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"Differing factor adjustment costs across industries:
Evidence from Japan"

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Differing factor adjustment costs across industries: Evidence from Japan*

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Abstract

In this paper, we use industry data from Japan to examine the joint behavior of investment and hiring. We estimate factor adjustment costs in industries and focus on the industrial difference in such costs. Our analysis reveals that heavy industries such as steel and transport equipment need relatively large adjustment costs. A comparison between the U.S. and Japan reveals that the ratio of labor adjustment costs in total adjustment costs tends to be higher in Japan. Our findings are useful in considering the mechanism of factor adjustment costs.

JEL Classification Numbers: E22, E24, J23

Keywords: joint estimation of investment and hiring, substitutability, complementarity, industry-level adjustment costs

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1 Introduction

This paper examines the joint behavior of investment and hiring. Investment and hiring are the two most important aspects of macroeconomics, often discussed separately. (See Yashiv (2011)) Structural understanding of these two factors is necessary to predict the impact of various economic policies such as reduction of corporate tax rate or subsidies for employment adjustment. In this paper, we consider a dynamic optimization problem of the firm, which allows these two factors to interact. This intertemporal decision depends on the existence of adjustment costs for capital and labor. We use industry data from Japan to estimate this structural model.

Some existing works, pioneered by Shapiro (1986), estimate both capital and labor adjustments structurally. He estimates the first-order conditions of the optimization problem of firms by using quarterly data from U.S. manufacturing firms. Contrary to previous results of the reduced form estimation, he shows that capital adjustment is very rapid. Hall (2004) similarly estimates the adjustment costs for capital and labor using annual data from U.S. two-digit industries. His estimation suggests low adjustment costs for both the factors and he concludes that transitory rents from these two factor adjustments are not an important source of variation in the market value of the firm.

Merz and Yashiv (2007) and Yashiv (2011) are some of the recent studies that analyze two factor adjustments. These studies extend the existing research in the following three aspects. First, the adjustment costs for capital interact with those of labor. Second, all adjustment costs relate to gross rather than net changes. Third, they estimate the degree of convexity of the adjustment costs function without assuming that it is a traditionally used quadratic form. Their analysis reveals that investment and hiring are complementary in terms of adjustment costs and that this complementarity explains the aggregate fluctuations in the U.S. economy.

While the studies discussed above use aggregate data, some other works, like the pioneering study by Bloom (2009), use disaggregate data. He estimates two factor adjustments using a panel of firm level data from U.S. Compustat. He considers both convex and non-convex adjustment costs. Here, non-convex adjustment costs imply the fixed costs of factor adjustments. These costs are necessary to examine the firm level optimizing behavior, although they generally violate the differentiability of adjustment costs function. In order to solve this difficulty, he adopts Simulated Method of Moments (SMM) to estimate the structural parameters. This analysis reveals that fixed costs are important rather than convex adjustment costs and that the capital adjustment costs are much larger than the labor adjustment costs. Asphjell et al. (forthcoming) extend this research by allowing the interaction of investment costs and hiring costs. They use a panel of plant level data from Statistics Norway and find that adjusting these two factors simultaneously is a financially attractive alternative compared to a sequential strategy.

The number of studies analyzing factor adjustment costs has gradually increased in recent years. However, except for Hall (2004), none of them analyzes the industrial difference of the factor adjustment costs. Bloom (2009) refers to this point in the paper and states that there is a strong argument for running this estimation on an industry-by-industry basis. Unifying industry information will only give us the average size of the factor adjustment costs, making it difficult to understand the mechanism of these adjustment costs.

One aim of this paper is to provide industry-level estimates of factor adjustment costs. We compare factor adjustment costs among industries by estimating these values separately. The other aim of this paper is to compare the adjustment costs between the U.S. and Japan. It is stated that compared to the U.S., Japan has high long-term employment and a low turnover rate. (See Waldman (2012)) The difference in the circumstances in which investment and hiring decisions are made in the two countries leads to difference in the factor adjustment costs. These analyses will enable setting up some hypothesis about the mechanism of factor adjustment costs. Because the greater part of the mechanism of factor adjustment costs is black box, it will shed new light on the analysis of this fundamental problem.

The rest of the paper is organized as follows. Section 2 gives the benchmark model, which becomes the basis for estimation, and derives the optimality conditions for capital and labor. Section 3 explains the estimation strategy such as the parameterization or the selection of instrumental variables and Section 4 discusses the data characteristics. Section 5 summarizes the estimation results and Section 6 refers to the quantitative aspects of factor adjustment costs by comparing them between industries and countries. Section 7 concludes.

2 The Model

This section gives a benchmark model, which serves as the basis for estimation. The basic model is followed by Bond and Van Reenen (2007). We consider three types of production factors: capital, labor, and materials. We assume that the capital and labor inputs are quasi-fixed and that the materials are freely adjustable.[1]

[1] Note that the capital and labor inputs become state variable and that the materials become control variable. Therefore, the materials are optimally selected following the policy function of capital and labor.

The firm's production function is expressed as follows:

$$y_t = f(a_t, n_t, m_t, k_t), \tag{1}$$

where y denotes the output, a denotes productivity, n is the number of employees of the firm, m is the usage of material goods, and k is the quantity of capital stock. The function f satisfies the assumption of constant returns to scale.

The law of motion for the capital stock is:

$$k_t = (1 - \delta)k_{t-1} + i_t, \tag{2}$$

where δ represents the depreciation rate and i represents the gross investment. We assume that the deprecation rate is exogenous and constant across time. This value is followed by Ogawa et al. (1996).

Similarly, the law of motion for the workers becomes:

$$n_t = (1 - \psi_t)n_{t-1} + h_t, \tag{3}$$

where ψ represents the separation rate of workers and h represents gross hiring. Unlike the depreciation rate, the quit rate is published data and varies across time. Merz and Yashiv (2007) emphasize the importance of using gross values as opposed to net hiring flows showing the difference in stochastic properties between these two series. Further, Hamermesh (1995) finds that gross hiring is especially important in the determination of labor adjustment costs. Therefore, we have also used gross terms here.

The firm's dividends are calculated as follows:

$$d_t \equiv (1-\tau_t)[f(a_t, n_t, m_t, k_t) - w_t n_t - p_{m,t} m_t - g(i_t, k_t, h_t, n_t)] - i_t, \tag{4}$$

where τ is the corporate income tax rate, w is the wage per worker, and p_m is the price of material goods. We normalize the capital goods price to one. The function g is an adjustment costs function, which meets the strictly convex and constant returns to scale property. This type of costs is derived from recruiting, training, planning, installation, learning, etc. (See Hamermesh and Pfann (1996))

Since the variable m is freely adjustable, we can also derive the reduced form from the optimization of m. Several previous works have adopted this formula. In this formula, operating revenue y is replaced with value added (*cf.* $y = f(a, n, k)$). We do not use this formula for the following two reasons. First, our database does not cover the data on value added. Therefore, we must retrieve it from the observed data. As our dataset does not have enough information for calculating value added, we cannot construct this variable with precision. This leads to the problem of mis-measurement.[2] Second, as seen in Gilchrist and Himmelberg (1995) and Cooper and Haltiwanger (2006), profit indicators such as value added potentially encompass the measurement error. That is, some parts of the adjustment costs take the form of purchased goods or services that are not captured in this type of variable, leading to the problem of double counting. Therefore, our setting is preferable since there is potentially less measurement error involved.

[2]For the same reason, Bond et al. (2003) use real sales as a proxy for output (see page 157).

The firm's objective function is the present value of future dividends:

$$\max_{\{h_{t+j}, m_{t+j}, i_{t+j}\}} E_t \sum_{j=0}^{\infty} \left(\prod_{i=0}^{j} \frac{1}{1 + r_{t+i-1}} \right) d_{t+j}, \tag{5}$$

where r represents the required rate of return and E_t denotes the expectation operator conditional on information available in period t. The representative firm chooses sequences of h_{t+j}, m_{t+j}, and i_{t+j} in order to maximize this objective function, subject to the definition of d_{t+j} and the constraints (2) and (3).

The first-order necessary conditions for capital and labor are summarized as:

$$g_{i_t} + \frac{1}{1 - \tau_t} = E_t \Big[f_{k_t} - g_{k_t} + \left(\frac{1 - \tau_{t+1}}{1 - \tau_t} \right) \left(\frac{1 - \delta}{1 + r_t} \right) \left(g_{i_{t+1}} + \frac{1}{1 - \tau_{t+1}} \right) \Big], \tag{6}$$

$$g_{h_t} = E_t \left[f_{n_t} - w_t - g_{n_t} + \left(\frac{1 - \tau_{t+1}}{1 - \tau_t} \right) \left(\frac{1 - \psi_{t+1}}{1 + r_t} \right) g_{h_{t+1}} \right], \tag{7}$$

where f_x denotes the marginal product of raising variable x and g_x denotes the marginal adjustment cost of raising variable x. Equation (6) states that the marginal cost of investment is equal to the expected marginal profits from this investment. Similarly, Equation (7) states that the marginal cost of hiring is equal to the expected marginal profit from hiring. Note that the right hand sides of these equations are the expected values given the information at time t. Therefore, ex post, the above conditions do not hold. These ex post errors are not predictable at time t, so these terms are orthogonal to any variable in the information set at time t. This property leads to the fundamental principle of our estimation method.

3 Estimation

3.1 Parameterization

To estimate the Euler equations for capital and labor, we must specify the relevant functions. For the production function, we use the standard Cobb-Douglas function:

$$f(a_t, n_t, m_t, k_t) = a_t n_t^{\alpha} m_t^{\beta} k_t^{1-\alpha-\beta}. \tag{8}$$

For the adjustment costs function, we adopt the following specification:

$$g(\cdot) = \frac{e_1}{2}\left(\frac{i_t}{k_t}\right)^2 k_t + \frac{e_2}{2}\left(\frac{h_t}{n_t}\right)^2 n_t + e_3\left(\frac{i_t}{\sqrt{k_t}}\frac{h_t}{\sqrt{n_t}}\right). \tag{9}$$

This function has several important properties. First, it is linearly homogeneous in its arguments i, k, h, n. Second, the third term allows hiring costs and capital adjustment costs to interact. Recent studies such as Merz and Yashiv (2007) and Asphjell et al. (forthcoming) emphasize the importance of the interaction between hiring costs and capital adjustment costs in explaining the joint behavior of hiring and investment. We will also take this term into account and investigate the implications for the complementarity of investment and hiring.

The above specification does not consider any non-convexities of the adjustment costs function. However, some arguments in favor of using convex adjustment costs in aggregate data are presented in the Q-literature. Cooper and Haltiwager (2006) estimate a model with non-convex adjustment costs using plant level data and show that over 80 percent of the aggregate data variation created by a simulation of this estimated model can be accounted by a quadratic adjustment costs model. In addition, from the theoretical viewpoint, Wang and Wen (2012) show that the financial frictions at the firm level can give rise to convex adjustment costs at the aggregate level. They analytically give a micro foundation for using convex adjustment costs in the aggregate data.[3] The studies discussed here assume no adjustment costs for labor. Therefore, strictly speaking, considering both capital and labor adjustments does not straightforward provide these results. However, Hall (2004) investigates this problem in the two-factor adjustment model and shows that the likely biases from this specification error are relatively small.

3.2 Estimation Strategy

Before estimating the Euler equations, we conduct preliminary estimation. We estimate the parameters $\alpha, 1-\alpha-\beta$ in the production function (8). In the steady state or long-run equilibrium of the above model, the following equations hold approximately:

$$\alpha = \frac{w_t n_t}{y_t}, \tag{10}$$

$$1-\alpha-\beta = \left[\frac{(r_t+\delta)}{(1+r_t)(1-\tau_t)}\right]\frac{k_t}{y_t}, \tag{11}$$

where the first term on the right hand side of (11) represents the user cost of capital. (See Hall (2004)) These equations indicate that the parameters in the production function are equal to the cost share in the operating revenues. Note that the above conditions do not hold in the short-run equilibrium due to the adjustment costs for capital and labor. However, they do hold in the long-run equilibrium. Therefore, we can believe that the historical average of the cost share in operating revenues gives consistent estimates for the parameters in the production function.

[3]In addition to the studies discussed here, Thomas (2002) and Khan and Thomas (2003) show that the aggregate effects of non-convex adjustment costs at the plant level are negligible in a general equilibrium setting using a computational manner.

This preliminary task serves the following two purposes. First, estimating many structural parameters simultaneously makes it difficult to get reasonable results. If we fix plausible values for some parameters, we can reasonably estimate the other parameters. (See Cochrane (1996)) Second, (7) contains the non-stationary terms, f_n and w, which make it impossible to estimate the structural parameters consistently in the usual manner. However, if we substitute the preliminary results into (7), we can formulate the equation in stationary terms because of the co-integration between f_n and w.

We can now estimate the Euler equations using Hansen's (1982) Generalized Method of Moments (GMM). As previously stated, ex post errors from the Euler equations are not predictable at time t. That is, these terms are orthogonal to any variable in the information set at time t. Then, the following condition holds:

$$E(j_t \otimes Z_t) = 0, \tag{12}$$

where j_t represents the vector of the expected errors at time t and Z_t is any variable contained in the information set at time t. The expected error vector j_t is given by:

$$j_t^K = g_{i_t} + \frac{1}{1-\tau_t} - \left\{ f_{k_t} - g_{k_t} + \left(\frac{1-\tau_{t+1}}{1-\tau_t}\right)\left(\frac{1-\delta}{1+r_t}\right)\left(g_{i_{t+1}} + \frac{1}{1-\tau_{t+1}}\right)\right\}, \tag{13}$$

$$j_t^N = g_{h_t} - \left\{ f_{n_t} - w_t - g_{n_t} + \left(\frac{1-\tau_{t+1}}{1-\tau_t}\right)\left(\frac{1-\psi_{t+1}}{1+r_t}\right) g_{h_{t+1}} \right\}. \tag{14}$$

Appendix A depicts the first derivatives included in these equations. To estimate the structural parameters, we replace the expected values with actual values and use instrumental variables. The instrumental variables used are constant terms and once, twice, and thrice lagged of the following variables: $\left\{r, \frac{y}{k}, \frac{i}{k}, \frac{h}{n}, \left(\frac{i}{k}\right)^2, \left(\frac{h}{n}\right)^2, \frac{wn}{y}\right\}$.[4] We conduct the augmented Dickey-Fuller test and confirm that these variables are generated by the stationary processes. We calculate iterative GMM estimator, estimating the parameters repeatedly until the weight matrix converges. This method generally outperforms the two-step efficient GMM in terms of the bias and variance in finite samples. (See Ferson and Foerster (1994)) We also calculate the J-statistics from the estimation results and test the overidentifying restrictions. (See Hansen (1982))

4 The Data

We primarily use the Quarterly Report of Financial Statements of Incorporated Business (QRFS) compiled by the Ministry of Finance in Japan. From this database, we choose 11 industries: Manufacturing; Food and Beverages; Pulp, Paper, and Paper Products; Chemicals; Steel; Metal Products; Machinery; Electrical Machinery; Transport Equipment; Wholesale & Retail Trade; and Real Estate. Japan Standard Industrial Classification has changed several times during the sample period, so we focus on the industries where continuous data series can be used. Construction is not included because this group has no information on the quit rate (ψ_t) before 1991. Each industry contains companies capitalized at more than JPY 1 billion. This is because this group is a complete count survey, which enables us to avoid

[4] We drop the time t variable from the instruments for the following reasons. First, in the case of misspecification or mismeasurement, these errors are part of the information set, which contributes to the forecastability. (See Shapiro (1986)) Second, the time t variables such as n_t, k_t are actually influenced by the events occurring at time t. Then, the expectation errors are not orthogonal to the variables during that year. (See Hall (2004))

discontinuity from the renewal of the corporations in the sample.[5] The sample period covers from 1980: I to 2010: IV and the sample size is 124. In the machinery industry, there was a complex change in industrial classification in April 2009. Therefore, we use the sample from 1980: I to 2008: IV. Since our database, QRFS, is quarterly based and is seasonally unadjusted, we include seasonal dummies into (6), (7), and the instrumental variables.[6] Detailed explanation for constructing the variables is given in Appendix B.

Table 1 depicts the descriptive statistics for the key variables. On comparing these statistics among industries, we find the following characteristics. First, the gross investment rate (i/k) shows a similar trend across industries. The mean of this variable is close between manufacturing and non-manufacturing sectors, and the average size of the investment rate is around 0.03. Second, unlike the gross investment rate, the gross hiring rate (h/n) shows a different trend. The average size of the gross hiring rate in manufacturing sectors is around 0.03, and this rate is around 0.05 in non-manufacturing sectors. Third, the capital share of income and the labor share of income are distributed over a wide range. The capital share of income shows the highest value 0.155 in the steel industry and the smallest value 0.010 in the wholesale & retail trade industry. Similarly, the wage share of income shows the highest value 0.163 in the machinery industry and the smallest value 0.035 in wholesale & retail trade.

[5]Ogawa et al. (1996) use the overlapping recording in this database to connect the discontinuous series in a consistent manner. However, our main variable, total number of staff, has no information for this overlapping recording. Therefore, we cannot connect this variable in a consistent manner, which is why we focus on companies capitalized at more than JPY 1 billion.

[6]It is also possible to seasonally adjust each data using X-12-ARIMA program. This approach may have the advantage of saving costs, however, it also implies that the user runs a severe risk of not using the information available most effectively. In order to use the information effectively, seasonality needs to be treated as an integrated part of an econometric analysis. (See Hylleberg (2010))

Next, we compare these statistics with corresponding values in the U.S. economy. We compare our results with the table in Merz and Yashiv (2007). This literature uses the sample from 1976: I to 2002: IV and this term is relatively close to our sample period. This comparison enables us to find the following. First, the gross investment rate shows a similar trend between these two countries. The gross investment rate reported in Merz and Yashiv (2007) has a mean of 0.023 and standard error 0.004. These figures are close to the values in Table 1. Second, unlike the gross investment rate, the gross hiring rate has a different trend. The gross hiring rate in Merz and Yashiv (2007) has a mean of 0.089 and standard error 0.009. These values are different from Table 1. This difference is triggered by the significantly high quit rate in the U.S. as compared to Japan. Specifically, the quit rate in the U.S. is about three times that of Japan. This difference is caused by the institutional distinction between these two countries.

Further, we divide the 11 industries into three groups: Heavy industry (Manufacturing, Metal Products, Machinery, Electrical Machinery, Steel, and Transport Equipment); Light Industry (Food and beverages; Pulp, Paper, and Paper Products; and Chemicals); and Non-manufacturing (Wholesale & Retail Trade and Real Estate). This classification is based on Hori (1997) and is useful to interpret the estimation results for the adjustment costs function.

5 Estimation Results

We introduce the estimation results in three steps. First, we present the estimates of a simple quadratic capital adjustment costs model, assuming that the parameters e_2 and e_3 are equal to zero. Second, we show the estimates of a standard quadratic labor adjustment costs model, assuming that the parameters e_1 and e_3 are equal to zero. Each of these approaches considers only one side of the Euler equations. We then give the estimates of the most general formulation, which considers both labor and capital adjustments simultaneously. We admit that the parameters e_1, e_2, and e_3 are not equal to zero and estimate both the Euler equations simultaneously. While the third estimation nests the others, it is useful to introduce the other estimations because we can compare our estimation results across estimation methods.

5.1 Quadratic capital adjustment costs model

Table 2 reports the estimation results for the basic quadratic capital adjustment costs model. We estimate the investment Euler equation (6) by considering that the parameters e_2 and e_3 are equal to zero.

From Table 2, we can find the following. In 6 out of the 11 industries, the capital adjustment costs parameter (e_1) is critically estimated at 5% significance level and the sign of this parameter is positive. These industries are pulp, paper, and paper products; steel; electrical machinery; transport equipment; wholesale & retail trade; and real estate. The estimated values (e_1) range from 0.103 to 0.986. For other industries, this parameter is not critically estimated and can be regarded as zero. From the J-statistics and the associated P-values, the overidentifying restrictions are not rejected at any significance level for all the industries. From these results, we can conclude that the estimation results for the basic quadratic capital adjustment costs model are good in their performance.

To visualize these findings, Figure 1 shows the distribution of the estimates (e_1) across industries. This figure is followed by Hall (2004). Each diamond describes the estimates of the quadratic adjustment costs parameter. The horizontal position of the diamond shows the precision of the estimate. This precision is measured as the reciprocal of the standard errors. The solid curving lines mark a 5% significance level. From this figure, we can observe that the capital adjustment costs are relatively small and that they are not statistically different from zero in half of the industries.

5.2 Quadratic labor adjustment costs model

Table 3 depicts the estimates of a standard quadratic labor adjustment costs model. We estimate the employment Euler equation (7) by assuming that the parameters e_1 and e_3 are equal to zero.

Following points can be noted from the table. In 5 out of the 11 industries, the labor adjustment costs parameter (e_2) is critically estimated at 5% significance level and the sign of this parameter is positive. These industries are manufacturing, food and beverages, steel, electrical machinery, and transport equipment. In most of the other industries, this value is not significantly estimated and can be regarded as zero. Only in wholesale & retail trade, this parameter is critically and negatively estimated. This estimation result is not consistent with the theoretical model because theoretically the parameter (e_2) must have a positive value. This badness of fit is possibly caused by ignoring the interaction between capital and labor adjustment. We clarify this point in the next section. Finally, the J-statistics and the P-values show that the overidentifying restrictions are not rejected at any significance level for all industries. We can conclude that the estimation results for the standard labor adjustment costs model are good in their performance except for wholesale & retail trade. Figure 2 indicates the distribution of the estimates (e_2) across industries. From this figure, we can find that similar to the case of the capital adjustment costs model, the labor adjustment costs are relatively small and that they are not different from zero for many industries.

5.3 General formulation

Table 4 depicts the estimates of the most general formulation, which considers both labor and capital adjustments simultaneously. We admit that the parameters e_1, e_2, and e_3 are not equal to zero and estimate the investment and employment Euler equations simultaneously.

The following points can be noted from the table. (i) Only two industries do not satisfy the parameter constraints (chemicals and metal products). (ii) The parameter e_1 is significantly and positively estimated in nine industries (manufacturing; food and beverages; pulp, paper, and paper products; steel; machinery; electrical machinery; transport equipment; wholesale & retail trade; and real estate). (iii) The parameter e_2 is significantly and positively estimated in eight industries (manufacturing, food and beverages, steel, machinery, electrical machinery, transport equipment, wholesale & retail trade, and real estate). (iv) The interaction term e_3 is both positively and negatively estimated. (v) The J-statistics show that the overidentifying restrictions are not rejected at any significance level for all industries. We give some comments on these points below.

First, points (i) and (v) insist that the structural estimation in this general setting is valid for many industries. Only two industries do not satisfy the parameter constraints. Other industries have positive capital or labor adjustment costs. The negative sign of the parameters in chemicals and metal products is possibly due to the complexity in this estimation. The calculation of the estimates is more complex than the previous estimations in the following two ways. First, we now consider the interaction term (e_3) between investment and hiring adjustment costs, making the estimated equations more nonlinear. Second, we now consider the two Euler equations simultaneously, complicating the standard errors calculation. The amount of computation increases in the square.

Next, points (ii) and (iii) insist that the number of industries with positive adjustment costs increases once we take into account the interaction between labor and capital adjustments. Wholesale & retail trade has negative adjustment costs in the previous section, but this badness of fit improves once we consider the interaction. This finding indicates that the estimation results for the investment and employment Euler equations are affected by neglecting the other factor adjustment costs. Interestingly, this finding is also observed in some previous works. Bloom (2009) estimated the labor and capital adjustment costs using SMM and found that ignoring capital adjustment costs leads to substantial bias in labor adjustment costs. Similarly, Asphjell et al. (forthcoming) find that single factor demand models (capital or labor) yield inaccurate estimates of the parameters of adjustment costs functions.

Third, point (iv) insists that there are various adjustment costs patterns in the Japanese industry. If the interaction term e_3 has positive values, then corresponding adjustments become more costly. On the other hand, if the interaction term e_3 has negative values, then corresponding adjustments reduce in cost. In Japan, this interaction term can be positive or negative by industry. That is, both substitutability and complementarity exist between investment and hiring. Merz and Yashiv (2007) and Yashiv (2011) also estimate this interaction term. According to their estimates, this interaction term is negatively signed, which implies complementarity between investment and hiring. This point of difference between the U.S.

and Japan is possibly based on the aggregation of the industry or the institutional difference between these two countries.

6 Quantitative Analysis

We can construct the time series for total and marginal adjustment costs by substituting the point estimates into (9). In chemicals and metal products industries, we cannot calculate these costs because the parameters are not reasonably estimated. Alternatively, we use the results in Tables 2 and 3. According to these results, the adjustment costs for capital and labor are not critically estimated, so we assume that these costs are zero in these two groups. Table 5 and Figure 3 show these results.

6.1 Comparison among industries

From Figure 3, we can observe that factor adjustment costs are diverse in Japanese industries. High adjustment costs are observed in steel and transport equipment. Middle adjustment costs are observed in food and beverages, machinery, electrical machinery, wholesale & retail trade, and real estate. Low adjustment costs are observed in chemicals; pulp, paper, and paper products; and metal products. It can be noted that light industries and non-manufacturing industries have relatively low adjustment costs and heavy industries have relatively large adjustment costs. In particular, the adjustment costs for steel and transport equipment is large.

Such industry specific adjustment costs have not been studied before. Although Hall (2004) estimates both capital and labor adjustment costs using industry specific data, he concludes that the variety of capital and labor adjustment costs is attributed to pure sampling errors. Interestingly, the Top 3 industries with large adjustment costs in Hall (2004) are as follows: other transport equipment, instruments and related products, and water transportation for capital adjustment costs; and transport equipment, electrical & electronic equipment, and instruments for labor adjustment costs. Therefore, many industries with large adjustment costs are also in the heavy industry category.

Our finding leads to the following proposition: heavy industry needs relatively large adjustment costs. Why do these industries need such large adjustment costs? Here, we provide one explanation. To answer the question of large capital adjustment costs, we can refer to the types of physical capital stock such as building, equipment, machinery, automotive equipment, etc. Heavy industry will need relatively large-scale capital stock and this leads to large adjustment costs because of the long installation time. For the large labor adjustment costs, we can refer to the type of the workers. There are roughly two types of workers: the high skilled and the low skilled workers. Heavy industry will need many high skilled workers because the production operation needs relation-specific ability.

We believe that this explanation will be useful in directly analyzing the factor adjustment costs. Our measure of factor adjustment costs is categorized as indirect inference since we analyze the qualitative feature of the factor adjustment costs indirectly using the dynamics of investment and hiring. Another method called the direct inference method collects the data associated with the adjustment costs and measures the adjustment costs directly using this data. Blatter et al. (2012) estimate the labor adjustment costs using this direct method. They use Swiss administrative firm level survey data and show that the structure of hiring costs is convex and that the marginal hiring costs reach up to 24 weeks of wage payments.

Although this type of research is very limited due to reasons of data availability, we believe that such research will increase in the future due to data dissemination and scientific needs. Strictly speaking, the indirect method cannot answer how the factor adjustment costs are determined, whereas the direct method can answer this question. This type of research must be conducted more frequently to analyze the mechanism of factor adjustment costs. We intend to take this up in the future.

6.2 Comparison with the literature

Section 1 discussed some studies in the literature that analyze both capital and labor adjustments using U.S. aggregate data. In this section, we introduce the qualitative feature of factor adjustment costs reported in these studies and compare them with our results. As stated in Section 3, the quit rate in Japan is very low compared to the U.S. economy and this difference can lead to different factor adjustment cost structures. We can confirm this hypothesis by comparing our results with studies on the U.S. economy.

First, we focus on the adjustment costs for capital. Shapiro (1986) estimates the parameter e_1 between 0.0013 and 0.250 and this point estimate leads to the marginal adjustment costs for capital, which is 0.7 percent of the output for the quarter. He concludes that his low adjustment costs are more plausible than previous works that use the traditional q approach. Hall (2004) estimates the parameter e_1 using industry specific data and concludes that the variety of capital adjustment costs parameter arises from pure sampling errors and that his estimates of capital adjustment costs are very small.

Recently, Merz and Yashiv (2007) and Yashiv (2011) estimated this value using a more general formulation, in which the adjustment costs function is not necessarily quadratic and it can become a higher-order function. According to their estimates, the adjustment costs for capital seem to be large. The marginal cost of investment is between 0.72 and 1.31, expressed in terms of average output per capital. They also report the estimation results, which assume the usual quadratic adjustment costs function. In this formula, they report the parameter value e_1 between 144 and 152. Therefore, from this result, we can also find that their estimates for the capital adjustment costs are larger than those in previous works such as Shapiro (1986) and Hall (2004).

Our estimation results for the capital adjustment costs are summarized in the third column of Table 5. It is noted that the values for the capital adjustment costs range from 0% to 4.9%, expressed in terms of average sales per capital. We cannot directly compare these values with the results of Merz and Yashiv (2007) and Yashiv (2011) because the variable in the denominator is different. While we use operating revenues as the denominator, they use value added. Even if we take this difference into account, we can confirm that our estimates for the capital adjustment costs are relatively small compared to the results in these two studies in the literature. We conclude that our estimation results for the capital adjustment costs are classified into low adjustment costs such as those of Shapiro (1986) and Hall (2004).

Next, we focus on the adjustment costs for labor. Shapiro (1986) estimates the parameter value e_2 by distinguishing between the production and non-production workers and concludes that the cost of adjusting production workers is insubstantial and the cost of adjusting non-production workers is 1.8 percent of output for the quarter. Hall (2004) estimates this value at a very low level, similar to the case of the capital adjustment costs. His estimation results suggest that the parameter e_2

is not significantly estimated in all industries and that variety in labor adjustment costs parameter arises from pure sampling errors. Merz and Yashiv (2007) and Yashiv (2011) estimate this value at a higher level and conclude that these values are the same as 2 quarters (24 weeks) or 5 weeks of wage payments. [7]

Our estimation results for the labor adjustment costs are summarized in the last column of Table 5. Combining the values for the marginal labor adjustment costs with the descriptive statistics for wn/f, we can evaluate our estimation results in wage payments basis. From this calculation, it turns out that the values for the labor adjustment costs range from 0 to 4 weeks of wage payments. These values are close to the results in Yashiv (2011). We can conclude that our estimation results for the labor adjustment costs are classified into the middle adjustment costs category such as Yashiv (2011).

Finally, we refer to the connection between capital adjustment costs and labor adjustment costs. On comparing our estimation results with previous works, we can find that the ratio of labor adjustment costs in total adjustment costs tends to be higher in Japan than the U.S. This is obvious in the following industries: manufacturing, steel, machinery, electrical machinery, and wholesale & retail trade. This high ratio of labor adjustment costs in total adjustment costs may reflect the institutional difference between the U.S. and Japan in that the Japanese conservative employment practices probably make it more costly to adjust the number of employees due to its high adjustment costs. As mentioned before, in order to precisely check this phenomenon, we must conduct direct inference of the factor adjustment costs, since this is the only approach that reveals the mechanism

[7] As already mentioned, Blatter et al. (2012) show that the marginal hiring costs reach up to 24 weeks of wages using the direct inference method. Their samples are based on annual data, so the value of 24 weeks of wages is equal to 6 weeks of wages in a quarter.

of the factor adjustment costs. However, through our analysis, we can find that institutional differences such as longer-term employment or low rates of turnover probably affect the quantity of factor adjustment costs.

7 Conclusion

In this paper, we estimate both capital and labor adjustment costs using industry data from Japan. A comparison of these costs across industries revealed that the heavy industry needs relatively large adjustment costs. We have explained this phenomenon by referring to the type of capital stock and the type of workers needed. Furthermore, a comparison of these costs between the U.S. and Japan revealed that the ratio of labor adjustment costs in total adjustment costs tends to be higher in Japan than in the U.S. These findings will be useful while considering the mechanism of factor adjustment costs, particularly the direct measurement of factor adjustment costs. Although this approach provides a deeper understanding of the mechanism of factor adjustment costs, such research is limited because of data unavailability. We aim to tackle this limitation in our future studies.

Appendix A

This appendix shows the results of the first derivatives of the adjustment costs function. The adjustment costs function is the following:

$$g(\cdot) = \frac{e_1}{2}\left(\frac{i_t}{k_t}\right)^2 k_t + \frac{e_2}{2}\left(\frac{h_t}{n_t}\right)^2 n_t + e_3\left(\frac{i_t}{\sqrt{k_t}}\frac{h_t}{\sqrt{n_t}}\right).$$

The first derivatives on i, k, h, n are calculated as:

$$
\begin{aligned}
g_{i_t} &= e_1 \frac{i_t}{k_t} + e_3 \frac{h_t}{\sqrt{k_t n_t}}, \\
g_{k_t} &= -\frac{e_1}{2}\left(\frac{i_t}{k_t}\right)^2 - \frac{e_3}{2}\frac{i_t}{k_t}\frac{h_t}{\sqrt{k_t n_t}}, \\
g_{h_t} &= e_2 \frac{h_t}{n_t} + e_3 \frac{i_t}{\sqrt{k_t n_t}}, \\
g_{n_t} &= -\frac{e_2}{2}\left(\frac{h_t}{n_t}\right)^2 - \frac{e_3}{2}\frac{h_t}{n_t}\frac{i_t}{\sqrt{k_t n_t}}.
\end{aligned}
$$

Appendix B

This appendix gives information on the data set used in the text. Our data comes mainly from the Quarterly Report of Financial Statements of Incorporated Business (QRFS) compiled by the Ministry of Finance in Japan. They report major items in the balance sheet and the profit and loss statement of industries. The following 11 industries are chosen here: manufacturing; food and beverages; pulp, paper, and paper products; chemicals; steel; metal products; machinery; electrical machinery; transport equipment; wholesale & retail trade; and real estate. The subsections below describe the construction of the variables in detail.

Construction of capital stock

The series of physical depreciable capital stock is constructed using the perpetual inventory method, as discussed in Hayashi and Inoue (1991). The main data set is based on QRFS. Our benchmark capital stock is that of the first quarter of 1970. We assume that the book value in this quarter is equal to the capital stock in terms of the replacement cost basis. We use the tangible fixed assets in this report. We exclude land and construction in progress in constructing our series of depreciable capital stock. The physical per annum depreciation rates are based on Ogawa et al. (1996) (manufacturing 0.0774; food and beverages 0.0735; pulp, paper, and paper products 0.0808; chemicals 0.0778; steel 0.0805; metal products 0.0792; machinery 0.0786; electrical machinery 0.0720; wholesale & retail trade 0.0692; and real estate 0.0519). Given the benchmark capital stock, we obtain the capital stock series from the following equation:

$$K_t = (1 - \delta)K_{t-1} + I_t,$$

where K_t is real capital stock at the end of period t and I_t is real investment in period t. In order to get real terms, we deflate nominal terms using the Corporate Goods Price Index (2005 Base), which is an index of Stage of Demand and Use measured by capital goods. This data is based on a survey by Bank of Japan.

Construction of gross hiring

First, we take the average number of officers and employees during the period as a measure of employment (n) from QRFS. Second, we take the separation rate (ψ_t) for each industry from the Survey on Employment Trend (SET) compiled by the Ministry of Health, Labour and Welfare. Since the separation rate reported here is annual data, we interpolate to obtain quarterly data. Then, we obtain the gross hiring flows (h) in the following manner:

$$h_t = n_t - (1 - \psi_t)n_{t-1}.$$

Construction of wage series

We divide total labor costs into the number of employees (n). The total cost of labor is based on QRFS and is calculated as the sum of the following: wage for officers and employees, bonus for officers and employees, and welfare expenses. Further, the welfare expenses are divided into legal and non-legal expenses. We deflate nominal labor costs using the Corporate Goods Price Index (2005 Base), which is an index of Stage of Demand and Use measured by capital goods.

Construction of revenue

We obtain operating revenue from QRFS, and deflate these series using the Corporate Goods Price Index (2005 Base), which is an index of Stage of Demand and Use measured by capital goods.

Construction of corporate tax rate

Necessary data are taken from the Annual Statistics of National Tax Administration.

Construction of the discount rate

First, we construct the nominal interest rate as follows:

$$i = \frac{\text{Interest Expenses}}{\text{Long term loans payable+short term loans payable+corporate bonds}}$$

These data series are based on QRFS. Second, we calculate the real interest rate using the Corporate Goods Price Index (2005 Base), which is an index of Stage of Demand and Use measured by capital goods. We use this variable as the time-varying discount rate considering the tax savings of the firm's debt.

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Table 1: Descriptive Statistics

industry	i/k	h/n	y/k	$\frac{(r+\delta)k}{(1+r)(1-\tau)y}$	$\frac{wn}{y}$	ψ
manufacturing	0.029	0.031	0.645	0.071	0.120	0.030
	(0.007)	(0.016)	(0.084)	(0.014)	(0.014)	(0.002)
food and beverages	0.030	0.041	0.900	0.050	0.095	0.038
	(0.010)	(0.024)	(0.182)	(0.011)	(0.009)	(0.003)
pulp, paper, and paper products	0.027	0.023	0.368	0.127	0.107	0.026
	(0.015)	(0.024)	(0.060)	(0.024)	(0.011)	(0.001)
chemicals	0.027	0.025	0.553	0.083	0.126	0.026
	(0.007)	(0.018)	(0.070)	(0.018)	(0.019)	(0.001)
steel	0.022	0.018	0.330	0.155	0.127	0.026
	(0.013)	(0.019)	(0.090)	(0.050)	(0.031)	(0.001)
metal products	0.030	0.027	0.591	0.080	0.148	0.026
	(0.013)	(0.030)	(0.079)	(0.015)	(0.017)	(0.001)
machinery	0.033	0.030	0.840	0.057	0.163	0.028
	(0.011)	(0.024)	(0.158)	(0.015)	(0.024)	(0.002)
electrical machinery	0.035	0.029	0.702	0.064	0.139	0.028
	(0.013)	(0.023)	(0.165)	(0.012)	(0.021)	(0.003)
transport equipment	0.032	0.029	0.740	0.062	0.118	0.028
	(0.010)	(0.016)	(0.113)	(0.013)	(0.010)	(0.003)
wholesale & retail trade	0.033	0.051	4.873	0.010	0.035	0.041
	(0.009)	(0.033)	(2.344)	(0.003)	(0.012)	(0.003)
real estate	0.031	0.052	0.319	0.114	0.065	0.045
	(0.020)	(0.068)	(0.094)	(0.037)	(0.016)	(0.007)

Note. Values in parentheses are standard errors. The sample size is 124.
Observations are from 1980:I to 2010 IV.

Table 2: Estimates of the Investment Euler Equation

industry	e_1	J-statistic	P-value
manufacturing	0.102 (0.073)	17.14	0.702
food and beverages	-0.024 (0.107)	21.52	0.427
pulp, paper, and paper products	0.103 (0.041)	21.07	0.454
chemicals	-0.062 (0.157)	16.83	0.720
steel	0.182 (0.043)	16.34	0.749
metal products	-0.040 (0.041)	17.01	0.710
machinery	0.138 (0.079)	20.00	0.520
electrical machinery	0.281 (0.065)	20.11	0.514
transport equipment	0.484 (0.112)	20.38	0.497
wholesale & retail trade	0.986 (0.173)	22.49	0.371
real estate	0.113 (0.024)	15.67	0.787

Note. The instrumental variables are constant term, seasonal dummies and once, twice, and thrice lagged of the following variables: $\left\{r, \frac{y}{k}, \frac{i}{k}, \frac{h}{n}, \left(\frac{i}{k}\right)^2, \left(\frac{h}{n}\right)^2, \frac{wn}{y}\right\}$. Values in the parentheses are SEs. The GMM weighting matrix is updated following the formulation of Newey and West (1987).

Table 3: Estimates of the Employment Euler Equation

industry	e_2	J-statistic	P-value
manufacturing	3.532 (1.137)	19.08	0.579
food and beverages	2.373 (0.556)	19.94	0.524
pulp, paper, and paper products	0.204 (0.653)	20.51	0.488
chemicals	-2.084 (1.274)	19.89	0.527
steel	10.57 (3.605)	19.83	0.532
metal products	0.356 (0.290)	21.37	0.436
machinery	0.529 (0.427)	21.89	0.405
electrical machinery	4.579 (0.948)	21.38	0.435
transport equipment	5.096 (1.159)	14.34	0.854
wholesale & retail trade	-6.952 (1.273)	25.23	0.237
real estate	-0.176 (0.296)	22.60	0.365

Note. The instrumental variables are constant term, seasonal dummies and once, twice and thrice lagged of the following variables: $\left\{r, \frac{y}{k}, \frac{i}{k}, \frac{h}{n}, \left(\frac{i}{k}\right)^2, \left(\frac{h}{n}\right)^2, \frac{wn}{y}\right\}$. Values in the parentheses are SEs. The GMM weighting matrix is updated following the formulation of Newey and West (1987).

Table 4: Estimates of both Euler Equations

industry	e_1	e_2	e_3	J-statistic	P-value
manufacturing	0.398	9.001	0.404	25.80	0.969
	(0.060)	(1.190)	(0.145)		
food and beverages	0.605	3.634	0.461	25.52	0.972
	(0.103)	(0.436)	(0.112)		
pulp, paper, and paper products	0.145	0.237	-0.205	26.50	0.961
	(0.020)	(0.359)	(0.057)		
chemicals	-1.538	-22.88	-4.720	26.78	0.957
	(0.165)	(2.418)	(0.521)		
steel	0.218	7.808	1.278	22.88	0.990
	(0.026)	(1.301)	(0.142)		
metal products	-0.022	-0.424	-0.312	25.09	0.976
	(0.031)	(0.257)	(0.071)		
machinery	0.189	2.328	0.480	25.31	0.974
	(0.037)	(0.300)	(0.090)		
electrical machinery	0.143	3.843	-0.017	27.63	0.945
	(0.035)	(0.647)	(0.051)		
transport equipment	0.879	4.281	1.160	24.59	0.980
	(0.087)	(1.080)	(0.230)		
wholesale & retail trade	0.356	9.173	-1.011	28.38	0.932
	(0.125)	(0.882)	(0.117)		
real estate	0.068	0.923	0.405	27.12	0.953
	(0.013)	(0.291)	(0.058)		

Note. The instrumental variables are constant term, seasonal dummies and once, twice and thrice lagged of the following variables: $\left\{r, \frac{y}{k}, \frac{i}{k}, \frac{h}{n}, \left(\frac{i}{k}\right)^2, \left(\frac{h}{n}\right)^2, \frac{wn}{y}\right\}$. Values in the parentheses are SEs. The GMM weighting matrix is updated following the formulation of Newey and West (1987).

Table 5: Value of the adjustment costs

industry	g/f	$g_i/(f/k)$	$g_h/(f/n)$
manufacturing	0.0009	0.023	0.030
	(0.0007)	(0.004)	(0.018)
food and beverages	0.0008	0.026	0.015
	(0.0007)	(0.007)	(0.008)
pulp, paper, and paper products	0.0001	0.008	-0.002
	(0.0001)	(0.006)	(0.001)
chemicals	0	0	0
	—	—	—
steel	0.0006	0.026	0.026
	(0.0007)	(0.015)	(0.017)
metal products	0	0	0
	—	—	—
machinery	0.0005	0.013	0.015
	(0.0005)	(0.005)	(0.008)
electrical machinery	0.0004	0.006	0.013
	(0.0006)	(0.001)	(0.013)
transport equipment	0.0012	0.049	0.023
	(0.0007)	(0.012)	(0.011)
wholesale & retail trade	0.0005	-0.001	0.013
	(0.0007)	(0.004)	(0.012)
real estate	0.0005	0.015	0.007
	(0.0007)	(0.014)	(0.005)

Note. These values are computed using the point estimates in Table 4. The adjustment costs function used is Equation (9). The values in the first row represents the average of the factor adjustment costs and the values in the parentheses are SEs.

Figure 1: Distribution of the capital adjustment costs parameter (e_1)

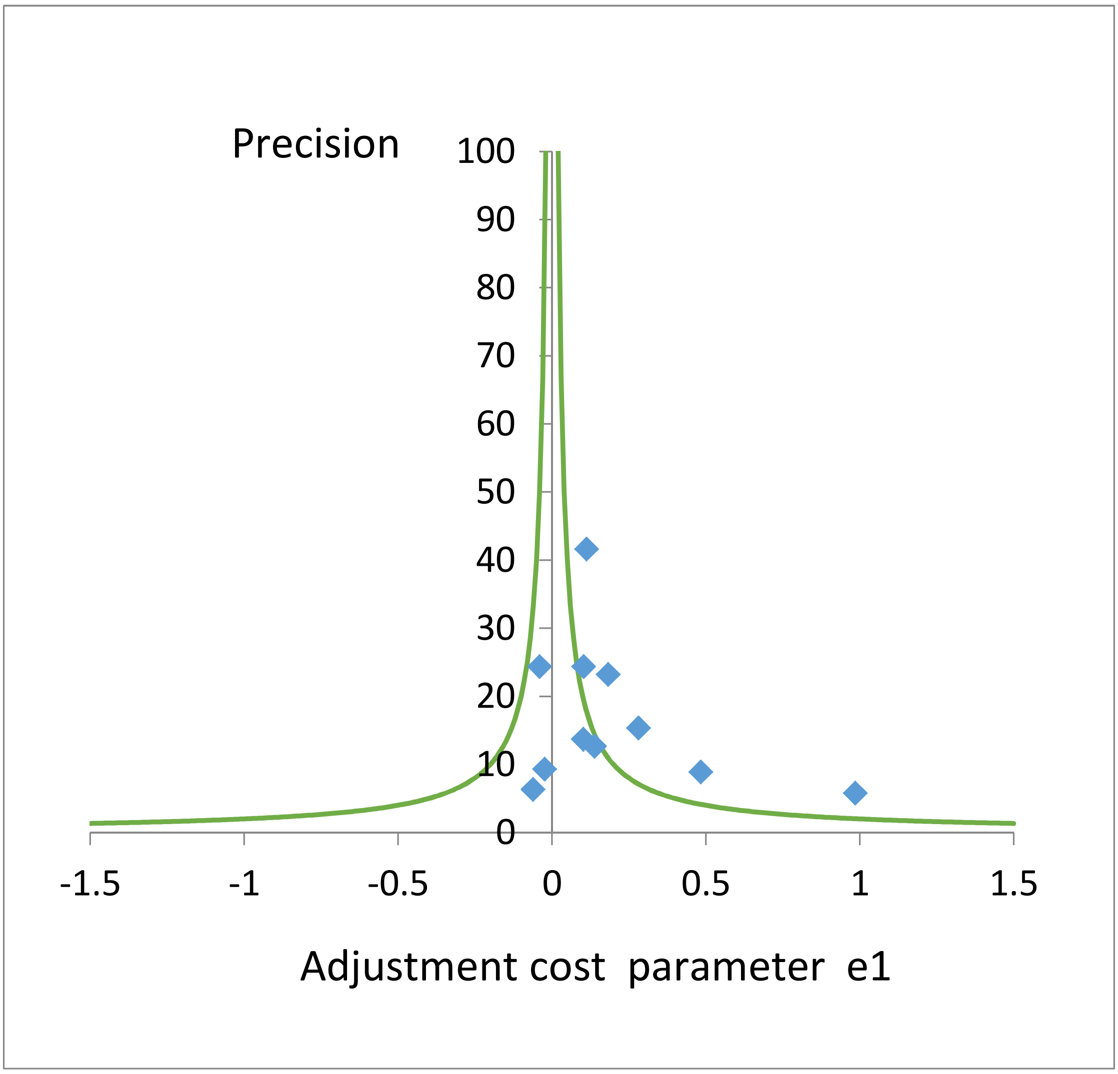

Figure 2: Distribution of the labor adjustment costs parameter (e_2)

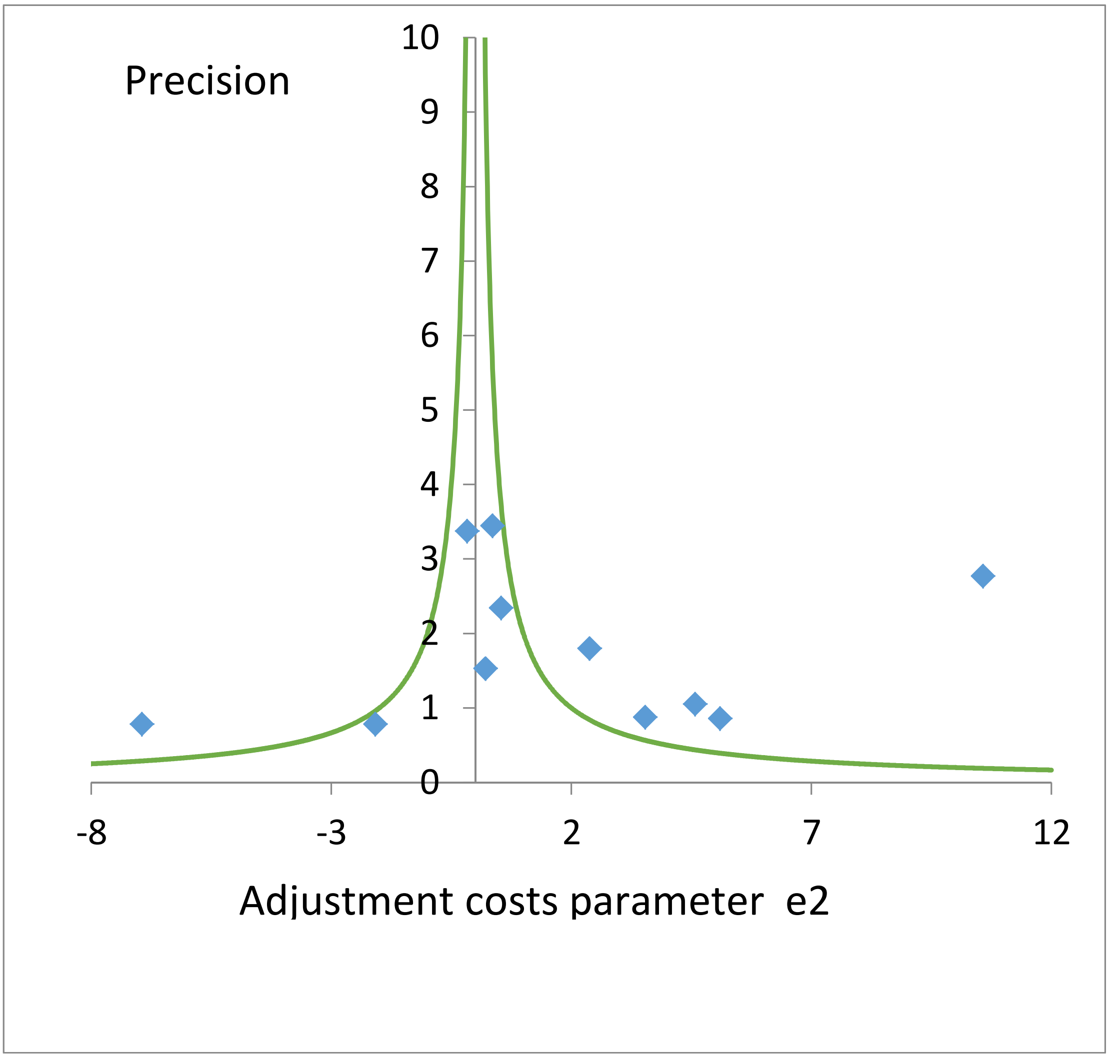

Figure 3: Diversity of the factor adjustment costs