Factor Adjustment and Intra-industry Trade:

An Application of the Adjustment Costs Model

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February 2001

Abstract:

The hypothesis of the adjustment costs associated with factor adjustments under intra-industry trade are lower than those under inter-industry trade is initially supported by a specific-factor model analysis theoretically. Yet there is no comprehensive empirical evidence to support that. This paper therefore, tested the hypothesis that factor adjustment under intra-industry trade specialisation predominantly occurs within industries rather than between industries using a dynamic factor demand system.

The test was carried out in three steps. First, the optimal solutions of factor demand and output supply were derived for the dynamic adjustment costs model when the function of production is assigned in a quadratic form. Secondly, using data obtained from the OECD's international sectoral database in the quasi-fixed input demand equations, adjustment coefficients were estimated at the subdivision level of ISIC manufacturing industries. This derivation was employed to Canada, Germany and the United States due to the availability of data. Thirdly, specifying two effects—a trade specialisation effect and a structural change effect—in the empirical model to explain the determinants of labour and capital adjustment coefficients. The results reveal strongly that if an industry has a high degree of intra-industry trade specialisation, the factor adjustments are more intra-industry oriented.

Introduction

There are theoretical reasons for believing that the adjustment costs associated with factor adjustments under intra-industry trade are lower than those under inter-industry trade. This idea is initially supported by a specific-factor model analysis. Where there are specific factors of production, the relative adjustment of labour depends on how the market is occupationally and geographically segmented (or concentrated). The nature of the determinants of intra-industry trade and inter-industry trade suggests that under intra-industry trade specialisation, firms within an industry are likely to be more geographically concentrated and the labour in that industry is likely to be less occupationally segmented. An implication is that intra-industry trade specialisation will be associated with lower factor adjustment costs as trade patterns change since much of the adjustment takes place within each industry.

Yet there is no comprehensive empirical evidence to support the hypothesis that factor adjustment under intra-industry trade specialisation predominantly occurs within industries rather than between industries. The aim of this paper therefore, is to test this hypothesis using a dynamic factor demand system.

Functional forms of adjustment cost models

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Theoretical model

When facing adjustment problems with a set of quasi-fixed inputs (K), firms are assumed to select an optimal level of variable inputs (L), and an investment rate (I), for their quasi-fixed inputs. They make these choices to maximise the value (V) of their production over an infinite time domain (*t*), given output prices (*p*), variable input prices (*w*) and rental prices (*q*) of quasi-fixed inputs.

This maximisation problem can be written as

$$V(p,w,q,K) = Max_{(Y,L,I)} \int_0^\infty e^{-rt}[p'Y - w'L - q'K]dt \qquad (1)$$

s.t.:

$\dot{K} = I - dK$,

$K(0) = K_0 > 0$, and

$Y = f(K,L,I)$

where r is the discount rate, $\dot{K}$ is the net investment in quasi-fixed inputs, $K(0) = K_0$ is the stock of investment at the base year, and d is a diagonal matrix with positive depreciation rates on the diagonal investment stocks. Earnings are measured as the difference between sales revenue and the costs of purchasing variable inputs and renting quasi-fixed inputs. The function $f(\cdot)$ is a multi-product production function, twice continuously differentiable, which satisfies $f(\cdot) > 0$, $f_K(\cdot) > 0$, and $f_I(\cdot) < 0$ if $I > 0$, $f_I(\cdot) > 0$ if $I < 0$, and is strictly concave in K and I (Epstein 1981). The relationship $f_I < 0$ reflects the adjustment costs associated with gross investment I, and is measured in terms of foregone output.

Given the regularity conditions on $f(\cdot)$ and static price expectations, the value function in Equation (1) satisfies the following Hamilton–Jacobi equation:

$$rV(p,w,q,K,I) = Max_I\left[p^*(p,w,q,K,I) - q'K + V'_K(p,w,q,K)(I - dK)\right] \qquad (2)$$

where $p*$ is variable profit and represents the optimum solution for profit maximisation in the short run, and V_k represents a vector of shadow prices associated with quasi-fixed stocks. Equation (2) indicates that producers can increase their earnings by accumulating net profit from production and by new investment in the quasi-fixed inputs with a marginal value of V_K. By the duality relationship which exists between V and $p*$, the value function V is expected to satisfy the following properties: V and V_K are twice continuously differentiable; V is homogeneous of degree zero in prices, non-decreasing in p, and K, non-increasing in w and q, convex in prices (p, w, and q), and concave in inputs (L and K).

By applying duality principles and the envelope theorem to (2), the following equations can be generated:

$$\begin{aligned} \dot{K}* &= V_{kq}^{-1}(rV_q + K) \\ L* &= -rV_w + V_{kw}^{'}\dot{K} \\ Y* &= rV_p - V_{kp}^{'}\dot{K} \end{aligned} \tag{3}$$

where the lower case subscripts are used to designate derivatives.

These equations indicate that the optimal solutions for the quasi-fixed inputs, variable inputs and output supply are functions of p, w, q and K.

The above system provides a useful representation of the determination of quasi-fixed input demand. In this study, the theory of optimal adjustment of all factors of production provides a basis for the study of adjustment costs resulting from resource relocation.

Empirical model

For the purpose of the empirical estimation of the dynamic factor demand response system of equation (3) above, an explicit functional form of the value function *V(.)* must be specified. Epstein (1981) proposed a number of functional forms for the value function which are useful in empirical studies. One of them, the normalised quadratic value function, has been used frequently in empirical work (Vasavada and Chambers 1986; Vasavada and Ball 1988; Huang, Rosegrant and Rozelle 1995). Following Huang et al., the specification that is used in this study is as follows:

The form of the value function can be expressed as

$$V(p,w,q,K) = a_0 + [a_1, a_2, a_3, a_4][p,w,q,K]' + \frac{1}{2}[p \ w \ q \ K] \begin{vmatrix} A & F' & G' & H' \\ F & B & L' & N' \\ G & L & C & R^{-1\prime} \\ H & N & R^{-1} & D \end{vmatrix} \begin{bmatrix} p \\ w \\ q \\ K \end{bmatrix} \qquad (4)$$

where, *V*, *p*, *w*, *q*, and *K*, are as defined in the theoretical model, and $a_0, \cdots, a_5$ and $A, F, G, H, B, L, N, C, R, D$ are parameter matrices with the appropriate dimensions.

Following the steps outlined in the theoretical model derivation, the empirical formulation of the dynamic factor demand equations (corresponding to the optimal solutions in equation (3)) has the following form:

$$\dot{K}_t = rRa_3 + (rU + R)K_{t-1} + rRGp_{t-1} + rRLw_t + rRCq_t + e_{12t}$$

$$L_t = -ra_2 - rF' p_{t-1} - rBw_t - rL' q_t - N' K_t * + e_{3t} \qquad (5)$$

where $K^* = rK_{t-1} - \dot{K}$ and U is an identity matrix. All matrices and vectors have the appropriate dimensions.

In this study, suppose each industry employs two primary factors—capital and labour—and both are treated as quasi-fixed inputs as a fraction of labour is skilled. Therefore only the first equation of the above factor demand system is required for empirical analysis.

Measuring intra-industry trade

There are two major issues in empirical studies involving intra-industry trade: defining an industry and measuring the extent of intra-industry trade within such industries.

Two main criteria have been used to define an industry. Two different products are the output of a single industry either if it is relatively easy to substitute one for the other in the production process or if consumers put them to essentially the same use. The choice between these two criteria depends on the use to which the data generated by the criteria is put.

Economists studying intra-industry trade often use data from published statistics on trade in various recognised ‘categories’. The most commonly used classification is the Standard International Trade Classification (SITC). There are 10 sections at the 1-digit level, 63 2-digit groups, and so on.

The level of IIT depends crucially on the level of aggregation. If IIT is measured at a very detailed classification, there might be very little intra-industry trade. On the other hand, if IIT is measured at very high level of aggregation, much trade will be intra-industry trade. Such problems have led some economists such as Finger (1975) to suggest that intra-industry trade is merely a 'statistical artefact'. Although relatively little effort has been devoted to measurement problems, they are of absolutely vital significance to the entire subject. The standard documentary work often reports IIT at the 3-digit level of aggregation. Efforts have been made to find a more constructive way to take some account of the bias due to the aggregation level or even to establish a more appropriate trade classification.

The first measure of the extent of intra-industry trade was proposed by Balassa in 1966. The most widely used measure is the Grubel–Lloyd index, which is a simple modification of the Balassa measure. The problem with the Grubel–Lloyd index is associated with biases created by trade imbalances at the multilateral level (Grubel and Lloyd 1975). Some economists have attempted to correct this, but a widely acceptable method of correction has yet to be found. As argued by Helpman (1987), attempts to modify the Grubel–Lloyd index to correct for trade imbalance bias are inappropriate since the nature of the bias is not known. In particular, we do not know whether the imbalance is caused by homogeneous or differentiated products and whether the trade structure is in equilibrium or not. This explains why in general, bilateral IIT is more interesting than overall IIT.[1]

Following Grubel and Lloyd (1975), the individual industry IIT index between countries *i* and *j* for product *k* in year *t* is given by

$$IIT_{ij,k}^{t} = [1 - \frac{\left| X_{ij,k}^{t} - M_{ij,k}^{t} \right|}{(X_{ij,k}^{t} + M_{ij,k}^{t})}] * 100 \qquad (6)$$

X and M are exports and imports of product k in year t between two countries respectively.

The aggregate IIT index is calculated as

$$IIT_{ij}^{t} = [1 - \frac{\sum_{k} \left| X_{ij,k}^{t} - M_{ij,k}^{t} \right|}{\sum_{k} (X_{ij,k}^{t} + M_{ij,k}^{t})}] * 100 \qquad (7)$$

This is a weighted average of the individual industry indices, where the weights are the share of the industry in total trade.

Factor adjustment in various industries

Before testing the central hypothesis relating factor adjustment and IIT across industries, as foreshadowed in the first section, it is necessary to derive factor adjustment for various industries by applying the adjustment costs model.

Justification for the use of the adjustment costs model

An industry's output can be produced under either constant returns to scale or economies of scale, and firms may form prices under perfect competition, monopolistic competition or oligopolistic behaviour. Firms may engage in trade in either inter- or intra-industry trade. Under these circumstances, it is necessary to discuss the justification for the use of the adjustment costs model first.

[1] There are, of course, many methodological questions which have been raised in the literature about calculation of intra-industry trade indexes. Fontagn and Freudenberg (1997) etc, for example, provide an excellent review of the aggregation issue in their work on European trade.

Whether the use of the adjustment costs model can be justified depends on whether the price-taking assumption, which is the key assumption of the adjustment costs model, can be attained. The assumption that firms are price takers holds not only under perfect competition but also under conditions with economies of scale and imperfect competition. When economies of scale are external to firms and internal to the industry, the price-taking assumption of firms is maintained. When economies of scale are internal to firms, only when firms follow price competition can the price-taking assumption be loosely maintained.

Inter-industry trade is explained in theory under a framework of constant returns to scale and perfect competition, and vertical intra-industry trade has essentially the same implication. Firms pricing under these circumstances are simply acting as price-takers.

For horizontal intra-industry trade, economies of scale, monopolistic competition and oligopolistic behaviour explain why trade takes place. In the presence of economies of scale and oligopolistic behaviour of firms, these explanations of horizontal IIT lie in their incorporation of two assumptions: (a) that there exist sectors with product differentiation and there exists in every country a demand for a wide spectrum of varieties; and (b) that each variety of a differentiated product is produced with internal economies of scale. Two assumptions have been used to model the demand for varieties. One approach, based on Dixit and Stigliz (1977), assumes that a representative consumer likes to consume a large number of varieties. An alternative approach, taken by Lancaster (1979), assumes that a consumer prefers a product whose characteristics are close to his or her ideal. In both cases it is assumed that firms engage in price competition. Thus the price-taking assumption is also attained under these circumstances.

Theoretically, horizontal intra-industry trade can also take place under the condition of monopolistic competition. According to Maddala and Miller (1989), the monopolistic competition model was received very enthusiastically in the 1930s, but later attracted much criticism. One criticism concerns problems associated with the product differentiation assumption. Downward-sloping demand curves are derived from the assumption of product heterogeneity. This is inconsistent with the assumption that either cost curves or demand conditions are the same for all firms. Long-run equilibrium in which firms earn normal profit is logically incompatible with this assumption. If a firm is providing a unique product and making super-normal profits as a consequence, other firms can erode these profits simply by providing the same product, rather than some differentiated product.

Another problem created by the introduction of product heterogeneity is that it is difficult to define an industry or ‘competing group’. For example, tea, coffee, soft drinks, beer, wine and liquor could form a chain of competing products. Under models of perfect competition or monopoly, these would be considered as different homogeneous products. Under monopolistic competition, it is not clear where to draw the line.

Finally, differentiated products are not necessarily produced by different firms. For instance, the fact that there are different brands of soaps and detergents does not mean that the market is monopolistically competitive. Different brands may be produced by a single firm, which has more than half of the market in soaps and detergents. This represents an oligopoly of multi-product firms.

Nevertheless, on the one hand we have observed that monopolies rarely exist in reality; on the other hand, there is no firm support for monopolistic competition in theory. Thus it is reasonable to rule out the case that horizontal intra-industry trade takes place under monopolistic competition.

Thus, firms' pricing behaviour is limited to either perfect competition or price competition for both inter- and intra-industry trade specialisations, making the price-taking assumption of the adjustment costs model justified.

Further, intra-industry trade is a fraction of an industry's total trade and a large proportion may be vertical intra-industry trade.[2] This fact may add more weight statistically to the justification of the use of the adjustment costs model under the condition that firms engage in both inter- and intra-industry trade.

Test equations

To facilitate testing of the adjustment costs hypothesis, the quasi-fixed input equations are linearised. For a two-factor system, the linearised first equation of (5) can be written as follows:

$$
\begin{aligned}
\hat{K}_t &= a_0 + a_1 K_{t-1} + a_2 L_{t-1} + a_3 p_{t-1} + a_4 w_t + a_5 r_t + e_1 \\
\hat{L}_t &= b_0 + b_1 K_{t-1} + b_2 L_{t-1} + b_3 p_{t-1} + b_4 w_t + b_5 r_t + e_2
\end{aligned} \qquad (8)
$$

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[2]A recent study by Greenaway, Hine and Milner (1994) reveals that, on average, more than two-thirds of the United Kingdom's total trade is in the form of vertical intra-industry trade.

in which, $\hat{K}_t$ and $\hat{L}_t$ represent the change of capital and labour employment levels in the current time period, respectively; K_{t-1} and L_{t-1} are the capital and labour employment levels in the previous time period; p_{t-1} is the output price in the previous time period; w_t and r_t are the current wage rate and rental price for labour and capital, respectively.

$M = \begin{vmatrix} a_1 & a_2 \\ b_1 & b_2 \end{vmatrix}$ is called an adjustment matrix. The direction and magnitude of the particular factor adjustment can be obtained from the sign and value of a_1 and b_2.

The dynamic nature of the model here is reflected as the changes of current labour or capital employment levels depending on labour and capital employment levels in the previous period.

Data

As shown in the above test equation of quasi-fixed input demand, the data needed in this study are time-series data for total employed persons, the value of capital stock, output prices, wage rates and returns to capital. These data are available only from the OECD's International Sectoral Database at a subdivision level of manufacturing industry, classified according to International Standard Industrial Classification (ISIC) as shown in Table 1. Only three economies—the United States, Canada and Germany—have the information necessary to construct the above measures.

Table 1 Industry classification code for ISIC manufacturing

ISIC code	description
3	Manufacturing
31	Food, beverages and tobacco
32	Textiles
33	Wood and products
34	Paper, printing and publishing
35	Chemicals
36	Non-metallic minerals products
37	Basic metal products
38	Machinery and equipment
39	Other manufactured products

Source: United Nations of Industrial Development Organisation (UNIDO) in International Economics DataBank, Australian National University.

Output price indices are obtained as a GDP deflator at 1985 prices for each industry. Gross domestic product is expressed in market prices, except for Canada, where it is given at factor cost.

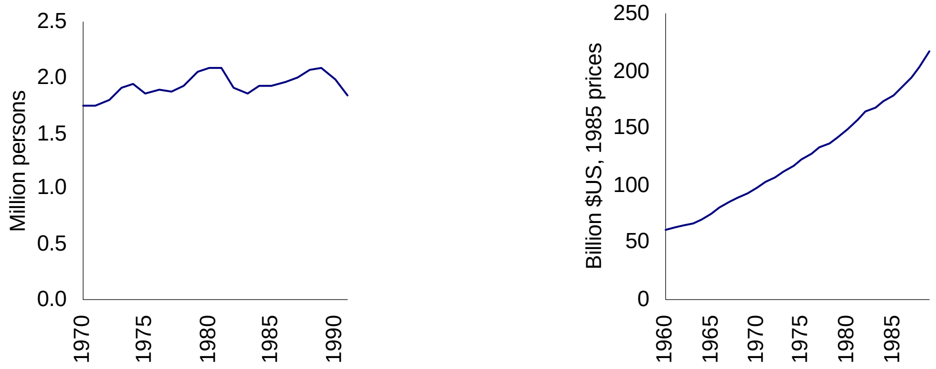
The value of capital stock available in this database is gross capital stock in 1985 prices and measured in US dollars. The return to capital is derived as the ratio of gross operating surplus to gross capital stock. The level of labour employment is measured as the number of employees. The wage rate is first calculated as the value of compensation of employees at current prices divided by the number of employees, then converted to a wage rate index in 1985 prices.

All the above data are available from 1970 to 1989 for Canada, from 1960 to 1987 for the United States, and from 1970 to 1990 for Germany.

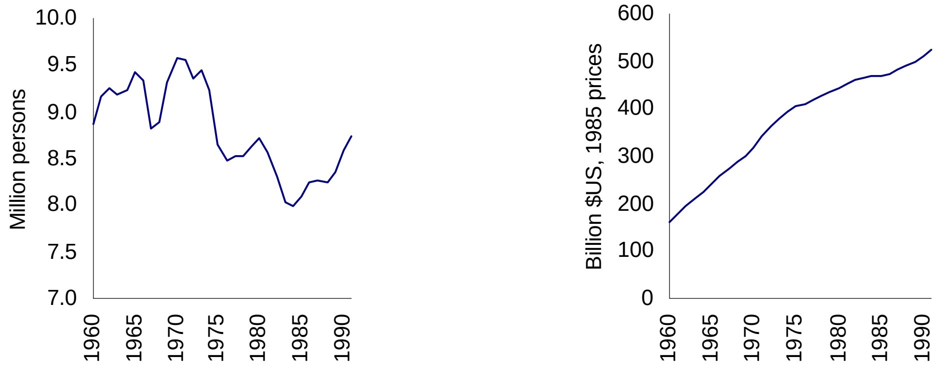
Figure 1 Changes in labour and capital over time

Labour   Capital

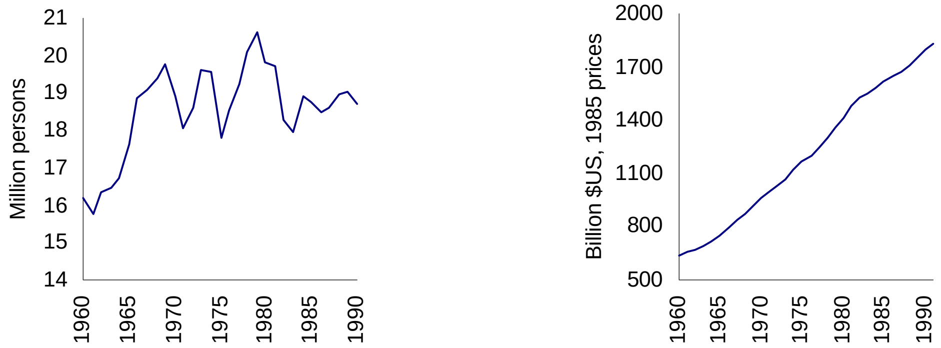
Canada



Germany



United States



Source: The International Sectoral Database, 1993 at Statistics Directorate, OECD.

Figure 1 shows changes in the level of labour and capital over time for total manufacturing for Canada, Germany and the United States. For all these economies, changes in the level of employment of labour fluctuate markedly, with increasing trends for Canada and the United States, and a decreasing trend for Germany. The changes in the level of capital all increase over time but fluctuate less than labour. There may be slight differences in changes in the employment of labour and capital at a disaggregated level, but they should show the same trends. Negative signs for labour adjustment coefficients are expected, with some positive and some negative signs for capital adjustment coefficients.

Empirical results

Given price changes over time, the labour and capital adjustment coefficients can be derived using the two-equation system in equation (8). An iterative, seemingly unrelated regression procedure is used for the estimations.

Two sets of hypotheses can be tested before the formal analysis. In the formulation suggested by Epstein (1981), if the coefficients, M11 and M22 are 1 or -1, and the rate of movement towards equilibrium of one quasi-fixed input does not rely on the adjustment rate of the other (i.e. M12=M21=0), complete and independent adjustment to the optimal point in capital and labour is made in a single period, and adjustment costs are minimal. If the hypothesis that M11 and M22 are equal to 1 or -1 is rejected, that would mean that, on average, only a fraction of equilibrium factor adjustment is made in a single period. If the independent adjustment hypothesis (M12=M21=0) is rejected, it means that the adjustment paths are not independent. In other words, after a change in output prices makes the original levels of labour and capital less than optimal, the movement of labour towards its new long-run equilibrium level is affected by the adjustment of capital stock (and vice versa).

Table 2 Quasi-fixity of inputs and dependent adjustment test

H0: No adjustment costs & independent adjustment	F Value		
	United States	Canada	Germany_
Labour: (M11=-1 & M12=0)			
3	52.58	22.97	40.52
31	13.31	1.94	9.97
32	13.96	4.86	17.88
33	3.68	7.82	3.92
34	33.17	4.39	25.38
35	126.07	3.71	16.87
36	44.02	18.02	15.44
37	36.51	8.15	8.69
38	33.59	8.18	16.48
39	29.22	0.16	5.65
Capital (M22=-1 or 1 & M21=0)			
3	561.91	7.28	125.54
31	61.18	78.06	45.75
32	448.07	29.75	36.58
33	545.64	27.41	70.34
34	369.80	13.62	16.61
35	334.62	7.38	40.41
36	392.80	36.65	45.57
37	422.27	44.23	90.43
38	287.58	55.403	111.34
39	291.72	77.24	18.86
DF	2/21	2/13	2/14
1% critical value	5.78	6.70	6.51
5% critical value	3.47	3.81	3.74

Source: Author's calculation.

Table 2 shows that the hypothesis of no adjustment costs and independent adjustment is rejected for most industries for the three economies at both 1 per cent and 5 per cent significance levels. The high F-statistics in the tests of quasi-fixity of capital by itself and labour by itself and the joint test of the two quasi-fixed inputs point to the importance of accounting or dynamic adjustment costs in the analysis.

The adjustment coefficients (M) for labour and capital for each industry are calculated by applying the data constructed above to equation (8). As the model is written in the form of first differences, the Eigen values of the adjustment matrix provide a check on the stability of the adjustment process of capital and labour. Their absolute values, as calculated, are less than unity. Therefore the quasi-fixed demand system is stable. The results are shown in Table 3.

Table 3 Adjustment coefficients from dynamic adjustment analysis

Labour adjustment coefficients

Industry code	United States	t-ratio	Canada	t-ratio	Germany	t-ratio
3	-0.22334	-1.87	-0.27955	-2.64	-0.14225	-1.35
31	-0.37185	-3.12	-0.92302	-5.65	-0.17388	-1.12
32	-0.48328	-3.11	-0.62938	-4.58	-0.39492	-3.02
33	-0.59581	-3.36	-0.70465	-4.82	-0.50539	-3.41
34	-0.01501	-0.12	-0.88760	-5.91	-0.14964	-0.74
35	-0.16365	-0.96	-0.48179	-2.92	0.02063	0.15
36	-0.47410	-3.26	-1.01610	-6.19	-0.43351	-4.72
37	-0.58103	-5.44	-0.80051	-4.32	-0.36043	-2.24
38	-0.18442	-1.43	-0.63471	-3.64	-0.24313	-0.89
39	-0.63918	-2.93	-0.92067	-6.30	-0.34815	-1.77

Capital adjustment coefficients

Industry code	United States	t-ratio	Canada	t-ratio	Germany	t-ratio
3	0.04134	1.35	0.14425	0.76	-0.13384	-2.81
31	0.15610	2.31	0.17769	3.26	-0.28331	-4.43
32	0.09182	2.73	0.23681	2.66	-0.23446	-2.68
33	0.19997	8.68	-0.07629	-0.63	-0.17758	-3.01
34	0.03349	0.91	0.20821	1.58	0.09596	0.45
35	-0.01271	-0.15	-0.45260	-2.99	-0.16200	-2.06
36	0.06969	1.95	0.25669	2.58	-0.20479	-3.39
37	0.05745	1.74	-0.17589	-1.77	-0.27930	-5.86
38	-0.08525	-1.95	0.12723	1.66	-0.16233	-1.63
39	0.26153	3.90	0.10945	1.84	-0.07798	-0.53

Note: All the coefficients are significant at least at the 5 per cent level with the exception of the following: industries 34 and 35 in the United States and 34, 35, 38 in Germany for labour adjustment coefficients; industries 34 and 35 in the United States, 3 and 33 in Canada and 34 and 39 in Germany for capital adjustment coefficients.
Source: Author's calculation.

To interpret these adjustment coefficients, it is necessary to clarify that the sign and value of these adjustment coefficients are the indicators of the direction and magnitude of adjustment, respectively. For example, the labour adjustment coefficients of industry 32 for the United States is -0.48328 which means that, on average over the sample time period, 48 per cent of labour adjustment decisions are carried out annually in the US textile industry. In other words, after changes in price, the full adjustment for labour to the long-run equilibrium value takes on average about two years. Fractional adjustments in the labour and capital markets keep producers from making instantaneous adjustments (within one year) to long-run equilibrium.

Factor adjustment and intra-industry trade

After testing the adjustment coefficients, the next step is to examine how the adjustment coefficients vary across industries with respect to the extent of the level of intra-industry trade for these industries. This leads to a test of the central hypothesis of this paper, namely the higher the level of intra-industry trade in an industry, the greater the intra-industry factor adjustment.

Model specification

There are several ways of looking at the relationship between labour and capital adjustment coefficients and the level of IIT across industries. One way, and possibly the most appropriate way under the circumstances, is to set up an econometric model to estimate the determinants of adjustment coefficients with IIT as one of the explanatory variables: a cross-industry and cross-country model in which

$$\begin{aligned} &\textit{Labour adjustment coefficients} = f(IIT, \cdots) \\ &\textit{Capital adjustment coefficients} = f(IIT, \cdots) \end{aligned} \qquad (9)$$

There are many factors that can affect labour and capital adjustment. They include whether or not an industry is highly unionised; socio-economic variables like sex, race and age composition of an industry can also affect labour adjustment. However, this study is only concerned with industry-specific factors. Two major factors are considered here: specialisation (intra-industry trade or inter-industry trade specialisation) and structural change effects. The test equations are therefore written as:

$$\begin{aligned} L &= a_0 + a_1 IIT + a_2 GIG + m_1 \\ K &= b_0 + b_1 IIT + b_2 GIG + m_2 \end{aligned} \qquad (10)$$

Where L represents labour adjustment coefficients and K represents capital adjustment coefficients. IIT and GIG denote the variables of intra-industry trade level and industry structural change.

It is expected that, expressing adjustment coefficients in absolute values, there are negative signs to the coefficients of IIT and positive signs to the coefficients of GIG.

Data

In the labour and capital adjustment coefficients estimated above, there are 10 coefficients of one variable for each country. The intra-industry trade level for each industry is calculated by using the Grubel–Lloyd index at the 4-digit ISIC level, and average IIT indices are calculated for each industry over the period 1970 to 1990 using data from the ANU’s International Economic DataBank. These are set out in Table 4. The structural change variable is constructed as the average change in the ratio of industry GDP over total GDP over 1970 to 1989. The estimated results are shown in Table 5. There are negative signs associated with almost all structural changes in these industries which means that, on average, from 1970 to

1989, these industries' share of total GDP declined. This was probably associated with a sharp increase in the output of the services industry in all three countries.

Estimation

The test of the hypothesis is conducted using an Ordinary Least Square (OLS) estimation. Cross-country and cross-industry data have been applied to the above- specified a group of test equations (10). Originally, there were 30 observations for estimations of labour and capital adjustment determinants. Due to insignificant factor adjustment coefficients and structural changes, 24 and 23 observations were applied in the final estimation for labour and capital adjustment, respectively.

In the regression analysis, several diagnostic tests were carried out in order to ascertain the reliability of the results.

Table 4 Intra-industry trade levels for the United States, Canada and Germany, 1970, 1980, 1990 and average (per cent)

Industry Code	70	80	90	average
United States				
3	62.32	63.01	68.45	64.59
31	44.33	55.86	57.26	52.48
32	50.44	52.71	38.05	47.07
33	54.62	69.30	70.07	64.66
34	74.48	77.62	80.20	77.43
35	63.83	55.81	69.62	63.09
36	70.42	64.62	71.11	68.72
37	76.44	69.10	61.17	68.90
38	63.28	65.16	73.14	67.19
39	51.16	67.26	37.04	51.82
Canada				
3	60.63	59.36	66.47	62.15
31	56.25	59.13	67.81	61.06
32	40.60	39.86	37.60	39.35
33	28.13	28.74	38.03	31.63
34	11.21	14.78	22.43	16.14
35	61.12	65.81	74.66	67.20
36	36.00	40.52	53.17	43.23
37	44.78	55.64	67.56	55.99
38	79.67	72.55	75.55	75.92
39	36.24	41.01	43.10	40.12
Germany				
3	59.38	65.39	72.09	65.62
31	48.62	70.09	79.12	65.94
32	79.85	71.69	71.08	74.21
33	53.66	64.43	76.46	64.85
34	47.24	59.48	64.08	56.93
35	64.26	67.26	74.90	68.81
36	73.14	84.87	85.58	81.20
37	69.88	77.62	86.67	78.06
38	51.93	59.19	68.22	59.78
39	77.70	69.77	80.91	76.13

Source: Author’s calculation using UNIDO data at the International Economic DataBank, Australian National University.

Table 5 Average structural change for Canada, Germany and the United States, 1970–90 (per cent per year)

	Canada	Germany	United States
3	-0.2167	-0.4033	-0.3418
31	-0.0357	-0.0938	-0.0517
32	-0.0435	-0.0923	-0.0533
33	-0.0151	-0.0278	-0.0159
34	-0.0098	-0.0173	-0.0004
35	0.0111	-0.0383	-0.0053
36	-0.0157	-0.0473	-0.0154
37	-0.0275	-0.0709	-0.0677
38	-0.0694	-0.0134	-0.1255
39	-0.0110	-0.0020	-0.0064

Source: Author's calculation using data from the International Sectoral Databank, OECD.

This is, at this level of analysis, a cross-section analysis. One of the potential problems associated with cross-section analysis is hetroscedasticity, where the variances of the error term are not constant. In the presence of hetroscedasticity, the coefficients of a regression are still unbiased, but the estimation is no longer efficient. In this estimation, hetroscedasdicities for both cases are apparent. This problem is overcome by using White's hetroskedasticity-consistent covariance matrix estimation for unknown forms of heteroscedasticity. The results reported in Table 6 have been corrected for this problem.

As noted, this estimation is based on a very small sample. The use of OLS estimation is justified if several assumptions can be made. One assumption is that the error term must be normally distributed. In a large sample case, the central limit theorem ensures that estimators are asymptotically normal. But in a small sample case, normality can be violated. In this analysis the Jarque–Bera Asymptotic LM normality test has been applied in both cases. The results show that there are no violations to normality in either case.

Thirdly, a model specification test was applied to this estimation to ensure that there were no missing variables for the initial specified estimation models. The Ramsay misspecification test was applied and the results reveal that there were no misspecifications for this estimation.

The final regression results are presented in Table 6.

Table 6 Regression results

	L	K
IIT	0.008	-0.01
t-ratio	3.45*	-4.65*
GIG	-1.22	-0.08
t-ratio	-7.38*	-0.30
Constant	-1.08	0.63
t-ratio	-7.20*	5.14*
$\bar{R}^2$	0.50	0.29
No. of observations	24	23

Note: * significant at least at 1 per cent level.
Source: Author's estimation.

Interpretation of results

In Table 6, the extent of intra-industry trade specialisation has a positive and significant effect in explaining the labour adjustment coefficients. As all labour adjustment coefficients have negative signs originally, the result that intra-industry trade is associated with labour adjustment coefficients positively and significantly, can be expressed as follows: the higher the level of intra-industry trade for an industry the less the inter-industry labour adjustment. Alternatively, when faced with a price change over the relevant time period, profit-maximising firms (industries) will change their decision on labour use. In order to achieve long-run equilibrium, an industry has to reduce its labour force by a certain amount every year. Suppose over the time period concerned, an average of 1,000 employees have to be laid off. A negative adjustment coefficient merely says that on average a fraction of them are released from the industry each year. If the level of IIT and labour adjustment coefficients are positively associated across industries, higher levels of intra-industry trade for an industry are associated with a smaller fraction of labour released for that industry in each year.

The coefficient of the structural change variable is negatively and significantly related to the labour adjustment coefficients as expected. The interpretation of that coefficient is the same for intra-industry trade levels. The negative sign is due to the fact that all industries are shrinking over the time period in question. If an industry declines more sharply than others, the fraction of labour moving out of that industry is higher.

For the capital adjustment coefficients, while the coefficient of structural change variable is insignificant, the coefficient of IIT is negative and significant. As the capital adjustment coefficients are positive (some of them originally have negative signs, but in conducting the regression, an absolute value has been imposed on them), the interpretation will be exactly the same as for the labour adjustment coefficients. If an industry is more geared towards intra-industry trade specialisation than other industries, that industry's capital adjustment will be more intra-industry oriented. This seems a reasonable interpretation from an empirical point of view, but from the perspective of firms' actual operation, it is not that obvious. However, suppose a profit-maximising industry's decision is to accumulate a certain amount of capital stock over the time period concerned. If that industry has a high level of intra-industry trade specialisation, it will only need to raise a small fraction of the capital outside the industry and the bulk will be found within the industry. It may be the case that some firms within an industry simply re-employ some equipment or machinery shed by other firms within the industry. Obviously, there is also the possibility that some firms might buy capital goods produced by other firms within the industry.

In summary, if an industry is geared more towards intra-industry trade specialisation, when facing price changes, the factor adjustments are more intra-industry oriented and, it may be inferred, less costly.

Conclusion

The hypothesis that intra-industry factor adjustment is associated with industries with high levels of intra-industry trade was tested in this paper. The test was carried out in three steps. First, the optimal solutions of factor demand and output supply were derived for the dynamic adjustment costs model when the function of production is assigned in a quadratic form. Secondly, using data obtained from the OECD's international sectoral database in the quasi-fixed input demand equations, adjustment coefficients were estimated at the subdivision level of ISIC manufacturing industries. Availability of data allowed this derivation to be employed for Canada, Germany and the United States. Thirdly, in explaining the determinants of labour and capital adjustment coefficients, two effects—a trade specialisation effect and a structural change effect—were specified in the empirical model. The results reveal strongly that if an industry has a high degree of intra-industry trade specialisation, the factor adjustments are more intra-industry oriented.

The empirical evidence provided in this paper provides initial support for the debating hypothesis that in the face of trade liberalisation, the adjustment costs of factor relocation under intra-industry trade specialisation are less than those under inter-industry trade specialisation. From the perspective of adjustment costs, intra-industry factor adjustment means that there are likely to be fewer costs associated with retraining and relocation of labour and that laid-off capital can be re-used more effectively. For example, workers displaced from internal labour markets tend to experience greater difficulty in finding alternative employment because of the importance of institutional and human capital factors in internal labour markets. Workers who are thrust upon external labour markets after a relatively long-term, stable employment relationship appear to have lower re-employment prospects, *ceteris paribus*, and may thus suffer greater economic losses (Gray 1996). The relative adjustment costs issue has only been addressed implicitly here. A more direct and comprehensive empirical analysis of the issue would provide more insight of the factor adjustment in relation to trade patterns.

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