labor, white collar labor and capital respectively. A key step in the present methodology is the construction of this "desired" level.

The growth rates of labor and capital inputs are defined as the ratio between the input changes and the averages between its past and present values. These definitions follow Davis and Haltiwanger (1992), and Davis *et al* (1996).[2] Using the notation Δ for the rates of growth, we have

$$\Delta B_{jt} = \frac{B_{jt} - B_{jt-1}}{\frac{1}{2}\left(B_{jt} + B_{jt-1}\right)}$$
$$\Delta W_{jt} = \frac{W_{jt} - W_{jt-1}}{\frac{1}{2}\left(W_{jt} + W_{jt-1}\right)} \qquad (1)$$
$$\Delta K_{jt} = \frac{K_{jt} - K_{jt-1}}{\frac{1}{2}\left(K_{jt} + K_{jt-1}\right)}$$

Before a firm adjusts its factors of production, the employment (capital) shortage at time t can be defined as the difference between the desired level of employment (capital) at time t and the actual level at time $t-1$. Paralleling the previously defined growth rates, the shortage rate is

[2] A feature of these growth rates is that they are bound between –2 and 2. There is a monotonic relation between the rates of growth so defined and the usual ones.

expressed as a fraction of the average between the present desired level and the past observed level. Therefore, employment (blue and white collar respectively) and capital shortages (ZB_{jt}, ZW_{jt}, ZK_{jt}) are:

$$
\begin{aligned}
ZB_{jt} &= \frac{B^{*}_{jt} - B_{jt-1}}{\frac{1}{2}\left(B^{*}_{jt} + B_{jt-1}\right)} \\
ZW_{jt} &= \frac{W^{*}_{jt} - W_{jt-1}}{\frac{1}{2}\left(W^{*}_{jt} + W_{jt-1}\right)} \qquad (2) \\
ZK_{jt} &= \frac{K^{*}_{jt} - K_{jt-1}}{\frac{1}{2}\left(K^{*}_{jt} + K_{jt-1}\right)}
\end{aligned}
$$

Following Eslava *et al* (2005) adjustment functions (AB_{jt}, AW_{jt}, AK_{jt}, for blue and white collar employment and capital, respectively) are defined as the fraction of each shortage that is actually closed. Hence adjustment functions are defined as follows:

$$
\begin{aligned}
AB_{jt} &= \frac{\Delta B_{jt}}{ZB_{jt}} \\
AW_{jt} &= \frac{\Delta W_{jt}}{ZW_{jt}} \qquad (3) \\
AK_{jt} &= \frac{\Delta K_{jt}}{ZK_{jt}}
\end{aligned}
$$

The next step is to characterize such adjustment functions in terms of the shortages in all three factors. It is relevant to consider the case in which the adjustment function in each of them is not independent of the shortages observed in the other two. We follow a parametric strategy in which we allow capital and labor shortages to depend on their own shortage, on the other factors shortages and on interactive terms. In particular, the adjustment functions are not restricted to be linear and we allow for different intercept and slope for shortages and surpluses (or *negative shortages*). We do so because the sources of adjustment costs are different in the creation and destruction side. For instance, hiring new employees entails search, recruiting and training costs while firing current employees is associated with severance payments and eventual effects on the moral of the remaining employees. The basic specifications omitting the asymmetric interactions for positive shortages are:

$$AB_{jt}(ZB_{jt},ZW_{jt},ZK_{jt})=\lambda_0+\lambda_1 ZW_{jt}^2+\lambda_2 ZW_{jt}ZK_{jt}+\lambda_3 ZW_{jt}ZB_{jt}+\lambda_4 ZB_{jt}^2+\lambda_5 ZB_{jt}ZK_{jt}+\lambda_6 ZK_{jt}^2$$

$$AW_{jt}(ZB_{jt},ZW_{jt},ZK_{jt})=v_0+v_1 ZW_{jt}^2+v_2 ZW_{jt}ZK_{jt}+v_3 ZW_{jt}ZB_{jt}+v_4 ZB_{jt}^2+v_5 ZB_{jt}ZK_{jt}+v_6 ZK_{jt}^2 \tag{4}$$

$$AK_{jt}(ZB_{jt},ZW_{jt},ZK_{jt})=\kappa_0+\kappa_1 ZW_{jt}^2+\kappa_2 ZW_{jt}ZK_{jt}+\kappa_3 ZW_{jt}ZB_{jt}+\kappa_4 ZB_{jt}^2+\kappa_5 ZB_{jt}ZK_{jt}+\kappa_6 ZK_{jt}^2$$

In practice, the estimated models are the following:

$$\Delta B_{jt}=ZB_{jt}\left[\lambda_0+\lambda_1 ZW_{jt}^2+\lambda_2 ZW_{jt}ZK_{jt}+\lambda_3 ZW_{jt}ZB_{jt}+\lambda_4 ZB_{jt}^2+\lambda_5 ZB_{jt}ZK_{jt}+\lambda_6 ZK_{jt}^2\right]$$

$$\Delta W_{jt}=ZW_{jt}\left[v_0+v_1 ZW_{jt}^2+v_2 ZW_{jt}ZK_{jt}+v_3 ZW_{jt}ZB_{jt}+v_4 ZB_{jt}^2+v_5 ZB_{jt}ZK_{jt}+v_6 ZK_{jt}^2\right] \tag{5}$$

$$\Delta K_{jt}=ZK_{jt}\left[\kappa_0+\kappa_1 ZW_{jt}^2+\kappa_2 ZW_{jt}ZK_{jt}+\kappa_3 ZW_{jt}ZB_{jt}+\kappa_4 ZB_{jt}^2+\kappa_5 ZB_{jt}ZK_{jt}+\kappa_6 ZK_{jt}^2\right]$$

The significance of the non linear terms would indicate that a firm with a larger gap between desired and actual factor levels adjusts more, hence this would be evidence of the presence of fixed costs associated with adjustment. These fixed costs cause the adjustment decisions to be lumpy. In other words if there is lumpiness in the adjustment process, then the percentage of adjustment towards the desired levels for each factor is expected to be increasing in the absolute value of the shortage of that factor.

Our policy exercises will be framed in terms of an extended version of equation (5). We focus basically on tariff protection and trade reform. The first step would be then to estimate pre and post Mercosur adjustment functions as in Eslava *et al* (2005) detect shifts in the response of firms arising from changes in the environment. However, since this does not allow isolating the effect of individual policies from other factors also present in the period, we prefer to study the interactions of a set of policy variables (with variability at the time and firm level) with the adjustment functions. In our policy experiments we use the tariff level and the changes in tariffs to capture the effect of protection and trade liberalization.

Finally, we find it useful to calculate the output gap attributable to adjustment costs. As argued in the absence of adjustment costs the desired use of inputs may be higher or lower than the actual levels. Adjustment costs are natural stabilizers of output. Suppose for instance there is a temporary positive shock to demand, firms wanting to profit from this positive shock are likely to increase their factor demand. Adjustment costs reduce the size of this increase. On the contrary, on a recession firms may want to reduce the input use. Due to irreversibility in capital investments this may translate even in larger labor demand reductions. Again, adjustment costs buffer such changes. Without denying the relation between economic performance and the ability of producers to adjust their input mix, it may be that at certain specific time period's adjustment costs may not be welfare reducing. Once we have estimated the desired employment and capital it is straightforward to obtain the firm's production at these factor usage levels and to calculate the output gap with respect to actual production levels.

3. Firm maximizing behavior

A technical description of the methodology for the estimation of the desired input levels follows. We start by stating a general optimization framework and proceed to present the computation of the desired input levels and several necessary parameters. The reader interested mostly in the results of our exercises may skip this section and proceed directly to section 4.

3.1. The general framework

We assume a monopolistic competition framework in which firms have certain degree of market power. The inverse demand function for a firm is given by:

$$P_{jt} = Y_{jt}^{-\frac{1}{\eta}} D_{jt} \qquad (6)$$

where η is the elasticity of demand and D is a time and firm specific demand shock capturing all factors other than firms' own price affecting demand and Y is output demand.

The firm's production function is assumed to be:

$$Y_{jt} = K_{jt}^{\alpha} \left(B_{jt} H_{jt}\right)^{\beta} W_{jt}^{\mu} E_{jt}^{\gamma} M_{jt}^{\phi} V_{jt} \qquad (7)$$

where K is capital, B is blue collar employment, H are blue collar hours, W is white collar employment, E is energy, M are materials and V is total factor productivity shock.

Firms face competitive factor markets with the following total costs for blue collar labor, white collar labor, capital, energy and material:

$$\begin{aligned}
&\omega_B(L_{jt}, H_{jt}) = w_{0t} B_{jt} \left(1 + w_{1t} H_{jt}^{\delta}\right) \\
&\omega_W(W_{jt}) = P_{Wt} W_{jt} \\
&\omega_K(K_{jt}) = P_{Kt} K_{jt} \\
&\omega_E(E_{jt}) = P_{Et} E_{jt} \\
&\omega_M(M_{jt}) = P_{Mt} M_{jt}
\end{aligned} \qquad (8)$$

where P_W is the white collar wage, P_K is the user cost of capital, P_E is the per unit cost of energy and P_M is the per unit cost of materials. In the case of blue collar employees, total compensation is the product of employment B_{jt} times a wage function that depends on total hours H_{jt}. This tries to capture the fact that the marginal wage is not constant. As the firm tries to increase hours per worker, it must resort to overtime hours and a premium must be paid at least for some workers. This function is indexed by parameters w_0 (straight-time blue-collar wage), w_1 (overtime premium) and δ (marginal wage elasticity). [3]

Eliminating the firm subscript, the maximization problem in the presence of adjustment costs for a typical firm is:

$$\underset{\{K,B,H,W,E,M\}}{Max} \sum_t \beta^t E\left[P_t Y_t - \omega_B(L_t,H_t) - \omega_W(W_t) - \omega_K(K_t) - \omega_E(E_t) - \omega_M(M_t) - C(K_t, K_{t-1}, B_t, B_{t-1}, W_t, W_{t-1})\right] \quad (9)$$

where $C(K_t, K_{t-1}, B_t, B_{t-1}, W_t, W_{t-1})$ are the adjustment costs for blue collar, white collar and capital. Note that we specifically allow the adjustment cost not to depend only on the change of each factor, but also on the past levels of the others.[4]

3.2. Frictionless factor levels

To obtain the firm's desired factor input levels, our procedure starts by estimating the firm's frictionless factor demands. Frictionless levels correspond to those levels of inputs that the firm would choose in absence of adjustment costs, and are derived from the firm's optimization problem. In the absence of adjustment costs, the dynamic problem of (9) can be rewritten as a static problem.

$$\underset{K,B,H,W,E,M}{Max} P_t Y_t - \omega_B(L_t,H_t) - \omega_W(W_t) - \omega_K(K_t) - \omega_E(E_t) - \omega_M(M_t) \quad (10)$$

After taking logs, the first order conditions for both types of employment, hours, capital, energy and materials yield the following system of equations (where $\overline{X}$ denotes the frictionless levels, $\tilde{\overline{X}} = ln\,\overline{X}$ for variables and $\tilde{P} = ln\,P$ for input prices, and subscripts are omitted to simplify notation):

[3] As in Caballero and Engel (1993), our functional form for the blue collar compensation implies that in the absence of employment adjustment costs, the firm would always choose the same number of hours per worker, and adjust to productivity and demand shocks only varying employment. Our data does not have information on white-collar hours, thus we have to assume a simpler compensation mechanism. In order to verify that our results are not produced by an asymmetric treatment of white and blue collars we experimented without considering blue-collar hours and effectively the main conclusions remained unaltered.

[4] We do not model explicitly the adjustment costs. The very interesting issue of which of the suggested (or other) mechanisms is behind the link between policy changes and adjustment costs goes beyond the scope of the present paper.

$$\tilde{\tilde{K}}=\frac{\frac{\eta}{\eta-1}\left(-ln\frac{\eta-1}{\eta}-\tilde{D}\right)+\frac{\eta}{\eta-1}\left(\tilde{P}_K-ln\alpha\right)-\beta\left(\tilde{\tilde{B}}+\tilde{\tilde{H}}\right)-\mu\tilde{\tilde{W}}-\gamma\tilde{\tilde{E}}-\varphi\tilde{\tilde{M}}-\tilde{\tilde{V}}}{\alpha-\frac{\eta}{\eta-1}} \qquad (11)$$

$$\tilde{\tilde{B}}=\frac{\frac{\eta}{\eta-1}\left(-ln\frac{\eta-1}{\eta}-\tilde{D}\right)+\frac{\eta}{\eta-1}\left(\tilde{P}_{B_0}-ln\beta\right)+\frac{\eta}{\eta-1}\left(1+\tilde{P}_{B_1}\overline{H}^{\delta}\right)-\alpha\tilde{\tilde{K}}-\beta\tilde{\tilde{H}}-\mu\tilde{\tilde{W}}-\gamma\tilde{\tilde{E}}-\varphi\tilde{\tilde{M}}-\tilde{\tilde{V}}}{\beta-\frac{\eta}{\eta-1}} \qquad (12)$$

$$\tilde{\tilde{H}}=\frac{\frac{\eta}{\eta-1}\left(-ln\frac{\eta-1}{\eta}-\tilde{D}\right)+\frac{\eta}{\eta-1}\left(\tilde{P}_{B_0}-ln\beta\right)+\frac{\eta}{\eta-1}\left(\tilde{P}_{B_1}+\tilde{\tilde{B}}\right)+\frac{\eta}{\eta-1}ln\delta-\alpha\tilde{\tilde{K}}-\beta\tilde{\tilde{L}}-\mu\tilde{\tilde{W}}-\gamma\tilde{\tilde{E}}-\varphi\tilde{\tilde{M}}-\tilde{\tilde{V}}}{\beta-\delta\frac{\eta}{\eta-1}} \qquad (13)$$

$$\tilde{\tilde{W}}=\frac{\frac{\eta}{\eta-1}\left(-ln\frac{\eta-1}{\eta}-\tilde{D}\right)+\frac{\eta}{\eta-1}\left(\tilde{P}_W-ln\mu\right)-\alpha\tilde{\tilde{K}}-\beta\left(\tilde{\tilde{B}}+\tilde{\tilde{H}}\right)-\gamma\tilde{\tilde{E}}-\varphi\tilde{\tilde{M}}-\tilde{\tilde{V}}}{\mu-\frac{\eta}{\eta-1}} \qquad (14)$$

$$\tilde{\tilde{E}}=\frac{\frac{\eta}{\eta-1}\left(-ln\frac{\eta-1}{\eta}-\tilde{D}\right)+\frac{\eta}{\eta-1}\left(\tilde{P}_E-ln\gamma\right)-\alpha\tilde{\tilde{K}}-\beta\left(\tilde{\tilde{B}}+\tilde{\tilde{H}}\right)-\mu\tilde{\tilde{W}}-\varphi\tilde{\tilde{M}}-\tilde{\tilde{V}}}{\gamma-\frac{\eta}{\eta-1}} \qquad (15)$$

$$\tilde{\tilde{M}}=\frac{\frac{\eta}{\eta-1}\left(-ln\frac{\eta-1}{\eta}-\tilde{D}\right)+\frac{\eta}{\eta-1}\left(\tilde{P}_M-ln\varphi\right)-\alpha\tilde{\tilde{K}}-\beta\left(\tilde{\tilde{B}}+\tilde{\tilde{H}}\right)-\mu\tilde{\tilde{W}}-\gamma\tilde{\tilde{E}}-\tilde{\tilde{V}}}{\varphi-\frac{\eta}{\eta-1}} \qquad (16)$$

We assume that in absence of adjustment costs for hours, energy and materials, the frictionless levels of those inputs coincide with the observed levels. Therefore, the first order conditions can be reduced to a system of three equations and three unknowns. After solving it, we can write the log of the frictionless levels of capital, blue-collar employment and white collar employment as functions of the parameters of the model to be estimated and observed variables as follows:

$$\tilde{\tilde{K}}=\frac{\frac{\eta}{\eta-1}\left(-ln\frac{\eta-1}{\eta}-\tilde{D}\right)-\beta\tilde{\tilde{H}}-\gamma\tilde{\tilde{E}}-\varphi\tilde{\tilde{M}}-\tilde{\tilde{V}}+\left(\frac{\eta}{\eta-1}-\beta-\mu\right)\left(\tilde{P}_K-ln\alpha\right)+\beta\left[\tilde{P}_{B_0}-ln\beta+\left(1+P_{B_1}\overline{H}^{\delta}\right)\right]+\mu\left(\tilde{P}_W-ln\mu\right)}{\alpha+\beta+\mu-\frac{\eta}{\eta-1}} \tag{17}$$

$$\tilde{\tilde{L}}=\frac{\frac{\eta}{\eta-1}\left(-ln\frac{\eta-1}{\eta}-\tilde{D}\right)-\beta\tilde{\tilde{H}}-\gamma\tilde{\tilde{E}}-\varphi\tilde{\tilde{M}}-\tilde{\tilde{V}}+\left(\frac{\eta}{\eta-1}-\alpha-\mu\right)\left[\tilde{P}_{B_0}-ln\beta+\left(1+P_{B_1}\overline{H}^{\delta}\right)\right]+\alpha\left(\tilde{P}_K-ln\alpha\right)+\mu\left(\tilde{P}_w-ln\mu\right)}{\alpha+\beta+\mu-\frac{\eta}{\eta-1}} \tag{18}$$

$$\tilde{\tilde{W}}=\frac{\frac{\eta}{\eta-1}\left(-ln\frac{\eta-1}{\eta}-\tilde{D}\right)-\beta\tilde{\tilde{H}}-\gamma\tilde{\tilde{E}}-\varphi\tilde{\tilde{M}}-\tilde{\tilde{V}}+\left(\frac{\eta}{\eta-1}-\alpha-\beta\right)\left(\tilde{P}_W-ln\mu\right)+\beta\left[\tilde{P}_{B_0}-ln\beta+\left(1+P_{B_1}\overline{H}^{\delta}\right)\right]+\alpha\left(\tilde{P}_K-ln\alpha\right)}{\alpha+\beta+\mu-\frac{\eta}{\eta-1}} \tag{19}$$

3.3. Desired factor levels and output gap

Frictionless levels are not the same as the desired ones. Both concepts differ in that the desired levels are the ones observed if adjustment costs are momentarily removed, while frictionless levels are the ones observed in absence of adjustment costs in all periods. Bertola and Caballero (1994) state reasonable conditions under which the desired levels can be approximated, up to a constant, by frictionless levels.

$$\begin{aligned} K^*_{jt} &= \overline{K}_{jt}\theta_{Kj} \\ B^*_{jt} &= \overline{B}_{jt}\theta_{Bj} \\ W^*_{jt} &= \overline{W}_{jt}\theta_{Wj} \end{aligned} \tag{20}$$

where $\left(K^*_{jt},\overline{K}_{jt}\right)$, $\left(B^*_{jt},\overline{B}_{jt}\right)$ and $\left(W^*_{jt},\overline{W}_{jt}\right)$ are respectively the desired and frictionless levels of capital, blue-collar and white collar employment. The firm specific constants to be estimated are θ_{Kj},θ_{Bj} and θ_{Wj}.

Following Caballero, Engel and Haltiwanger (1995, 1997) θ_{Kj},θ_{Bj} and θ_{Wj} can be determined as the ratio between the actual and frictionless capital, blue collar and white collar employment, for the year where investment and employment growth for each type take their median values respectively. It is then implicitly assumed that, in the year of the median employment growth and median investment, the desired and the actual adjustment of employment and capital respectively coincide.

3.4. Output gap

To define the output gap we make the extra assumption that total factor productivity is an exogenous shock whose stochastic process is not dependent on the levels of the inputs. Given the production function and the previous assumption that the desired and actual hours, materials and energy consumption coincide, the desired output is:

$$Y_{jt}^{*} = K_{jt}^{*\,\alpha} \left(B_{jt}^{*} H_{jt} \right)^{\beta} W_{jt}^{*\,\mu} E_{jt}^{\,\gamma} M_{jt}^{\,\phi} V_{jt} \qquad (21)$$

Adding firms' output and desired output it is straightforward to estimate the output gap.

3.5. Estimation of various variables and parameters

3.5.1. Productivity shock estimation

We use Levinsohn and Petrin's (2003) methodology to obtain a measure of total factor productivity by estimating a production function where an electricity consumption variable is used to control for unobservables. Such method specifically controls for two problems in this type of estimations: the selection problem (i.e. in a panel a researcher would only observe the surviving firms, hence those likely to be the most productive), and the simultaneity problem (the input choices of firms conditional on the fact that they continue to be in activity depend on their productivity).

Given the production function specification in equation (6) we compute total factor productivity as:

$$\widetilde{V}_{jt} = \widetilde{Y}_{jt} - \hat{\alpha}\widetilde{K}_{jt} - \hat{\beta}\left(\widetilde{B}_{jt} + \widetilde{H}_{jt} \right) - \hat{\mu} W_{jt} - \hat{\gamma} E_{jt} - \hat{\phi} M_{jt} \qquad (20)$$

where $\hat{\alpha}, \hat{\beta}, \hat{\mu}, \hat{\gamma}$ and $\hat{\phi}$ are the estimated factor elasticities for capital, blue collar employment hours, white collar employment, electricity and materials respectively, and all variables are expressed in logs. The estimated coefficients of the production function are shown in Table 1. The null hypothesis of constant returns of scales is not rejected, though is not imposed. The standard errors are estimated across 100 bootstrapped samples.

3.5.2. Demand shock estimation

We also estimate establishment level demand shocks based on the inverse demand equation (7). The inverse demand function is estimated in logs, and the demand shock recovered as the residual.

$$\widetilde{D}_{jt} = \ln \hat{D}_{jt} = \ln P_{jt} + \hat{\varepsilon} \ln Y_{jt} \tag{21}$$

where $\varepsilon = -\frac{1}{\eta}$. In order to identify the elasticity of the demand equation we estimate a two equation system of demand and supply, using three stage least squares. Supply shifters include total factor productivity and a sector wage index, while time and industry effects are also included. Demand elasticity turn out to be -1.16 below Eslava *et al* (2005) (two stage least squares) estimate of -2.28 for Colombia. Given the smaller size of the Uruguayan market it is not surprising that firms face more inelastic demands and benefit for larger market power. Results are presented in Table 2.

3.5.3. Input prices and compensation function estimation

Our database has input prices for goods, white collars, materials and energy. They all vary across years and four digit sectors. For the user cost of capital we use a constant value of 10%. The only parameters remaining to be estimated are those of the compensation function for blue collar workers.

The postulated compensation function for blue collars is stated in (8). Bils (1987) and Cooper and Willis (2004) estimate for the U.S. the wage marginal elasticity δ to be *2*. Eslava *et al* (2005) working with Colombian firms calibrate δ to 2 and w_1 to the legally overtime premium and estimate from their data the straight-time wage w_0. We also calibrate δ to 2 and perform a non linear least squares procedure to estimate the parameters w_0, and w_1. Table 3 shows the results of this estimation.

4. Data

In this paper we exploit Uruguayan establishment level data covering a considerably long period of time. We use annual establishment level observations from the Manufacturing Survey conducted by the Instituto Nacional de Estadística (INE) for the period 1982-1995. The survey-sampling frame encompasses all Uruguayan manufacturing establishments with five or more employees.

The INE divided each four digit International Standard Industrial Classification (ISIC) sector in two groups. All establishments with more than 100 employees were included in the survey; the random sampling process of firms with less than 100 employees satisfies the criterion that the total employment of all the selected establishments must account at least for 60% of the total employment of the sector according to the economic Census (1978 or 1988). In total, we have 627 different establishments present in at least one period.[5]

[5] A more detailed analysis of the data is available in Casacuberta, Fachola and Gandelman (2006)

In respect of employment categories The INE distinguish between *obreros* and *empleados* (in Spanish). This corresponds to our definitions of blue and white collar workers respectively. The first category includes personnel in operative activities involving mainly manual and physical tasks. The second includes workers performing mainly intellectual tasks, including administrative, clerical, sales-persons, managers, supervisors, directors, laboratory and research and development personnel.

Starting from the 1988 capital stock data from the economic census, the capital series is constructed using the perpetual inventory method back and forward (see the appendix for details). Finally, we use data on import tariffs for the period 1985-1995 from Casacuberta, Fachola and Gandelman (2004).

5. Adjustment functions and the effects of policy changes in the adjustment process

5.1. General results

In this section we present our baseline adjustment function estimations. In Figure 2 we display the histograms of the estimated shortages for blue and white collar workers and capital. Their distributions are roughly symmetric. Table 4 presents summary statistics on the desired, frictionless and actual input levels. All correlations are high suggesting the model predicts reasonably well. For the whole manufacturing sector the level of desired white collar jobs is 15% above the actual one and the desired blue collar jobs and capital are 10% above the actual ones.

Figure 3 shows the mean and median output gap defined as the ratio between firm's desired output and actual output. The mean output gap for the whole period is 2%. The gap follows the Uruguayan business cycle in a procyclical manner. In 1982, Uruguay suffered a deep exchange rate and financial crisis that led to three years of recession. In such years the desired output was below the observed one. In 1985, the economy started to recover but the desired output was still lower than the actual one. The next five years are expansion years and firms tend to desire more employment and capital than what they actually were hiring implying positive output gaps. Due to inflationary problems the government in 1990 undertook contractionary fiscal policies that led to a halt in GDP growth that was resumed two years later. This implied the negative gaps in the early nineties and the positive ones of the last years of our sample.

Turning now to the adjustment functions themselves, we estimate the parameters in equations (5) by panel fixed effects regressions. For each factor separately we generate a dummy variable that takes the value of 1 when the shortage is positive and 0 otherwise. Interacting this dummy with the factor shortage and with the cube of the shortage we allow for asymmetric effects of shortages and surpluses, i.e. we allow for different levels as well as slopes of the adjustment for shortages and surpluses.

The adjustment functions for white and blue collar employment and capital are displayed in Figure 4. Since our specification implies that every shortage in every factor and the interactions between them can potentially have an effect on the adjustment of each factor, we present our baseline estimation setting the shortages of other factors at zero. The percentage of the adjustment is plotted as a function of the shortage. Negative shortages would indicate that the past level of the input is above the desired one (factor surplus), hence to close this gap the firm needs to decrease this factor, and it finds itself in the job or capital destruction side. Conversely, positive shortages show a past level of the input below the desired one, hence if the firm wants to close the gap, it will be in the factor creation side, i.e. it will invest or hire.

Table 5 reports the estimated coefficients of the baseline adjustment functions. The significance of the Pos interactions variable shows that the adjustment function in all cases is asymmetric with respect to shortages and surpluses in the intercept and the slope, with the exception of capital, where the asymmetry is in the slope only.

Figure 4 also shows that there is an asymmetric behavior in the adjustment process. First, for small values of the observed shortage, white and blue collar employment adjustment functions show an upward shift in the positive side. This means that firms tend to adjust a larger fraction of the gap between the desired and the actual employment when the observed levels are below the desired ones, i.e. firm finds it easier to create labor than to destroy it except when the destructive adjustment is large. Note that for shortages in absolute value below 1, firms close a larger fraction of the gap of blue collar workers than the gap in other factors. A shortage of 1 or -1 corresponds to firms desiring to triplicate or reduce to one third the actual use of the input. Therefore, for most firms, blue collar adjustment costs are lower than adjustment in other factors.

Since in most cases the cross product terms that include the adjusting factor are significant, we can infer that, as conjectured, shortages of other factors are relevant to understand the adjustment process. The negative sign of these cross shortages terms imply that large shortages of one factor lead to less responsiveness in adjustment in the creation side of other factors but larger adjustment in the destruction side. In simpler words suppose a firm whose desired level of two factors is above the current level, the larger the shortage in one factor the lower the adjustment in the other. Suppose now a firm desiring to have a lower level of two factors than their actual value, the larger the surplus in one factor the larger the adjustment in the other. This points against (in favor or) economies of scope in the adjustment cost function in the creation (destruction) direction. That is to say, when firms want to hire more it is cheaper to adjust one factor at a time but when a firms wants to reduce employment or scrap capital it is cheaper to reduce the use of both factors together. To observe the effect of the rest of the factors in each adjustment function, figure 5 shows separately the adjustment function of each factor, where the shortages in the other factors are set at their mean values, and their mean values plus and minus one standard deviation respectively.

The lumpiness of the adjustment process is shown by the fact that the size of the adjustment is increasing in the absolute value of the shortage observed in almost all cases, both in the creation and the destruction side. Our results also confirm nonlinearity of the adjustment process; nonlinear terms are in all tables statistically significant.

Another asymmetry is given by the fact that estimated adjustment functions display a smaller slope in the creation side than in the destruction side. The differences in the slopes can be understood together with the differences in the intercepts. The higher intercept in the creation side indicates higher adjustment for firms with smaller factor shortages, while a relatively flat slope of the adjustment schedule shows that they are able only to undertake smaller adjustments when there is a high positive shortage. On the contrary, the lower adjustments for small surpluses are associated with firms closing higher percentages of the gaps when surpluses become large enough in absolute values. A natural interpretation of this result is that there are larger adjustment costs associated to factor destruction (severance payments, loss of specific human capital, etc.) than to factor creation (search, training, etc.).

Comparing the different factor adjustment functions, both in the creation and the destruction side, the slopes for white collar are larger than for blue collar labor. Such features can be seen as related to the differences in adjustment costs for each factor. Labor unions tend to be stronger in industries more intensive in blue collar labor inducing higher adjustment costs on the destruction side when employment surpluses are large; i.e. there will produce to lower adjustment when shortages are large in the destruction side. The white collar adjustment function has higher slope than blue collar adjustment on both sides. When the shortage is small in absolute value, adjustment is lower in white collar than in blue collar. Conversely, if the shortage is large in absolute value, a larger proportion of the gap is closed for white collars than for blue collars.

Probably this relates to the fact that white collar labor includes workers with specific human capital, which is difficult to create. Therefore firms probably may be willing to accept small shortages without adjusting, but the adjustment will be fuller when the shortage becomes large in absolute value. For instance, consider a firm that has more clerks that needed, but these clerks are familiar with the workings of the firm: if this shortage is not too large, the firm may prefer to keep these extra workers. On the other hand, if blue collars have less specific training, they may be more easily disposed. On the creation side, hiring an extra clerk implies higher training costs; hence the firm may prefer to use the existent workers more intensively if the shortage is small. If the shortage becomes large enough, the cost of the extra hours will be higher than the training cost of the newly hired white collar workers. This search and training costs have a fixed cost that can be covered only when the percentage of the gap closed is large enough.

Finally, the effects of the shortage of the other factors in the adjustment function are captured both by the direct effect and the cross product effects terms, but their impact comes mostly from the latter. A negative sign of the coefficients of the cross product of the shortages (see Table 5) causes that the higher the shortages of the other factors, the higher the adjustment in the destruction side, and the lower the adjustment in the creation side (see figure 5). Many firms downsized and even exited over the period of trade liberalization. This implied the simultaneous destruction of labor (both white and blue collar) and capital. This explains why higher shortages in absolute value for capital (white collar employment) provoke higher adjustment on white collar (capital). According to the evidence presented in Casacuberta, Fachola and Gandelman (2004), firms in order to remain competitive switched towards more capital intensive production methods. Therefore, the lower the shortage in capital (employment), the higher the adjustment in employment (capital).

5.2. The impact of international exposure

To study the impact of trade liberalization and international exposure on the adjustment process we estimate several adjustment functions. We are looking at the way sectoral shocks (protection level, trade liberalization) affect the way firms respond to idiosyncratic shortages. Industries that were more open from the beginning should experience lower shifts in their adjustment functions due to the generalized higher international exposure.

A problem with using tariffs or change in tariffs in the right hand side of equations is that they may possibly be endogenous. In our case this problem is less severe due to the fact that Uruguay is a relatively minor player integrated with its larger neighbor economies in Mercosur. Hence the common external tariff and the changes in Uruguayan tariffs to converge to the trade block protection level are basically affected by Argentinean and Brazilian political players and beyond control for local firms.[6]

Descriptive statistics of our policy and firm variables are presented in Table 6 and Figure 1. We find that the average tariff was reduced significantly from an average of 43% to 14% between 1985 and 1995. On average, annual tariff changes accelerated from –2.1% before 1990 to –3.0% after 1990.

5.2.1. Changes in import taxes

To analyze the effects of trade liberalization in the adjustment functions, we interact the intercept and each factor's own shortage terms (allowing for asymmetric effects in the creation and destruction sides) in the adjustment equations with the industry level change in tariffs. Table 7 displays the estimated coefficients. In all regressions at least one policy interaction is significant. In order to assess how important are the differences in adjustment with varying levels of trade liberalization we simulate the predicted adjustment using the coefficients reported in Table 7 for different levels of changes in tariffs (0, 2 and 4 percentage points reductions) in Figure 6.

Looking at the plotted adjustment functions, while for capital the impact of tariff reductions is really minor, a pattern emerges for both types of labor, in which the fraction of the gap actually adjusted decreases in the creation side, while increases in the destruction side. For white collars this is produced by a statistically significant change in the intercept while for blue collars it is produced by a change on the slope, also statistically significant. Firms in sectors that experienced higher tariff reductions where able to adjust a larger proportion of their surpluses than those not so exposed. It is interesting that this result is produced mostly for low levels of shortages while for blue collar is for higher shortage levels. Although, there is a small change in the plotted slope for white collars, this change is not statistically significant, therefore the lumpiness of the adjustment is not affected and changes should be considered more as parallel shifts. On the creation side it was the opposite: firms with lower tariff reductions adjusted a larger proportion of their shortages.

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[6] This is discussed in more detail in Casacuberta, Fachola and Gandelman (2004)

5.2.2. Tariff trade barrier levels

This exercise is similar to the previous experiment, but instead of using the import tax change in the firm's sector as a shifter of the adjustment functions, we use the import tax level. Table 8 shows the regression coefficients. Most policy interaction terms are statistically significant for blue collar and capital. For white collar only the constant shifter for the creation side changes significantly. Figure 7 displays the estimated functions for tariff levels of 10, 20 and 30 percent points and confirms the impression that the effects of protection level is stronger for blue collar and capita than for white collar.

Lower tariff levels are associated to higher adjustment on the creation side, especially for blue collar jobs but also for white collar jobs and capital. The destruction side seems not to change with tariff levels in the case of white collar adjustment functions. For capital and blue collar labor, higher tariff levels are associated with lower adjustments in the destruction side, the opposite than the creation side. Thus, higher protection seems associated with lower adjustment costs for firms wishing to fire blue collars.

This is an indirect way of showing that protection may in fact destroy jobs, rather than create. If shocks to firm are iid, our result implies that protection will lead to lower levels of employment. The reason may have to do with firms' expectations. For instance suppose there is a generalized positive demand shock. A firm in a highly protected sector will not adjust completely in the presence of adjustment costs (e.g., firing workers) unless the government has credibly committed to maintain protection. If there is any risk that the tariff will go down, then the firm may be more reluctant to hire many workers than a similar firm in other sector that is not exposed to the risk of the government reducing tariffs. The same applies on the job destruction side. A highly protected firm that suffers a negative shock will be more likely to fire workers if the government's tariff is not a credible permanent policy.

Finally, note the higher the protection level the more convex the adjustment functions look like. Then, it may be that convex adjustment costs are not as bad an approximation in more closed economies like the US, but definitely obscure the adjustment process in smaller and more open economies.

6. Conclusions

This paper intends to use micro data to improve our understanding of the effects of policy measures on the adjustment of factors of production. On the one hand, the paper finds evidence supporting a number of regularities that the previous literature on adjustment functions has highlighted.

Our investigation confirms that aggregate investment and job creation might be seen as the result of lumpy and discontinuous microeconomic decisions. Individual adjustment constraints depart significantly from the constraints implicit in the quadratic adjustment cost model. There are several sources of irreversibilities (technological, market-induced, increasing returns in the adjustment technology). The evidence provided seems to confirm a pattern that has important nonlinear features, hence consistent with such constraints. This impacts the use of all factors of production, particularly employment.

Adjustment costs faced by capital, skilled and unskilled labor are non trivial in the Uruguayan manufacturing sector, which has consequences in terms of factor unemployment and economic efficiency. For skilled an unskilled labor, they tend to be larger in the presence of small surpluses (when the firms need to fire workers) than in the presence of small shortages (when the firm needs to hire workers). However, for large surpluses and shortages (e.g., exit and entry of firms), adjustment costs are larger on the entry side. These results suggests that in order to introduce more efficiency and generate more employment in the Uruguayan manufacturing sector, policies should focus at reducing adjustment costs for those firms that would like to fire workers (severance payments, mobility of pension schemes, etc.) and those that would like to enter the market (reduction of the number of bureaucratic procedures required, the number of days it takes, and the cost of the business registration license). Overall, most firms find that the factor of production with the lowest adjustment costs is blue collar employment.

The existence of adjustment costs implies that the desired levels of white and blue collar employment and capital often deviate from the observed ones. In our data these deviations imply that the yearly gaps might be above 10%. To have an idea of the welfare costs of the adjustment costs, it is useful to consider that for the fourteen years covered in this study the average output gap is 2%.

On the other hand, the paper intended to assess the effects of protection and trade liberalization on firms' adjustment process. The constraints arising from the adjustment cost functions may become an important part of the policy analysis. Our results point to a significant shift in the adjustment functions for all the production factors before and after the increased liberalization that followed the Mercosur treaty. Specifically, trade policy variables measured by tariffs levels and reductions in tariffs significantly shifted adjustment functions. Firms in less protected sectors have shown higher adjustment fractions in the creation side and lower in the destruction side, particularly for blue collar labor. Sectors facing larger tariff changes, adjust less in the creation side, particularly for blue collars, and more on the destruction side. In the context of tariff reductions of Mercosur, those sectors more highly protected were probably those that faced the largest tariff reductions. Overall the impact of higher international exposure on factors of production is stronger for blue collar workers than for white collar workers.

7. References

Baldwin R., J. Mutti and J. Richardson (1980), Welfare effects on the United States of a significant multilateral tariff reduction, *Journal of International Economics* 10, 405-423.

Bertola, G., and R. Caballero (1994), Irreversibility and aggregate investment*, Review of Economic Studies*, Vol 61(2): 223-46.

Bils, M., (1987) The cyclical behavior of marginal cost and price*, American Economic Review*, Vol 77 No. 5.

Black S. and L. Lynch (1997) *How to compete: the impact of workplace practices and information technology on productivity*, NBER WP 6120.

Caballero, R., and E. Engel (1993) Microeconomic adjustment hazard and aggregate dynamics, *Quarterly Journal of Economics* 108 (2): 359-383.

Caballero, R., E. Engel and J. Haltiwanger (1995) Plant-Level Adjustment and Aggregate Investment Dynamics, *Brookings Papers on Economic Activity* 2: 1-54.

Caballero, R., E. Engel and J. Haltiwanger (1997) Aggregate employment dynamics: building from microeconomic evidence*, American Economic Review* 87 (1): 115-137.

Casacuberta, C., G. Fachola, and N. Gandelman, (2004) The Impact of Trade Liberalization on Employment, Capital and Productivity Dynamics: Evidence from the Uruguayan Manufacturing Sector, *Journal of Policy Reform*, 7 (4).

Casacuberta, C., G. Fachola, and N. Gandelman, (2006) Employment, Capital and Productivity Dynamics: Evidence from the Manufacturing Sector in Uruguay, forthcoming *World Development.*

Cooper, R., and J. Willis, (2004) The economics of Labor adjustment: mind the gap, *American Economic Review*, 94(4).

Eslava, M., J. Haltiwanger, and M. Kugler, (2005) *Factor adjustments after deregulation: panel evidence from colombian plants,* NBER Working Paper No. 11656.

Davis, S., and J. Haltiwanger, (1992) Gross job creation gross job destruction and employment reallocation, *Quarterly Journal of Economics*, 107(3).

Davis, S., J. Haltiwanger, and S. Schuh, (1996) *Job creation and destruction*, MA: MIT Press

Hall, R., (2004) Measuring Factor Adjustment Costs, *Quarterly Journal of Economics*, 119(3).

Hammermesh, D. and G. Pfann, (1996) Adjustment Costs in Factor Demand*, Journal of Economic Literature*, 34(3).

Levinsohn, J., and A. Petrin, (2003) Estimating production functions using inputs to control for unobservables, *Review of Economic Studies*, Vol 70 (2).

Magee, S., (1972), The Welfare Effects of Restrictions on US Trade; *Brookings Papers on Economic Activity* 3, 645-701.

Matusz, S. and D. Tarr, (1999), Adjusting to trade policy reform*, Policy Research Working Paper #2142*, The World Bank.

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

Muendler, M. (2002), *Trade, technology and productivity; a study of Brazilian manufacturers 1986-1998*, Department of Economics, UC San Diego, University of California at San Diego, Economics Working Paper Series.

World Bank (2006), Doing Business, *The World Bank, Washington DC.*

8. Appendix

To construct the establishment capital stock series, we follow a methodology close to Black and Lynch (1997). The 1988 Census reports information on the capital stock. We use machinery capital. We avoid overestimation of the amount of depreciation by calculating an average depreciation rate by industrial sector and year. The resulting depreciation rate is then used for all firms within each sector yearly. We further exclude the value of assets sold in our measure of capital, assuming assets have been totally depreciated at that point. Thus, the equation for estimating the capital stock for years later than 1988 is:

$$K_{jit} = K_{jit-1} + I_{jit} - \delta_{it} K_{jit-1} \tag{22}$$

with

$$\delta_{it}^{x} = \frac{\sum_{j} D_{jit}}{\sum_{j} K_{jit}} \tag{23}$$

where j indexes firms; i the industrial sector, t the year. K is the capital stock; I is amount invested; δ is the depreciation rate; and D is depreciation in pesos.

For years before 1988, the equation is reversed and each year's capital is obtained by subtracting each year's investment and applying a depreciation factor. The depreciation rate before 1988 was not available and was estimated using 1988 data. We ran a simple OLS model for the log of total depreciation conditional on the log of gross output, capital stock, total hours and electricity usage. Using this model we predicted the before 1988 depreciation levels.

$$K_{jit-1} = \left(K_{jit} - I_{jit}\right) \cdot \left(\frac{1}{1 - \hat{\delta}_{jit}} \right) \tag{24}$$

9. Tables

Table 1
Levinsohn-Petrin productivity estimation

	Coefficients	Std. Err.
White collar	0,148***	0,026
Blue collar hours	0,234***	0,036
Materials	0,314***	0,053
Machinery capital	0,120*	0,063
Electricity	0,200***	0,088
Number of observations	5903	
Number of establishments	685	
Wald test of constant returns to scale:	Chi2 =1,51 (p = 0,22)	

Note: Dependent variable is gross output. All variables are in logs
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 2
Demand shock estimation
Three-stage least squares regression

	Obs	Parameters
Demand equation	5903	9
Supply equation	5903	16
	Coef,	**Std. Err.**
Demand equation		
Price	-1,156*	0,619
Supply equation		
Price	0,863*	0,520
Total factor productivity	0,006*	0,003
Wage Index	-0,376**	0,166

Note: Dependent variable is gross output.
Endogenous variables: gross output and price.
Exogenous variables not reported: year dummies (supply) and 3 digit ISIC industry dummies (demand)
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3 Compensation function estimation		
Non linear least squares		
	Coefficient	Std. Err.
w_0	0,816***	0,016
w_1	1,24E-07***	6,36E-09
Delta	2	
Number of obs	6198	
R-squared	0.832	
Adj R-squared	0.844	

Note: * Parameter delta taken calibrated to 2.
significant at 10%; ** significant at 5%; *** significant at 1%

Table 4
Summary statistics: actual, desired and frictionless factor levels

Mean values

Variable	Observations	Mean	Std. Dev.
DW	5512	37	75
W	5512	32	63
DB	5512	115	208
B	5512	105	168
DK	5512	275333	788947
K	5512	249379	657317

Pariwise Correlations:

	FW	DW	W
FW	1.00		
DW	0.75	1.00	
W	0.72	0.85	1.00
	FB	**DB**	**B**
FB	1.00		
DB	0.66	1.00	
B	0.65	0.88	1.00
	FK	**DK**	**K**
FK	1.00		
DK	0.66	1.00	
K	0.63	0.82	1.00

Note: K = actual capital, FK = frictionless capital, DK= desired capital
Idem with B, FB, DB and W,FW,DK for blue and white collar

Table 5
Estimated parametric adjustment functions
Baseline specification

	White collar adjustment	Blue collar adjustment	Capital adjustment
Constant	0.074	0.166	0.060
	[0.022]***	[0.023]***	[0.021]***
Constant*Pos	0.137	0.1406	0.026
	[0.039]***	[0.037]***	[0.036]
(ShortageW)^2	0.189	0.029	0.006
	[0.011]***	[0.012]**	[0.013]
(ShortageW)^2*Pos	-0.103		
	[0.017]***		
(ShortageB)^2	-0.009	0.099	-0.025
	[0.015]	[0.012]***	[0.013]*
(ShortageB)^2*Pos		-0.071	
		[0.019]***	
(ShortageK)^2	-0.012	0.021	0.179
	[0.011]	[0.010]**	[0.007]***
(ShortageK)^2*Pos			-0.137
			[0.013]***
(ShortageW)*(ShortageB)	-0.042	0.0011	0.011
	[0.014]***	[0.013]	[0.016]
(ShortageW)*(ShortageK)	-0.025	0.001	-0.001
	[0.012]**	[0.014]	[0.012]
(ShortageB)*(ShortageK)	0.026	-0.058	-0.059
	[0.016]	[0.0121]***	[0.011]***
Observations	4945	4945	4945
Number of id	627	627	627
R-squared	0.3	0.29	0.37

Note: Constant*Pos: Dummy=1 if Shortage is positive
ShortageW. ShortageB. ShortageK are the shortages for white collar. blue collar and capital. Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6
Policy variables
Descriptive statistics

	tariff (%)	Tariff change
1982	.	.
1983	.	.
1984	.	.
1985	42.53	.
1986	38.96	-3.47
1987	35.49	-3.46
1988	32.64	-3.46
1989	32.07	-0.57
1990	31.50	-0.57
1991	24.59	-6.97
1992	20.68	-3.91
1993	17.09	-3.54
1994	17.11	0.02
1995	14.01	-3.14
All period		
Mean	26.3	-2.8
standard dev	9.9	2.7
Percentile 50	24.9	-2.9
Percentile 90	40.0	0.1
Before 1990		
Mean	34.7	-2.1
standard dev	8.2	1.8
Percentile 50	34.6	-2.2
Percentile 90	44.5	0.3
1990 and after		
Mean	21.3	-3.0
standard dev	6.9	2.9
Percentile 50	19.8	-3.1
Percentile 90	31.4	0.0

Table 7
Estimated parametric adjustment functions
Tariff changes effect estimation

	White collar adjustment	Blue collar adjustment	Capital adjustment
Constant	0.026	0.167	0.062
	[0.030]	[0.030]***	[0.031]**
Constant*Pos	0.196	0.116	0.038
	[0.050]***	[0.047]**	[0.048]
(ShortageW)^2	0.201	0.032	0.006
	[0.015]***	[0.013]**	[0.014]
(ShortageW)^2*Pos	-0.076		
	[0.023]***		
(ShortageB)^2	-0.006	0.044	-0.022
	[0.015]	[0.018]**	[0.016]
(ShortageB)^2*Pos		0.026	
		[0.026]	
(ShortageK)^2	-0.009	0.033	0.179
	[0.013]	[0.012]***	[0.013]***
(ShortageK)^2*Pos			-0.119
			[0.020]***
(ShortageW)*(ShortageB)	-0.047	-0.002	-0.013
	[0.015]***	[0.013]	[0.018]
(ShortageW)*(ShortageK)	-0.025	-0.013	0.016
	[0.014]*	[0.015]	[0.014]
(ShortageB)*(ShortageK)	0.036	-0.040	-0.063
	[0.018]**	[0.014]***	[0.013]***
Constant*Open	-0.019	-0.002	-0.017
	[0.007]***	[0.006]	[0.007]**
Constant*Pos*Open	0.012	-0.007	0.020
	[0.009]	[0.009]	[0.009]**
(ShortageW)^2*Open	0.005		
	[0.004]		
(ShortageW)^2*Pos*Open	0.006		
	[0.005]		
(ShortageB)^2*Open		-0.015	
		[0.003]***	
(ShortageB)^2*Pos*Open		0.027	
		[0.006]***	
(ShortageK)^2*Open			0.008
			[0.004]**
(ShortageK)^2*Pos*Open			-0.008
			[0.005]
Observations	4278	4278	4278
Number of id	627	627	627
R-squared	0.33	0.31	0.31

Note: Constant*Pos: Dummy=1 if Shortage is positive. ShortageW. ShortageB. ShortageK are the shortages for white collar. blue collar and capital. Open is the annual change in tariff levels. Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 8
Estimated parametric adjustment functions
Tariff level effect estimation

	White collar adjustment	Blue collar adjustment	Capital adjustment
Constant	0.052	-0.181	0.057
	[0.051]	[0.047]***	[0.051]
Constant*Pos	0.289	0.778	0.192
	[0.080]***	[0.071]***	[0.074]***
(ShortageW)^2	0.207	0.022	0.009
	[0.028]***	[0.012]*	[0.013]
(ShortageW)^2*Pos	-0.136		
	[0.044]***		
(ShortageB)^2	0.002	0.177	-0.022
	[0.015]	[0.031]***	[0.015]
(ShortageB)^2*Pos		-0.083	
		[0.047]*	
(ShortageK)^2	-0.008	0.026	0.119
	[0.013]	[0.011]**	[0.024]***
(ShortageK)^2*Pos			-0.102
			[0.035]***
(ShortageW)*(ShortageB)	-0.047	-0.012	-0.007
	[0.015]***	[0.013]	[0.017]
(ShortageW)*(ShortageK)	-0.022	-0.010	0.001
	[0.013]	[0.015]	[0.013]
(ShortageB)*(ShortageK)	0.030	-0.056	-0.052
	[0.017]*	[0.013]***	[0.01193]***
Constant*Tariff	0.00074	0.01419	0.002
	[0.002]	[0.002]***	[0.002]
Constant*Pos*Tariff	-0.006	-0.026	-0.008
	[0.003]**	[0.002]***	[0.002]***
(ShortageW)^2*Tariff	-0.001		
	[0.001]		
(ShortageW)^2*Pos*Tariff	0.002		
	[0.002]		
(ShortageB)^2*Tariff		-0.003	
		[0.001]***	
(ShortageB)^2*Pos*Tariff		0.002	
		[0.002]	
(ShortageK)^2*Tariff			0.001
			[0.001]*
(ShortageK)^2*Pos*Tariff			-0.000
			[0.001]
Observations	4507	4507	4507
Number of id	627	627	627
R-squared	0.32	0.34	0.32

Note: Constant*Pos: Dummy=1 if Shortage is positive. ShortageW. ShortageB. ShortageK are the shortages for white collar. blue collar and capital. Tariff is the sector average import tariff. Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

Figure 1. Average tariff by sector of activity (ISIC Rev. 2)

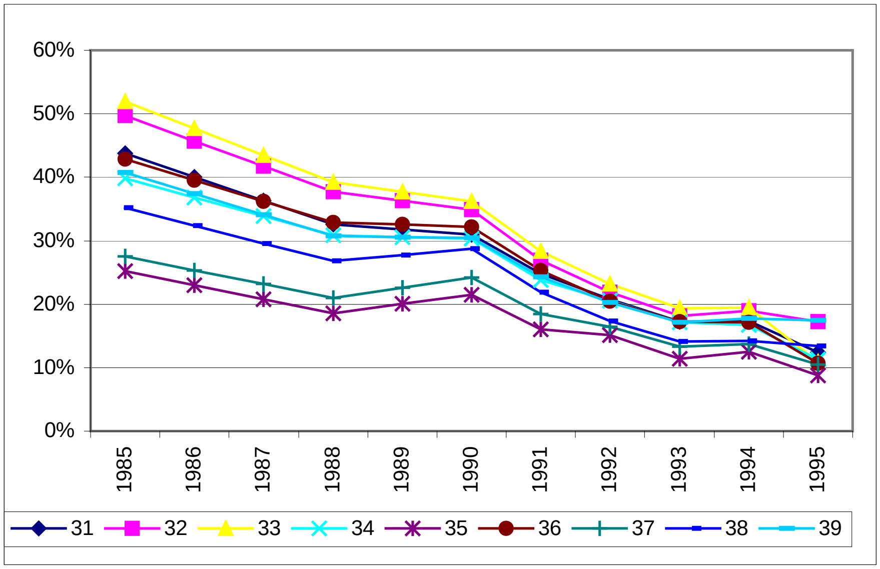


Figure 2. Shortages Histograms

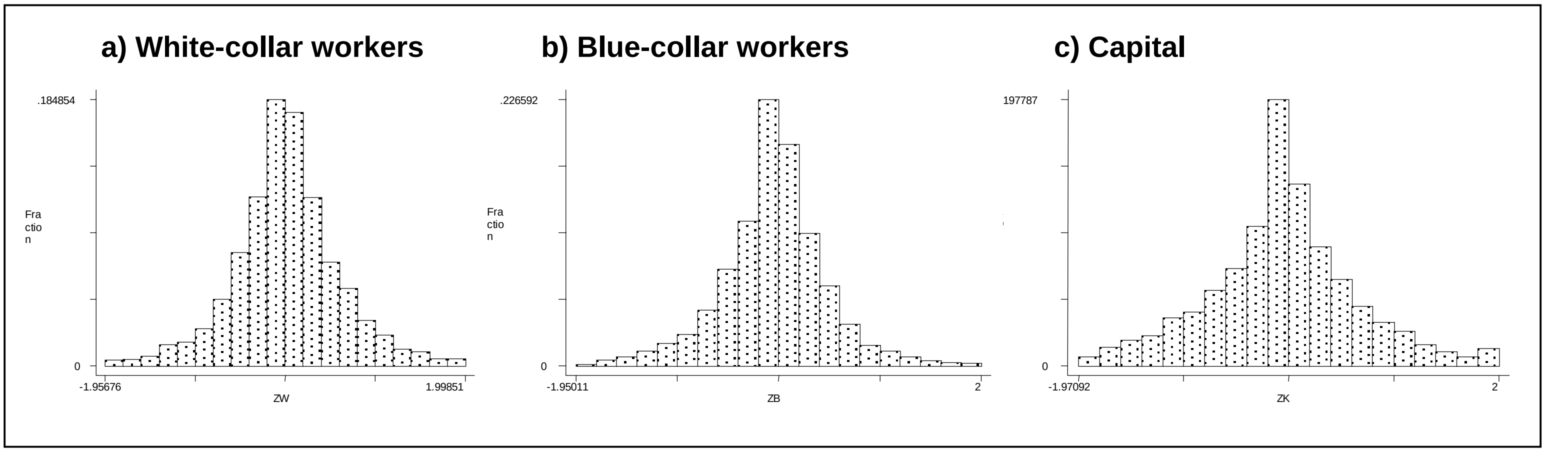


Figure 3. Firms' Outuput Gap

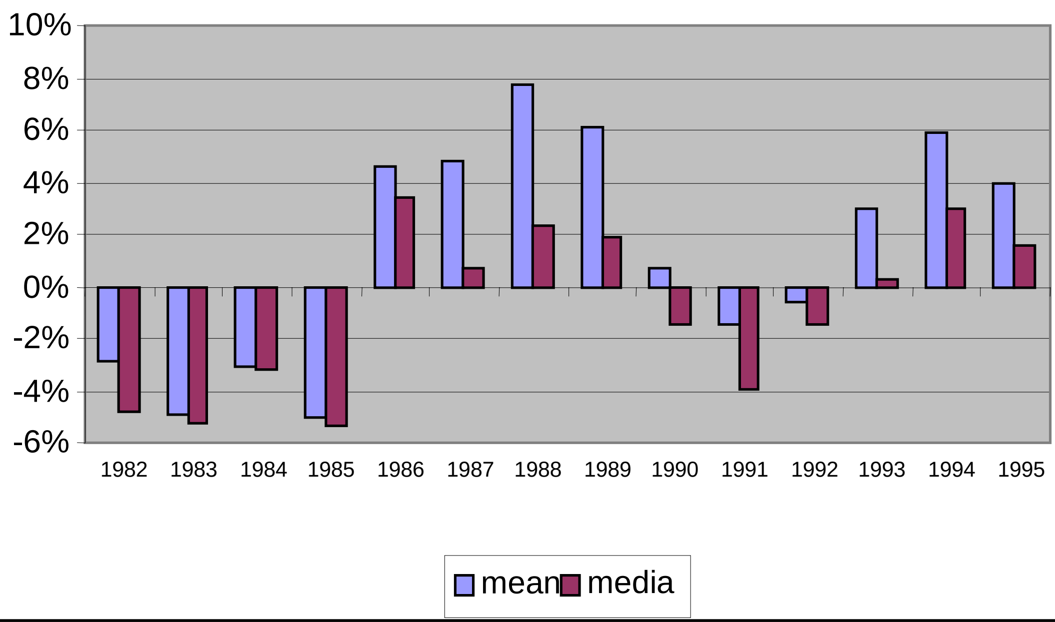


Figure 4 - Adjustment functions
Baseline estimation (all other shortages=0)

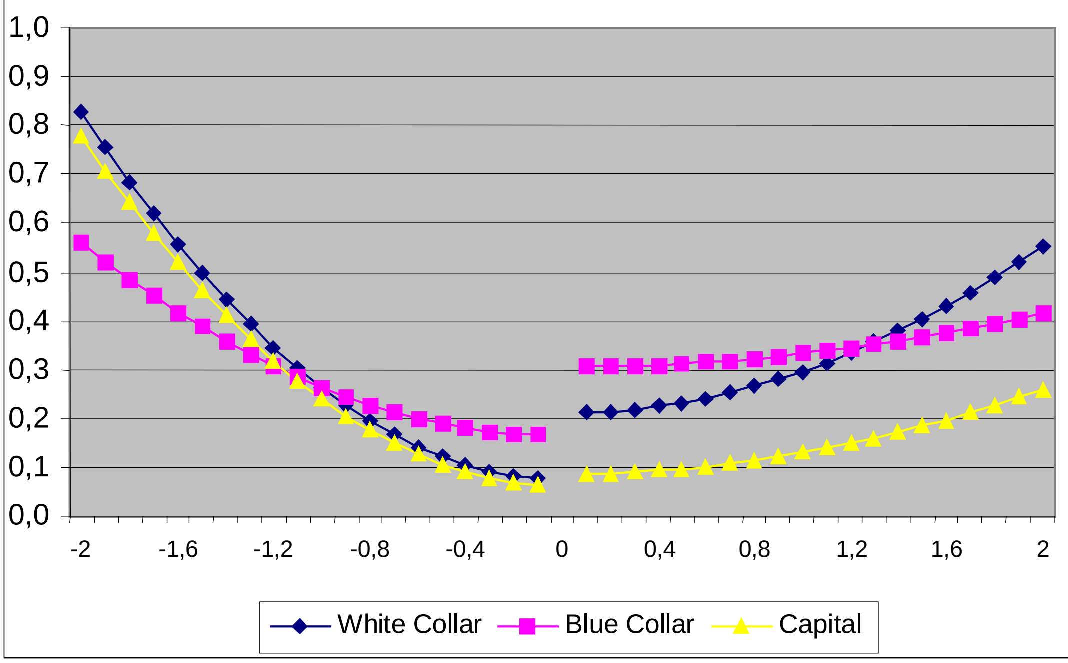


Figure 5. Adjustment Functions- shortage interactions

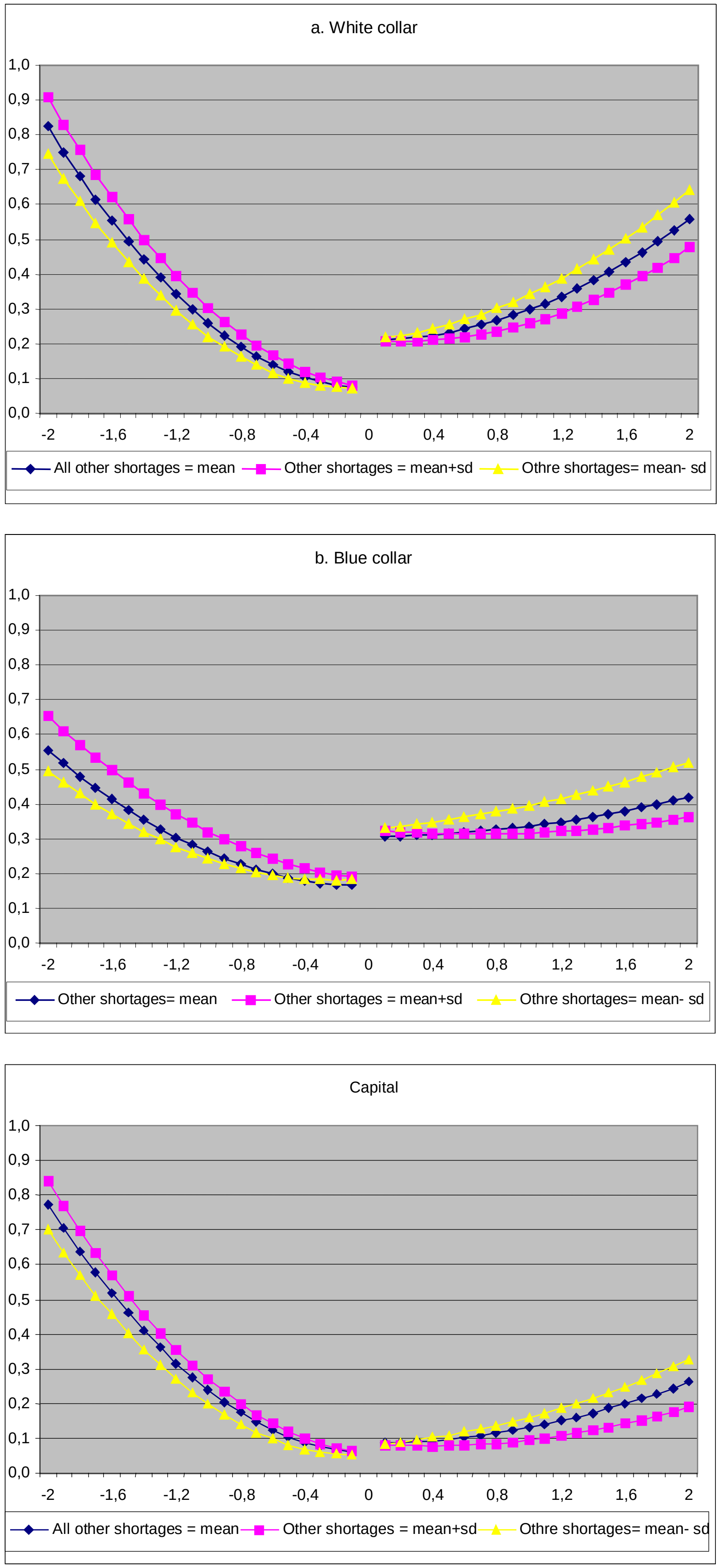
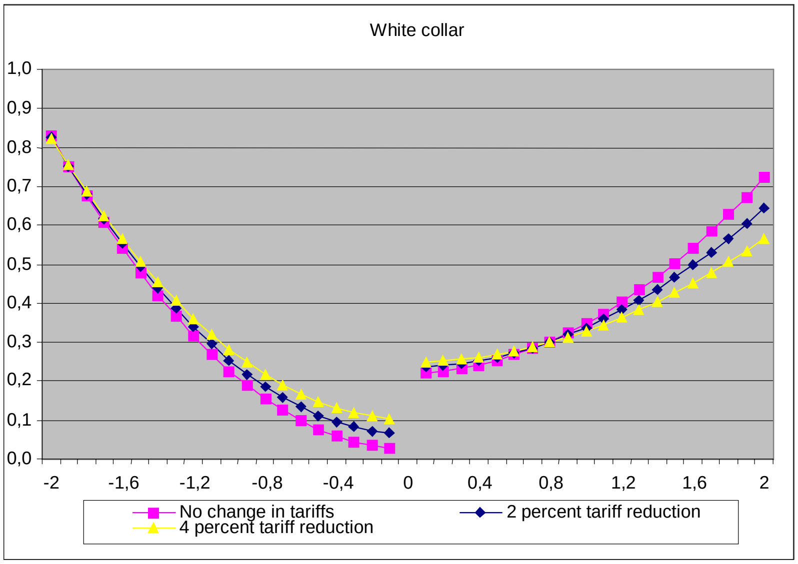
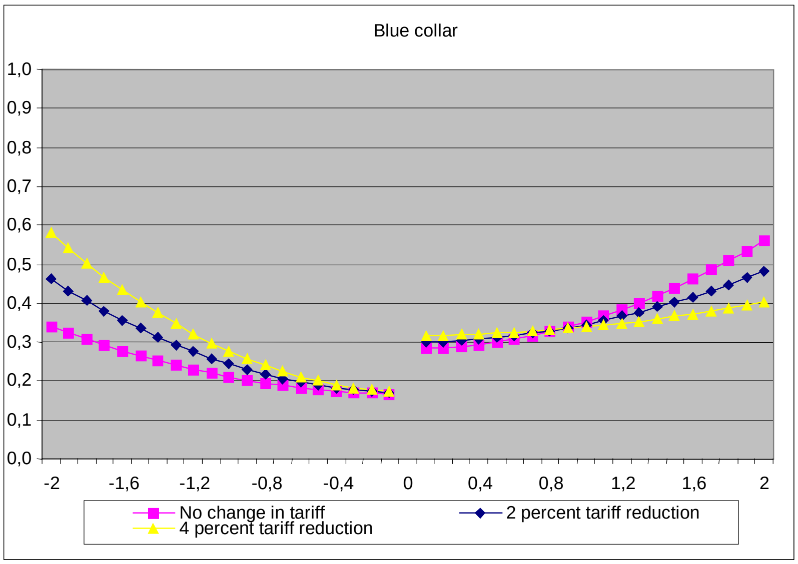


Figure 6. Adjustment Functions – tariff changes





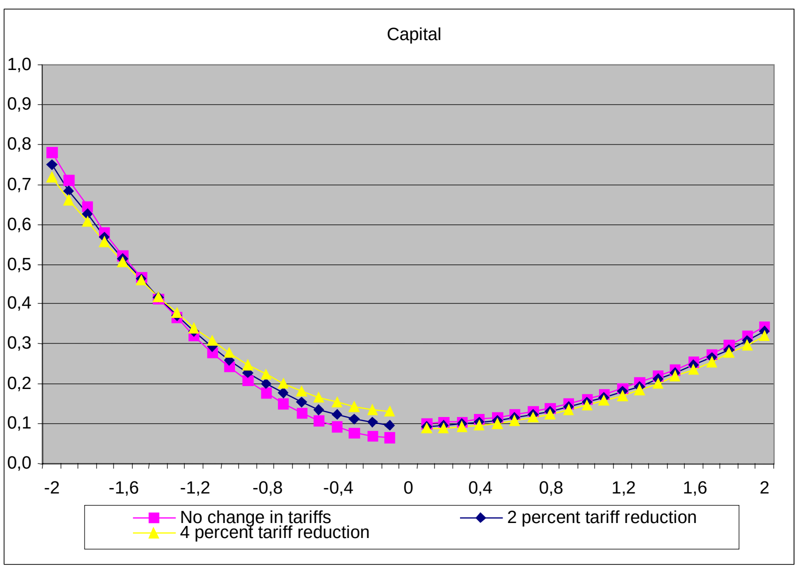


Figure 7. Adjustment Functions – tariff levels