Dynamic Labor Demand Estimation and Stability of Coefficients - The Case of the Czech Republic

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Abstract:

Estimates of the dynamic labor demand equation, derived from a cost-minimization model of monthly data from Czech firms from 1992 to 1993, are presented together with derived long-term elasticities. The different sets of instruments have been used and the tests of exogeneity carried out. The stability of the parameters and long-term elasticities between 1992 and 1993 have been tested. The low significant estimates of short and long-term elasticities, robust with respect to choice of instruments, suggest the possibility of labor hoarding.
Keywords: labor demand, estimation, monthly panel data, firm.

Abstrakt:

Odhady parametrů dynamické rovnice odvozené od modelu minimalizace nákladů odhadované pro ČR na firemních měsičních datech z let 1992 a 1993 datech spolu s odhady dlouhodobých pružností jsou prezentovány v tomto materiálu. Pro ověření vlastností odhadů byly provedeny testy exogenity a použity různé množiny instrumentů stejně, jako byly provedeny testy stability parametrů rovnice a dlouhodobých elasticit mezi roky 1992 a 1993. Nízké, ale signifikantní odhady krátkodobých i dlouhodobých pružností, které byly robustní vzhledem k volbě instrumentů, vedou k hypotéze o hromadění pracovní síly (labor hoarding).

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1. Introduction

In this work I present parameter estimates of a labor demand function derived from a dynamic optimization model with adjustment costs. The estimates are unique in two respects: they are based on large, firm-level panels of monthly data which come from an economy undergoing a rapid and successful transition from central planning to a market system -- the Czech Republic.

Labor demand estimates based on monthly data from a large number of firms have been virtually nonexistent. The first studies, published in the early 1960s, estimate a dynamic model of labor demand on aggregate annual or quarterly data.[1] From the late 1970s onward, the number of studies based on aggregate data increased dramatically as indicated by Hamermesh's 1993 representative survey. Nickell's 1984 study is probably the most influential. It contains the derivation of the most common specifications resulting from cost minimization under rational expectations and the corresponding econometric methodology. Although the derivation of the empirical specification in Nickell [1984] is based on a model of a representative firm (the model needs additional assumptions to hold on aggregated data), there were no micro-level counterparts of studies based on aggregate data for a number of years. The first micro studies (e.g. Nickell and Wadhwani [1987], Brown and Ashenfelter [1986]) were published in the second half of the 1980s.[2] The number of studies estimating labor demand parameters on firm-level data has grown in recent years, but studies based on monthly or quarterly data are still missing. Hamermesh's 1993 survey cites only one study which uses quarterly firm-level data on seven firms (Card [1986]). Similarly, in a survey of recent studies, Matyas and Sevestre [1992] quote the results of just one that uses monthly data (Hamermesh [1989][3]). The other studies cited by Hamermesh [1993] and Matyas and Sevestre [1992] are based on either aggregated or annual firm-level data. Even the most recently published articles are based on larger, firm-level **annual** panels (Bresson et al [1992], Arellano and Bond [1991], Jaramillo et al [1993], or Prasnikar et al [1994]).

Unfortunately, studies using annual panels of data, while often having a large number of observations, suffer from aggregation over time that smooths the changes in the labor input. As a result, the findings based on annual data have to be interpreted with great caution. In turn, the

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[1]See Brown and De Cani [1963] or Ball and St. Cyr [1966]

[2]Hammermesh [1993] provides an excellent recent survey of these studies and Matyas and Sevestre [1992] present a valuable survey of studies using panel data.

[3]The panel used in this study is again very small; seven plants.

studies based on monthly and quarterly data (Hamermesh [1989] and Card [1986]), suffer from the fact that they use a panel on only seven firms. This does not permit a reliable derivation of conclusions about the general labor demand behavior of firms.

My panel from the Czech Republic represents a notable exception to the rule. The 1992-93 monthly panel data collected by the Czech Statistical Office (CSO) covers almost all industrial firms that were in existence during this period. The data enables us to estimate labor demand equations which allow for complex dynamic processes in labor demand, and capture short-term variations in labor input in a transition economy. (For a comparative study of labor demand in several transition economies based on a simpler specification and annual data see Basu et al. [1995].)

In this study, I first estimate the most common specification of dynamic labor demand for 1992-1993. Then I estimate the same equation separately for each year and test for structural change of parameters. I also test for the exogeneity of predetermined variables and current output and I do not reject their exogeneity.

The study is organized as follows: in Section 2 I discuss the empirical specification of labor demand functions, the instruments and the estimation methodology. The data is described in Section 3 and the results are presented in Section 4. Conclusions and future research topics are discussed in Section 5.

2. Estimated Equations

The estimated equations are based on a standard theory of dynamic labor demand with adjustment costs. Probably the most commonly estimated model begins with the minimization of discounted future costs,

$$Min\ E_t \sum_{\tau=0}^{\infty} \frac{1}{(1+r)^{\tau}} (c_{t+\tau} K_{t+\tau} + w_{t+\tau} L_{t+\tau} + p(\Delta L_{t+\tau})^2 \quad \textbf{(1)}$$

given that production equals demand[4]

$$g(K_{t+\tau}, L_{t+\tau}) = Q_{t+\tau}, \quad \forall \tau, \quad \textbf{(2)}$$

[4] We adopted the assumption that no inventories exist. This assumption is questionable on empirical grounds, but is standard in this type of analysis given the unavailability of data on the stock of inventories and its valuation.

where r denotes interest rate, K capital, c costs of capital, L labor, w wages, p costs of adjustment of labor, e costs of adjustment of capital, and Q output demand.

The model thus assumes that the firm faces quadratic costs of changing employment. The hires and fires are assumed to be fully captured by changes in employment i.e., firms cannot fire and hire simultaneously in one period. This is clearly an unrealistic assumption that is easily criticized (for example, see Hamermesh [1989]), but my sample does not contain data on hires or fires. Also, the particular form of adjustment costs, especially its symmetry, has been the subject of sharp criticism (again see, e. g. Hamermesh [1989]), but the model is considered standard in this type of analysis. Given that monthly changes are not large in comparison to quarterly and annual changes, the assumption of symmetry is not too restrictive in my analysis.

The equation derived under these assumptions is:

$$\log L_t = \mu \log L_{t-1} + \xi \sum_{\tau=0}^{\infty} \psi^{\tau} \log L^*_{t+\tau} \quad , \tag{3}$$

where L, denotes labor, L^* denotes the expectation of the long-term equilibrium level of labor[5], μ, ξ and ψ are parameters. The logarithmic form of the equation is usually derived by a logarithmic approximation of small deviations of actual labor from the long-term equilibrium. The expression for the expected long-term equilibrium of employment is usually formulated as the log-linear form of the expectations of demand, Q, and the ratio of wages, w, and costs of capital (interest rate)[6], c, and a time dummy, d, proxying technological change and other time-specific factors.

$$\log L^*_{t+\tau} = E_t(\varphi_1 \log Q_{t+\tau} + \varphi_2 \log\left(\frac{w}{c}\right)_{t+\tau}) + d_{t+\tau} \quad , \tag{4}$$

If the logs of labor and the ratio of wage and capital costs both follow an AR(1) process, the typical equation derived in terms of observable variables is:

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[5]This is the optimal choice of labor without adjustment costs.

[6]Nickell [1984] provides justification for homogeneity of wages and costs of capital.

$$\log L_t = \mu \log L_{t-1} + \alpha \log Q_t + \beta \log\left(\frac{w}{c}\right)_t + \gamma' D_t + \delta + \omega_t \, , \qquad \textbf{(5)}$$

where D denotes a vector of time dummies, ω is an error and μ, α, β, γ and δ are parameters to be estimated.

This equation has been further generalized. Nickell [1984] has shown that if firms do not treat labor as homogenous, more lagged values of labor should be put into the equation. In the typical case of two groups of workers (e.g., white and blue-collar ones), the equations derived by aggregating labor over the white-collar and blue-collar categories also involve the second lag of the dependent variable.[7] Accounting for this phenomenon leads to the equation:

$$\begin{aligned} \log L_{i,t} &= \mu_1 \log L_{i,t-1} + \mu_2 \log L_{i,t-2} + \alpha_0 \log Q_{i,t} + \alpha \\ &+ \beta_0 \log\left(\frac{w}{c}\right)_{i,t} + \beta_1 \log\left(\frac{w}{c}\right)_{i,t-1} + \gamma' D_t + \delta + \omega \end{aligned} \qquad \textbf{(6)}$$

Since I estimate the model on panel data, I use subscript i in equation (6) to denote firms. In order to make the equation able to be estimated, I need to find information on the capital costs, c_{it}, for an individual firm i in time t. Since such data are virtually unavailable, the usual approach is to approximate the capital costs with time dummies.

Equation (6) can also be derived from a different model. In the absence of adjustment costs, a price setting firm facing a constant elasticity demand curve chooses to set employment according to the static log-linear demand equation with the expected output on the right-hand

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[7]This aggregation over types of labor is necessary, since we do not have data on employment by groups.

side. However, once the formation of expectations and the decision process inside the firm are taken into account, a specification close to (6) again arises (Layard and Nickell [1986]).[8]

The estimation of equation (6) on Czech firm-level panel data suffers from the problems of errors in variables and endogeneity. Firstly, as I have noted, I do not have accurate data on input cost ratios. Therefore, there is the problem of an error in variables. Secondly, the output of individual firms may be endogenous even under the assumption that the aggregate output of the economy is constrained (an assumption which may be realistic for the transitional economies). Thus, equation (6) has to be estimated with 2SLS or GMM estimators.

There are two other issues related to the estimation of equation (6) on panel data. The first is whether the form of the estimated equation is correctly specified or whether one should estimate a more complicated form. The second issue is whether one should estimate the equation on levels or the first differences of variables. I address the first question by estimating longer specifications such as:

$$\log L_{i,t} = \sum_{k=1}^{\kappa} \mu_k \log L_{i,t-k} + \sum_{k=0}^{\kappa-1} \alpha_k \log Q_{i,t-k} + \sum_{k=0}^{\kappa-1} \beta_k \log\left(\frac{w}{c}\right)_{i,t-k} + \gamma' D_t + \delta + \omega_{i,t} \quad , \tag{7}$$

where D denotes a vector of time dummies and $\kappa > 2$. Such forms obviously do not address other possible sources of incorrect specification of functional form such as nonlinearities. Nevertheless, longer specifications seem to be a good starting point with monthly data since the adjustment costs do not need to influence only one period. Firms may also be optimizing more than two categories of labor, and the right hand side variables in equation (4) could therefore follow a more complex AR process. For a number of reasons, longer lags of dependent and right hand side variables may thus belong to the estimating equation. I found, however, that the estimation results did not change significantly.

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[8]See also Hendry and Mison (1978) for a similar approach leading to the derivation of a dynamic equation from a static equation.

The second question has been discussed extensively in recent research. Arellano-Bond [1991], Arellano [1988], Anderson-Hsiao [1982] and especially Keane-Runkle [1992] provide a lucid discussion on the topic and it appears that a consensus is being found on the choice between estimation on levels vs. first differences of variables. Both this choice and the choice of estimation method are generally dependent upon the available instruments and the structure of the error term. The usual assumption about the error structure is that:

$$\omega_{it} = \epsilon_{it} + \eta_i \qquad (8)$$

Suppose one wants to use instruments Z that are not strictly exogenous in the sense that E $Z_{i,t}\omega_{i,s} \neq 0$ for $t \geq s$, but E $Z_{i,t}\epsilon_{i,s} = 0$ for $t<s$. In this case, instruments are to be correlated with the individual components and current white-noise components of error, but their lagged values are not correlated with the white-noise component of error ω. Typical examples are more lagged values of dependent variables once I condition on the individual component in the error. In this case, even lagged values of the dependent variable contain the same individual component and thus are correlated with the error of the estimated equation and therefore cannot be used as instruments.

Another example of the problem arises when variables measured with an error that has an individual component as in the case of the log of input cost ratio. For this case, assume that:

$$\log c_{i,t} = \log r_t + \lambda_i + \nu_{i,t} \quad , \qquad (9)$$

where r_t is the average interest rate in time t, λ_i is the individual factor of firm i (unobservable) and ν_{it} is the error for firm i in time t (which has a mean equal to zero and is uncorrelated with the average interest rate). In other words, I assume that the firm's capital costs differ from the economy-wide interest rate by a constant percentage and multiplicative random error. In this case, should I want to use lagged values as instruments, I would have to estimate on differences.

To summarize, estimation based on first differences of variables is generally considered to be more robust than estimation on levels once I account for all the right-hand side variables which could contain measurement errors in the case of the estimation on levels as well as on differences.

The estimation on differences is often considered less efficient. However, this is true only if the instrumental sets are the same for estimation on both differences and levels. In practice, this is often not the case. My examples showed some cases in which estimation on the first differences enable us to use more instruments than estimators based on levels. Hence nothing can be stated about their relative efficiency. Estimation on differences is also more robust with respect to the near multicollinearity, which is the usual problem in monthly panels.

My initial estimations did not produce significant estimates due to both the low correlation between my instrumental sets of 13 to 55 variables which shall be defined below and instrumented variables. However, point estimates of my parameters did not differ significantly from the values I report in the Section 4. Hence, I decided to interact the instruments with time dummies as in Arellano and Bond [1991], allowing for a change of coefficients in projecting the instrumented variables on instruments in time.

I have three sets of instruments. For each firm, the first set of instruments consists of average monthly data on right hand side variables and sales[9] from another two-digit industry. The pairs of instrumented and instrumenting industries were selected in such a way that I obtained pairs whose values of (differences in) variables were positively correlated. As an example, all steel firms were instrumented with averages from coal. For the exogeneity of monthly averages of other double digit industries with respect to the estimated equation, the independence of errors across firms is required, but this is a commonly accepted assumption.[10] For each variable in the equation I thus used averages of the same variable from another industry as an instrument. The second set of instruments uses average monthly price and output growth indices for double digit industries from Finland and Germany in 1992 and 1993. The German data is a natural choice as Germany is the main trading partner of the Czech Republic. Finland was selected because, among the OECD countries, it was, until 1990, the most dependent on CMEA markets. After the collapse of the CMEA, the conditions faced by Finnish firms resembled those faced by the Czech firms. The third set of instruments consists of labor force per district and active labor market policy data (the numbers of people in re-training, socially purposeful jobs and state-sponsored apprenticeships) at the district level. Re-training and other Czech district-level data are indicative of the state of regional labor markets and, as such, they help us to predict the right hand side variables.[11] In addition, I used predetermined right hand side variables and logs of sales up to t-6

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[9] In addition to output we had data on sales.

[10] We also accounted for changes of industry reported by a firm. If a firm moved from industry A to industry B, industry A averages were never used as instruments for the firm that moved to B.

[11] Note that since we omit industrial and geographical effects in equation (6), the estimation on differences is necessary for validity of these instruments.

as well as trying to treat sales and output variables as exogenous, including them in the instrumental variable sets.

I tried more sets of instrumental variables to assess the robustness of my results. The two smallest sets of instruments for an estimation of equation (6) based on "other industrial averages" and "foreign industrial averages" contain 13 instruments per period. "Other industrial averages" consists of constant and 12 industrial averages from a different industry: average of labor from t-1 to t-4, average of output from t to t-3, average of input costs ratio from t to t-3. "Foreign industrial averages" are formed by constant and 12 growth indexes from Finland and Germany (German and Finnish outputs and Finnish prices from t up to t-3). The widest instrumental set that includes "re-training, foreign industrial averages, predetermined variables, other industrial averages, sales, and outputs" uses 56 instruments: constant, 12 "other industrial averages" defined above, 15 predetermined variables (labor from t-4 to t-6, output sales and input costs ratios from t-3 to t-6), 10 labor policy variables (labor force in district[12], 3 active policy variables from t to t-2), 12 "foreign averages" defined above, sales from t to t-3 and changes in output at t and t-1[13]. The variables in these sets are interacted with monthly dummies. In tables reporting the estimates (discussed in Section 4), I list the sets of instruments under the header of each table.

To simplify the computational burden of my estimation and to avoid the computational errors in an inversion of the resulting block-diagonal matrix of instruments, I calculated my estimates by the following procedure:

1. I estimated predicted values for instrumented variables by regressing them by OLS **separately for each period**.

2. I then ran a normal 2SLS procedure with the predictions from the first step as the instruments Z according the formula,

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[12]Labor force does not usually change within a quarter.

[13]Obviously, the number of predetermined variables decreases for equations using higher lags. On the other hand, we use even more lagged variables from our 3 main instrumental sets (up to t-5 for a 3 lags equation and t-6 for a 4 lags equation).

$$b = (X'Z(Z'Z)^{-1}Z'X)^{-1}X'Z(Z'Z)^{-1}Z'Y = (X'Z)^{-1}Z'Y \qquad (10)$$

By this procedure I obtained exactly the same results as in the case of using the 2SLS estimator with a **block diagonal** matrix of instruments (**instruments interacted with dummies for month**) but without the necessity of working with very large matrices.[14]

$$\begin{aligned} V(b) &= (X'Z(Z'Z)^{-1}Z'X)^{-1}[X'Z(Z'Z)^{-1}\hat{\Omega}(Z'Z)^{-1}Z'X \\ &= (X'Z)^{-1}\hat{\Omega}(Z'X)^{-1} \quad , \\ \textit{where} \quad \hat{\Omega} &= \sum_{i=1}^{N} Z_i' E_i E_i' Z_i \end{aligned} \qquad (11)$$

I further calculated a corrected co-variance matrix,
The estimates E_i are the residuals from 2SLS. This co-variance matrix allows for errors to be correlated over time for a particular firm (which is the consequence of an estimation on differences) as well as for conditional heteroscedasticity of an arbitrary kind. Accordingly, I used this correction for an estimation on differences and levels.

To test for the endogeneity of a subset of instruments, Keane-Runkle [1992] suggest first estimating my parameters of interest with the set of instruments that are supposed to be exogenous with respect to differences. These estimates are maintained to be consistent. The test of consistency of estimates coming from regressions on levels (or regressions on differences using wider sets of instruments) is then carried out by comparing the consistent coefficients with

[14]This type of diagonal matrix of instruments is necessary for obtaining a more efficient estimator with weakly endogenous, predetermined variables used as instruments in panel data (Arellano-Bond [1991]).

tested coefficients with the Hausman tests modified for the case of two inefficient estimators (Hausman [1978]).[15]

3. Data

Since firm-level monthly panels are scarce and my panel represents the first such file from a transition economy, I have reserved some space for the description of the panel. The files cover data on **Czech** industrial firms from 1992-1993. The sample is supposed to contain all industrial firms with more than 25 employees, but it contains some smaller firms as well.[16] The files contain information on output, total sales, export sales, wage bill and labor (total number of employees) as well as the preceding year's values of these variables. In addition, the files contain data on enterprise identification numbers (scrambled), districts,[17] ownership, six digit industrial classifications and two other less important classification variables. Since 1992, files have contained the values of variables which are cumulated from the beginning of the year (i.e. labor reported on file from June 1992 was the average labor from the beginning of 1992 to June) and therefore, before the estimation, they would have had to have been decumulated back. The only values used in the analysis are the current ones and the previous ones from 1993.[18]

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[15]Modified Hausman tests for coefficients b^1 and b^2 use the following formulae for $V(b^1-b^2)$,

where $V(b^1)$ and $V(b^2)$ are calculated as in (11) and

$$Cov(b^1,b^2) = (X^{1'}Z^1(Z^{1'}Z^1)^{-1}Z^{1'}X^1)^{-1}[X^{1'}Z^1(Z^{1'}Z^1)^{-1}\hat{\Omega}^{12}(Z^{2'}Z^2)^{-1}Z^{2'}X^2$$

$$(X^{2'}Z^2(Z^{2'}Z^2)^{-1}Z^{2'}X^2)^{-1} = (X^{1'}Z^1)^{-1}\hat{\Omega}^{12}(Z^{2'}X^2)^{-1},$$

$$where \quad \hat{\Omega}^{12} = \sum_{i=1}^{N} Z_i^{1'}E_i^1E_i^{2'}Z_i^2,$$

where X^1, Z^1 and E^1 are right hand side variables, instruments and residuals associated with b^1, X^2, Z^2 and E^2 are right hand side variables, instruments and residuals associated with b^2.

$$V(b^1 - b^2) = V(b^1) + V(b^2) - Cov(b^1,b^2) - Cov(b^1,l$$

[16]In what follows, I ignore sample selection problems.

[17]Unfortunately, districts reflect the address of headquarters and not establishments.

[18]This decumulation and logarithmic transformation probably caused the strange results of the estimation carried out using 1992 data and the change between parameter estimates calculated using both 1992 and 1993 data in Singer [1995].

The data set was cleaned by eliminating unreliable observations which fall under the following categories:

1. Labor, output, total sales or wage bill being less than or equal to zero
2. Lagged (the previous years') output, total sales, export sales, or lagged export sales being less than zero[19]
3. Lagged or current export sales greater than the corresponding total sales
4. Average monthly wage less than 2,000 crowns (the minimum wage in early 1991)
5. Average monthly wage higher than 100,000 crowns (20 times more than the Czechoslovak average wage at the time).

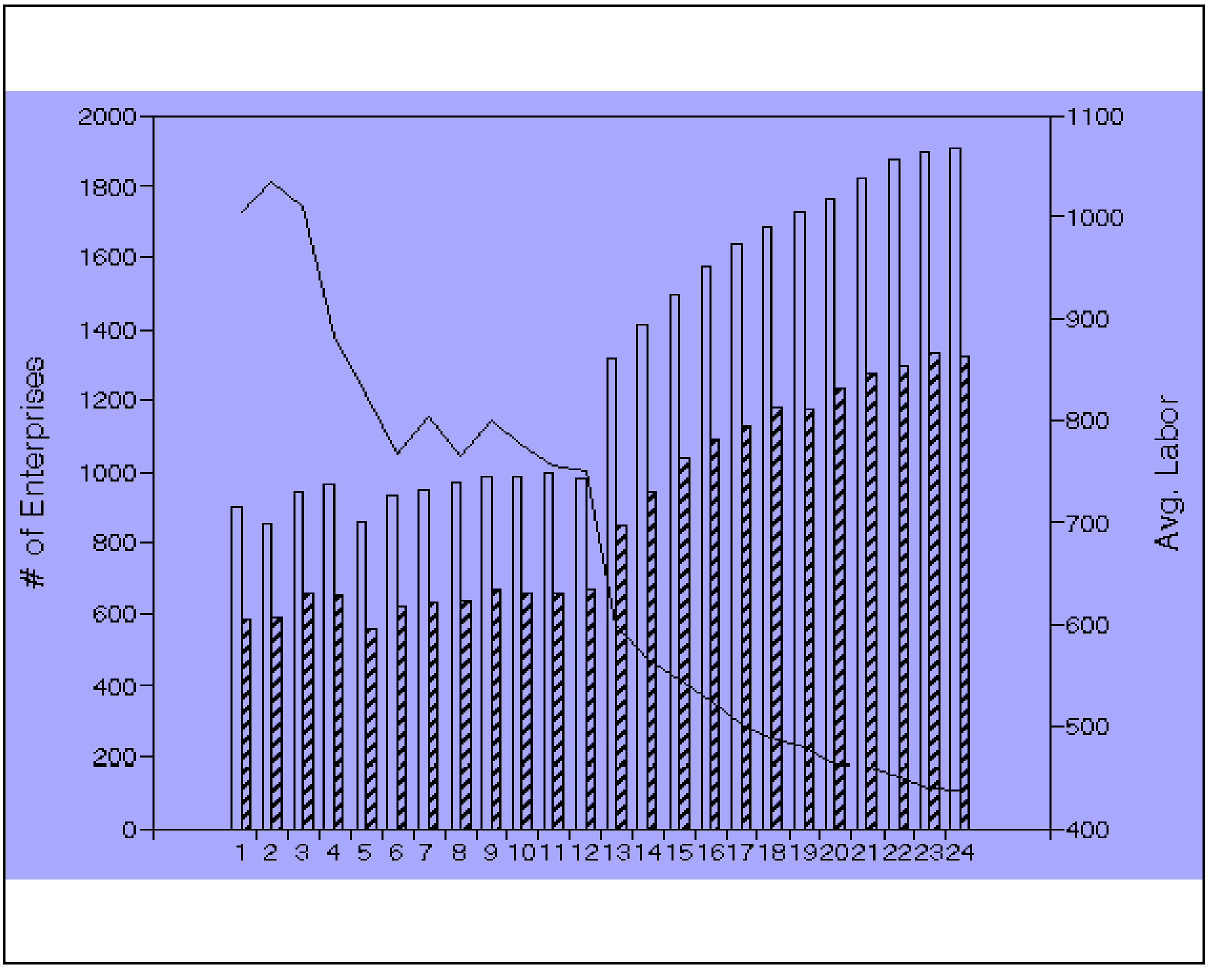

Figure 1 - Size of Enterprises

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[19]The Statistical Office unfortunately coded both zeroes and missing values as zeroes.

After dropping approximately 25-35% of the observations as unreliable, the panel contains 31,451 observations, with 11,331 of them from 1992 and 20,120 from 1993. As I mentioned earlier, this appears to be by far the largest available monthly panel of firm-level data.

A simple description of the data in the 1992 and 1993 files during the 24 months of the 1992-93 period is provided in Figure 1. The total number of firms is denoted by the empty bars and the number of exporting firms by filled bars. The solid line gives the average number of employees per firm. As can be seen from the figure, the proportion of exporting firms in the file is approximately 70-80% of the total in both 1992 and 1993. The division of Czechoslovakia at the end of 1992 thus did not result in a significant increase of the number of exporting firms.[20] A notable feature of the data is the decreasing average size of the firms' labor force. The major drop in the average size the labor force at the start of 1993 was generally not brought about by a failure of Czech enterprises to report information on their Slovak subsidiaries after the split. Rather, It instead reflects the superior ability of the CSO to induce reporting from small, newly established firms and the division of some large enterprises (such as main utilities) into separate Czech and Slovak entities.

Figure 2 depicts the average total and export sales during the same 1992-93 period. Average sales are denoted by the empty bars, export sales by filled ones and the ratio of export to average sales by the solid line. Average export sales contribute approximately 10-15% of the average total sales. The line that expresses the ratio of average exports to average total sales shows some seasonality in monthly changes. It jumped by approximately 3% at the beginning of 1993 with the division of Czechoslovakia. Again, I observe the decreasing average firm size, this time in terms of total sales.

Figure 3 depicts the average output per employee (dotted line) and average wage (solid line). As can be seen from the figure, the average wage

[20]It is necessary to keep in mind that these are firms which only export directly.

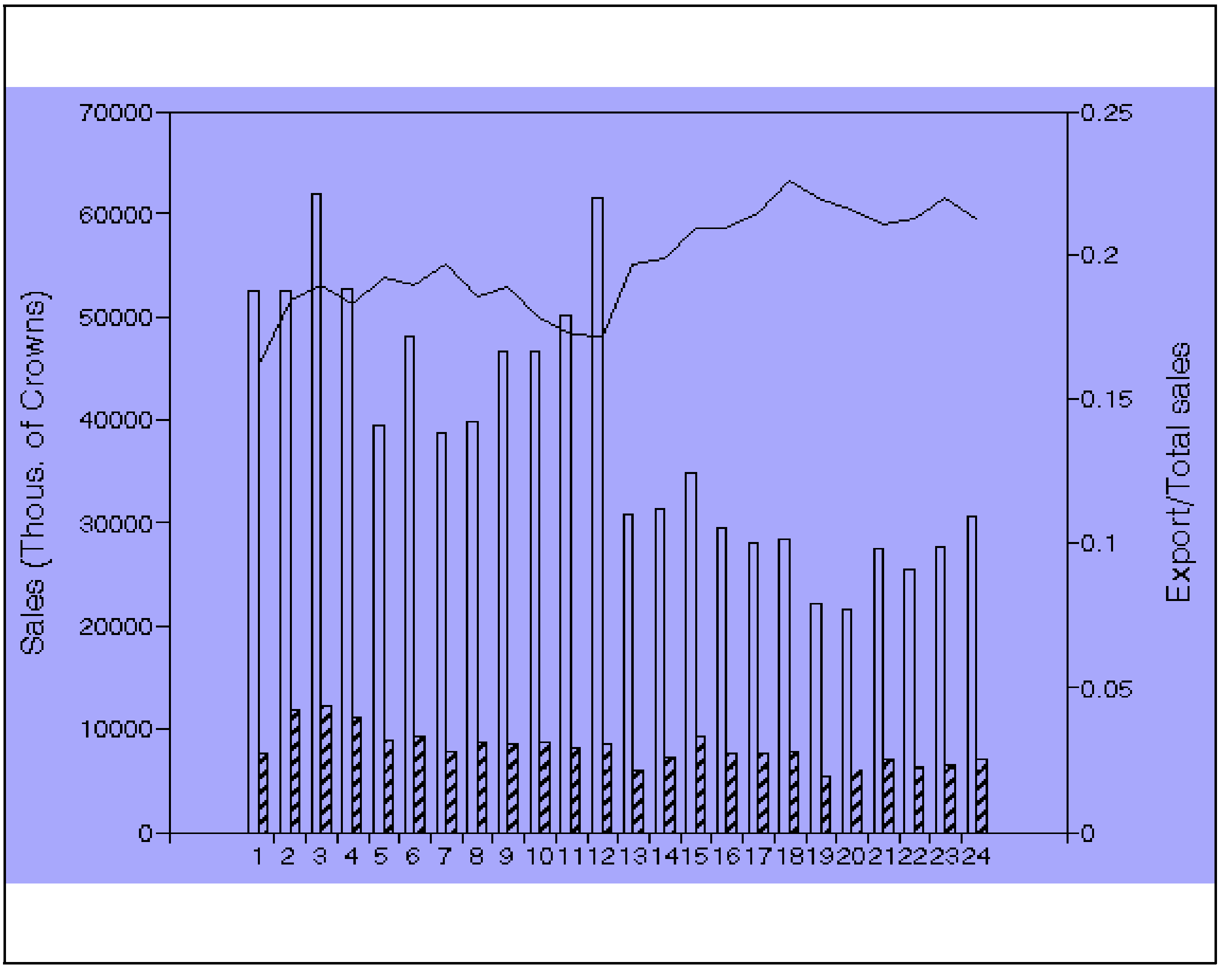

Figure 2 - Exports of Enterprises

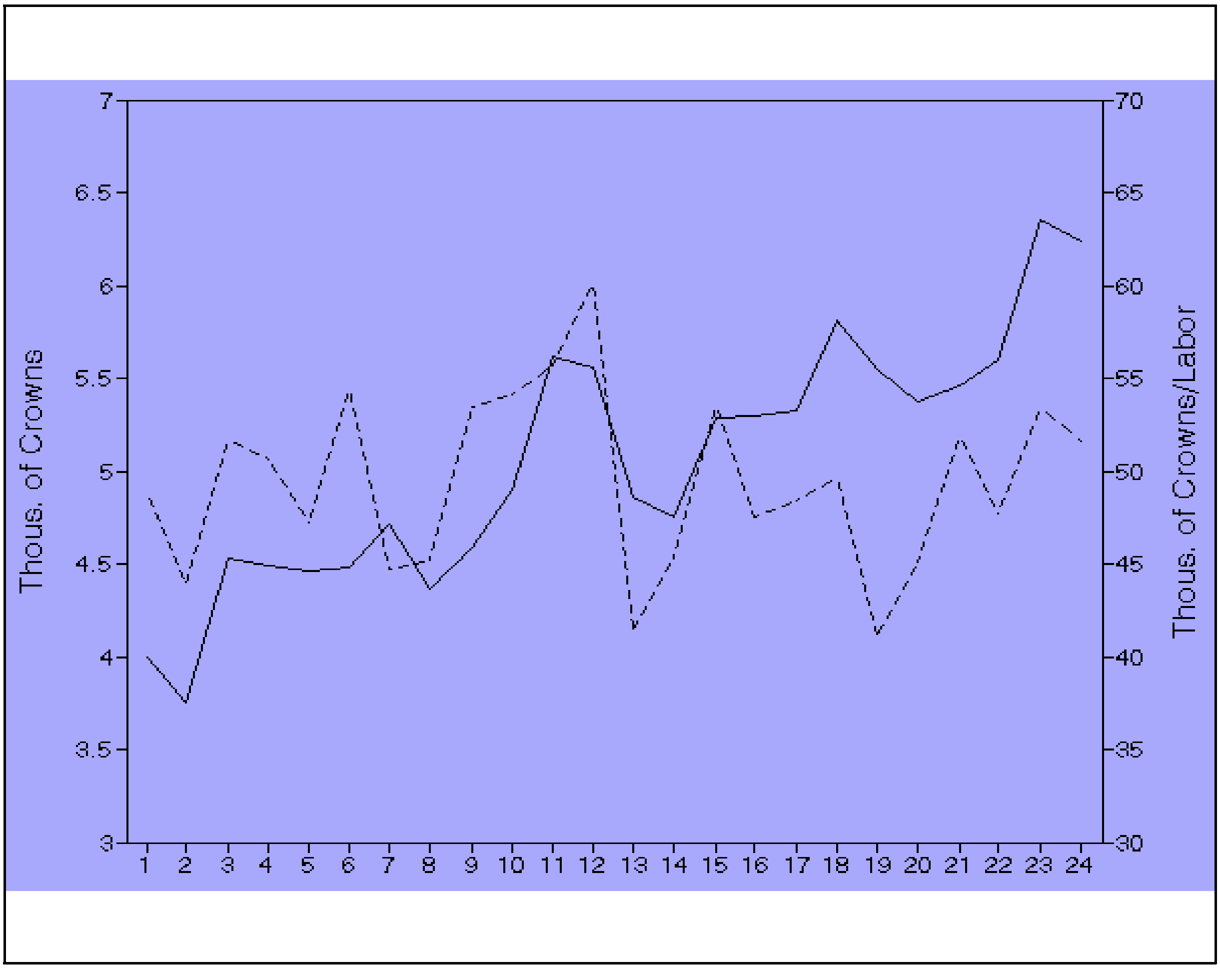

Figure 3 - Wages and Output per Labor

in industrial enterprises grew faster than the output per worker in 1992 and 1993. The government reintroduced wage regulations in the fall of 1993 to arrest this development, but the growth of wages relative to productivity accelerated after the re-introduction of the wage controls. The wage regulation thus appears not to have been very effective in holding back wage growth.

Next I created estimation panels by keeping only those observations that had all of the necessary instruments with lagged values extending to t-6. Table 1 presents summary annual characteristics of the entire cleaned data file as well as the file constructed for estimation purposes.

As can be seen from Table 1, one loses a significant percentage of observations by creating the estimation panel from the cleaned file. The loss is less severe in 1992 than in 1993, because many smaller firms which exist in the 1993 files did not report to CSO in 1992. In the 1992 data I use the observations from the first half of the year as instruments or right hand side variables, while in 1993, I instrument with 1992 data and drop only the first months of the year so as not to mix the labor demand adjustments with possible effects of the split of Czechoslovakia.[21]

4. Estimation Result

Due to the division of Czechoslovakia at the end of 1992, I divided the sample into two parts and estimated equation (6) not only on 1992-1993 data but also separately for 1992 and 1993. In Section 4.1. I discuss the estimates based on joint estimation on 1992 and 1993 data, while the results from 1992 data are discussed in Section 4.2 and those from 1993 data in Section 4.3. All estimates come from the specification using differences of logarithms with monthly dummies.

4.1. 1992-1993 Results

The results of the estimation of equation (6) on 1992-1993 data are summarized in Tables 2 and 3. Table 2 contains the results from estimations which do not assume that sales are exogenous, while Table 3 contains estimates which conversely rely on this assumption. The sets of variables that are used as instruments are listed in the headers of the tables. Long-term elasticities and their

[21]The number of dropped months is driven by the longest lag of variables in estimated equations. Thus, we drop first three months for the estimation of equation (6), four for equation (7) with κ=3 and five for equation (7) with κ=4.

asymptotic standard errors are reported together with adjusted R^2 at the end of each table. All estimates have been derived with dummies for months.

The results do not appear to be affected by the choice of instruments. The point estimates of short-term elasticities of labor demand with respect to output do not exceed 5% but are nevertheless significantly positive. The point estimates of long-term elasticities of labor demand with respect to output are also all significantly positive. They have a median value of about 5%, and do not exceed 7%. The lowest estimates are found in the middle column of Table 3 which contains estimates derived with changes in output in the instrumental variable set. The result probably signals some measurement error process, but the extent of the process does not appear to be serious. I thus conclude that output plays a significant positive role as a determinant of labor demand in both the short-term and long-term, but that the output elasticity is quite low, not exceeding 10 percent.

Estimates of the coefficients on the wage are also quite robust. The estimates of the short-term elasticities oscillate around -5% and the absolute values of long-term elasticity elasticities are slightly higher, ranging from -7 to -11 percent. Labor demand is thus much more sensitive to wages than output in the short- as well as long-term.

The coefficients on lagged labor suggest significant smooth and quite slow dynamic adjustment to the long-term equilibrium values. The relatively, though not exceptionally, low-adjusted R^2 signal low correlation of monthly changes of labor with changes in wages and changes in output.[22]

The modified Hausman tests for differences between the estimates of coefficients from estimations with different sets of instruments are presented in Tables 4-5. The tests in these tables are carried against two sets of estimates that are assumed to be consistent: estimates calculated with only other industry averages and estimates calculated with foreign industrial averages in the instrumental variable set. (These two estimates are also compared against each other.) The rejection of equality of the coefficients calculated with the two sets of instruments would imply endogeneity of the wider set of instruments. The instrumental sets assumed to be exogenous are listed in the first row of the header, while the tested sets of instruments are described in the second row. The descriptions in brackets denote the tables and columns containing the compared sets of coefficients. In calculating these tests, I had problems with near singularity of the variance-covariance matrix of the differences in the coefficients. Since modified Hausman tests require the

[22]As I have already noted, the estimates of longer forms of equation (6) did not differ significantly, but they are less percicely identified.

inverse of the matrix, in some cases I had to restrict the set of coefficients used for the tests to the coefficients of the most recent variables (the difference of logs of labor at t-1, output at t and input costs ratio at t).[23] The Hausman tests did not signal endogeneity of any instrument.

I also carried out tests of the structural change of coefficients of equation (6) from 1992 to 1993 (leaving monthly dummies unrestricted). The results of these Wald tests are summarized in Tables 6 and 7. These results correspond to the instrumental sets used in Tables 2 and 3. Table 6 thus reports the tests which have not used sales or output as instruments. In Table 7, the tests that have been carried out using sales and output variables in the sets of instruments. As opposed to the parameter estimates reported in Tables 2 and 3, the results of Wald tests depend significantly on the choice of instruments. The results reported in Table 6 did not signal a change of parameters of equation (6), but the results in Table 7, which are derived using an assumption of exogeneity of sales and output, suggest that such change indeed took place. There is a problem with the test of change of parameters in time: Since the equation (6) is derived with the help of the theory of rational expectation, the rejection of the equality of parameters in 1992 and 1993 can be caused, not by the genuine change of parameters, but by the unexpected random shocks correlated across the population of firms.[24] Therefore, the results of the Wald tests, as well as the estimates based on shorter panels from 1992 and 1993, ought to be interpreted with caution, and the estimates derived on 1992-1993 data should not be discarded. I split the 1992-1993 data and estimated the equation (6) separately for 1992 and 1993 to see which direction in the change of coefficient is suggested by these estimates.

4.2. 1992 Results

The results of estimation of equation (6) on 1992 data are summarized in Tables 8 and 9. Table 8 contains results from estimations which do not assume that sales are exogenous, while Table 9 contains estimates which are derived using this assumption.

Like the estimates derived using 1992-1993 data, the 1992 estimates are not significantly affected by the choice of instruments. The point estimates of short-term elasticities of labor

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[23]The near singularity of the variance-covariance matrix results from the fact that the variance-covariance matrix is calculated with use of both coefficient estimates. While this approach is asymptotically correct, it often leads to problems in finite samples.

[24]In my opinion, the danger of getting inconsistent results due to such correlated shocks influencing observations in a short panel might be slightly overstated for wide panels containing relatively heterogenous observations. It is difficult to speculate on shocks having the same effects on all kinds of industrial firms (i.e. brewery and a mining factory).

demand in respect to output do not exceed 6% and they appear to be approximately 1% higher that those estimated using 1992-1993 data. The point estimates of the long-term elasticities of labor demand with respect to output also appear higher than those in Section 4.1. Their median value is about 7%, and the highest almost exceed 9%.

The difference between the coefficients on wages derived using 1992-1993 data and 1992 data appears to be even higher. Some estimates of the short-term elasticities exceed even -15% and the estimates of long-term elasticity -23%. Labor demand in 1992 thus appears to be much more sensitive to wages than output in both the short-term and the long-term.

The significant estimates of coefficients on lagged labor do not differ from those derived from the 1992-1993 data, and suggest a smooth adjustment towards equilibrium. The adjusted R^2, are same or lower than the adjusted R^2 in Tables 2 and 3, reflecting the low correlation between changes in explanatory variables and changes in labor.[25]

The modified Hausman tests for differences between the estimates of coefficients from estimations with different sets of instruments are presented in Tables 10 and 11. The structure of these tables is the same as the structure of Tables 4 and 5. This is explained in Section 4.1. The Hausman tests did not signal endogeneity of any instrument used for estimation on 1992 data.

4.3. 1993 Results

The estimates of equation (6) for the 1993 data are summarized in Tables 12 and 13. Table 12 summarizes the results obtained without using sales and output as instrumental variables. Table 13 contains the results of selected specifications with sales and output used as instruments. The differences between the two sets of instruments do not seriously influence the results.

The estimates of output elasticities are lower than those found in the 1992, and approximately equal to the estimates calculated with 1992-1993 data. Short-term and long-term elasticities of output do not exceed 6%. All long-term elasticities are significant and the median estimate of the long-term elasticity is about 4%.

Input cost elasticities differ significantly from those obtained from either the 1992 or 1992-1993 data. The absolute values of short term elasticities are approximately 2% lower than those calculated with 1992-1993 data ranging from -2 to -4%. Similarly, the estimates of long-term elasticities are at least 2-3% lower than those using the 1992-1993 data. These range from

[25] The problems of identification of the estimates of the longer equation that have been already mentioned in Section 4.1. appear again.

-3% to -5.5%. Furthermore, while many of them prove to be significant at a 10% level of significance, only one is significant at a 5% significance level.

The lagged values of labor demand do not seem to matter much. In three cases I observe low significant positive values on lagged labor ranging from 0.19 to 0.25. Such parameter estimates suggest a smooth and quite fast adjustment process, although the large confidence intervals prevent me from drawing firm conclusions. Adjusted R^2 close to those discussed in Sections 4.1. and 4.2.[26]

Again I ran modified Hausman tests of the exogeneity of instruments for the estimates calculated with 1993 data. The results of these tests are reported in Tables 14 and 15. These tests did not reject exogeneity of all instruments used in estimation of results reported in Table 12 and Table 13.

5. Summary and Conclusions

In this paper I have presented parameter estimates of a dynamic labor demand function estimated on a unique data set. In particular, my estimates are the first ones to be based on large firm-level panels of monthly data. Previous studies are either based on annual panels, thus smoothing important variation in the data (e.g., Bresson et al [1992], Arellano and Bond [1991], Jaramillo et al [1993], or Prasnikar et al [1994]), or they are based on monthly or quarterly panels of very few (e.g., seven) firms. By utilizing over two thousand monthly observations in both 1992 and 1993, my study provides a unique opportunity to estimate dynamic labor demand parameters and recover both long and short-term elasticities of demand. Finally, this is the first study to analyze labor demand in an economy undergoing a transition from a central planning to a market system.

I found that the econometric model explains only a small part of the changes in the labor demand of Czech industrial enterprises during 1992-1993. However, it is important to note that the performance of the model is similar, though a bit worse than the performance of other models estimated on firm-level data in the studies mentioned in Section 1. Given that observed month-to-month changes in labor are undeniably noisier than similar changes from year-to-year, these results are not too surprising. I found statistically significant short-term and long-term elasticities of wages during 1992-1993. Estimates of short-term elasticities center around -5.5% (reported

[26]The estimates of the longer equations did not differ significantly from the results in Tables 12 and 13.

estimates about -0.055), estimates of long-term elasticities center around -9%. I found lower, yet statistically significant elasticities of output with both short-term and long-term elasticity estimates ranging from 2.5 to 6%. The estimates of coefficients on lagged labor suggest relatively quick adjustment of labor demand to its long-term equilibrium. Such low values of elasticities thus probably reflect labor hoarding.

I found that the Wald tests of unrestricted coefficients calculated an assumption of exogeneity of sales and output with sales and output in the set of instruments. This suggests a change of structural parameters from 1992 to 1993. Even though I have only short panels to test for the change of coefficients of equations in time, I decided to estimate equation (6) separately for 1992 and 1993 data. The results of these estimations suggest that the both output and wage elasticities were higher in 1992. The change is not very significant in the case of output; it appears that output elasticities dropped by one third from 1992 to 1993 and they still did not exceed 10%.[27] On the contrary, the difference between 1992 and 1993 estimates of wage elasticities is quite high. The absolute values of short-term and long-term elasticities calculated on 1992 data are about three times higher than the absolute values of these elasticities estimated on 1993 data. Thus, some estimates of long-term elasticity of labor with respect to wages have exceeded 20%.

The difference between the results from 1992 to 1993 is intriguing. At present, I have two potential explanations. The first natural explanation of the change in results comes to mind while observing the summary characteristics of my sample which are reported in Table 1. These summary characteristics suggest that in comparison with 1993, the 1992 data used for estimation primarily covers smaller firms. The difference between the two samples may thus cause the differences between the 1992 and 1993 results.

The second explanation of the differences between the 1992 and 1993 results is that the January 1, 1993 division of Czechoslovakia affected the behavior of firms. The results from 1992 are based on the second half of the year and reflect changes in labor demand caused by anxiety over the uncertain consequences of the division of the country. It must be remembered that the expectations of individuals and firms were greatly influenced by the consequences of the disintegration of both the Soviet Union and Yugoslavia. The possibility of a trade war with Slovakia was discussed and the untenable nature of a single currency was correctly predicted by

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[27]The low output elasticities can be explained by factors common among transition economies. These include imperfect credit markets, lack of effective corporate governance, an uncertain and rapidly changing economic environment in which monthly changes do not have to be interpreted as a signal of any future path, and the significant ability of insiders to control the behavior of a firm.

most individuals. In contrast, the results from 1993 reported in Table 2 and Table 3 are based on data from the second to the fourth quarter as the first 3 months of data were used for lagged variables at the right hand side of the equation.[28] Therefore, the 1993 results capture the period after the peaceful division of the country. The currency was divided, and the Czech economy achieved stability. It is therefore plausible to hypothesize that firms undertook minimal staff training in 1992 because of the uncertainty, but started to invest heavily in 1993 once much of this uncertainty had been removed. In 1993, enterprises therefore started to incur costs associated with training workers, and did not vary their labor input in response to month-to-month changes in relative input prices.

[28]Of course, the panels on which equations using 3 and 4 lags were estimated start at May and June respectively.

TABLES

Table 1: Main Summary Characteristics

File	1992 cleared	1992 data from 1993 file used for estimation	1993 cleared	1993 from 1993 file used for estimation
# of obs.	11331	7653	20120	10625
Output*	40463 (187544)	25740 (109170)	23830 (120561)	30435 (134839)
Sales*	49298 (259269)	31220 (130110)	27982 (138727)	36037 (152887)
Export Sales*	9263 (50589)	6733 (41945)	6984 (45040)	9444 (57466)
Labor	845 (1759)	575 (1330)	491 (1191)	607 (1344)
Avg. Wage*	4.636 (2.208)	4.752 (1.464)	5.532 (1.702)	5.749 (1.767)

std. errors in parentheses

* - in thousands of crowns

Table 2: Dynamic Labor Demand Equation, 1992-1993, 2 Lags, Sales Not Used As IV

(Dependent Variable = change in log of labor at t,
all right hand side variables are changes in logs)

	retraining, other industrial averages, predet'd variables	retraining, other industrial averages	other industrial averages	retraining, foreign industrial averages, predet'd variables	foreign industrial averages
$labor_{t-1}$	.159951** (.042143)	.043793 (.046837)	.018301 (.062077)	.173386** (.041495)	.082056 (.064922)
$labor_{t-2}$	.221888** (.040522)	.111655* (.065780)	-.000310 (.080435)	.204875** (.038599)	.025372 (.060694)
$output_t$	.032485** (.006500)	.038074** (.005258)	.045285** (.006149)	.031084** (.005635)	.042330** (.004849)
$output_{t-1}$	.005570 (.004622)	.012285** (.005485)	.008888 (.007921)	.004560 (.004013)	.006598 (.006145)
$wage_t$	-.050595** (.014109)	-.055491** (.013381)	-.065859** (.018890)	-.043059** (.012586)	-.037084** (.015216)
$wage_{t-1}$	-.006300 (.013813)	-.014344 (.014430)	-.039026* (.021433)	-.003746 (.012825)	-.025921 (.017539)
Long-term elasticity of output	.061562** (.013768)	.059629** (.011781)	.055167** (.011670)	.057331** (.011419)	.054818** (.009017)
Long-term elasticity of wages	-.092040** (.036638)	-.082689** (.028775)	-.106806** (.036508)	-.075282* (.033660)	-.070587** (.031158)
Adj. R^2	0.02	0.04	0.04	0.02	0.03

* - significant at a 10% level
** - significant at a 5% level
Standard errors in parentheses
Sample size = 17588 obs.

Table 3: Dynamic Labor Demand Equation, 1992-1993, Sales And Output Used As IV

(Dependent Variable = change in log of labor at t,
all right hand side variables are changes in logs)

Instruments	other industrial averages, sales	other industrial averages, output variables, sales	retraining, foreign industrial averages, predet'd variables, other industrial averages, sales
$labor_{t-1}$	-.006141 (.062485)	-.012145 (.062440)	.160127** (.040432)
$labor_{t-2}$	-.008813 (.080354)	-.023657 (.080641)	.226541** (.051281)
$output_t$	.028630** (.005021)	.025804** (.004172)	.027016** (.004704)
$output_{t-1}$	.017280** (.004542)	.014484** (.002592)	.011479** (.003598)
$wage_t$	-.069998** (.018401)	-.070568** (.018408)	-.040158** (.012570)
$wage_{t-1}$	-.044793** (.021622)	-.041559** (.021034)	-.016943 (.012842)
Long-term elasticity of output	.045233** (.008529)	.038895** (.006300)	.062764** (.011736)
Long-term elasticity of wages	-.113100** (.035481)	-.108251** (.034074)	-.093098** (.036062)
Adj. R^2	0.04	0.04	0.02

* - significant at a 10% level

** - significant at a 5% level

Standard errors in parentheses

Sample size = 17588 obs.

Table 4: Hausman Test Against Industrial Averages, 1992-1993, 2 Lags

(Table and Column in parentheses denote compared estimates)

Exogenous by assumption	Other Industry Averages (Table 2, Column 3)				
Test of exogeneity of	retraining, predet'd vars. (Table 2, Column 1)	retraining (Table 2, Column 2)	sales (Table 3, Column 1)	output variables, sales (Table 3, Column 2)	retraining, foreign industrial averages, predet'd variables, sales (Table 3, Column 3)
$X^2(21)$	4.08	0.00 [$X^2(3)$]	0.12	0.01	26.97
P-value	1.00	1	1	1	0.13

* - significant at a 10% level

** - significant at a 5% level

Sample size = 17588 obs.

Table 5: Hausman Test Against Industrial Averages, 1993, 2 Lags

(Table and Column in parentheses denote compared estimates)

Exogenous by assumption	Foreign Industry Averages (Table 3, Column 5)		
Test of exogeneity of	retraining, predet'd variables (Table 2, Column 4)	other industrial averages (Table 2, Column 3)	retraining, predet'd variables, other industrial averages, sales (Table 3, Column 3)
$X^2(21)$	0.05 [$X^2(3)$]	0.15 [$X^2(3)$]	0.58
P-value	1.00	1.00	1.00

* - significant at a 10% level

** - significant at a 5% level

Sample size = 17588 obs.

Table 6: Tests Of Equality Of Coefficients Between 1992 And 1993, 2 Lags, Sales Not Used As IV

Instruments	retraining, other industrial averages, predet'd variables	retraining, other industrial averages	other industrial averages	retraining, foreign industrial averages, predet'd variables	foreign industrial averages
Tests of Equality of Coefficients of (6)					
$X^2(6)$	12.15*	7.25	8.05	11.98*	8.65
P-value	0.06	0.30	0.23	0.06	0.19
Tests Of Equality Of Long Term Elasticities					
$X^2(2)$	2.31	1.87	4.43	1.37	0.65
P-value	0.32	0.40	0.11	0.50	0.72

* - significant at a 10% level

** - significant at a 5% level

Sample size = 17588 obs.

Table 7: Tests Of Equality Of Coefficients Between 1992 And 1993, 2 Lags, Sales Used As IV

Instruments	other industrial averages, sales	other industrial averages, output variables, sales	retraining, foreign industrial averages, predet'd variables, other industrial averages, sales
Tests of Equality of Coefficients of (6)			
$X^2(6)$	11.33*	15.32**	21.50**
P-value	0.08	0.02	0.00
Tests of Equality of Long Term Elasticities			
$X^2(2)$	6.40**	4.68*	5.40*
P-value	0.04	0.10	0.07

* - significant at a 10% level

** - significant at a 5% level

Sample size = 17588 obs.

Table 8: Dynamic Labor Demand Equation, 1992, 2 Lags, Sales Not Used As IV

(Dependent Variable = change in log of labor at t,
all right hand side variables are changes in logs)

Instruments	retraining, other industrial averages, predet'd variables	retraining, other industrial averages	other industrial averages	retraining, foreign industrial averages, predet'd variables	foreign industrial averages
$labor_{t-1}$	.128363** (.053263)	.011818 (.061451)	-.029942 (.089225)	.149008** (.055036)	.147854 (.091107)
$labor_{t-2}$	.282444** (.055647)	.165846* (.087635)	.068006 (.118374)	.265961** (.054541)	.071807 (.098785)
$output_t$	.039318** (.010237)	.046361** (.009321)	.057093** (.010900)	.037198** (.008884)	.048800** (.008606)
$output_{t-1}$	.003918 (.009420)	.011111 (.010313)	.008922 (.017815)	.000865 (.008081)	-.004785 (.012857)
$wage_t$	-.077033** (.028626)	-.092207** (.027027)	-.139937** (.041830)	-.061003** (.025608)	-.052454* (.029171)
$wage_{t-1}$	-.015597 (.027396)	-.022660 (.030347)	-.083078* (.053530)	-.005199 (.026083)	-.025773 (.034808)
Long-term elasticity of output	.073383** (.024651)	.069888** (.020247)	.068628** (.021492)	.065062** (.021498)	.056404** (.019734)
Long-term elasticity of wages	-.157214* (.079796)	-.139684** (.062183)	-.231840** (.089536)	-.113160* (.074735)	-.100246 (.068508)
Adj. R^2	0.02	0.03	0.03	0.01	0.02

* - significant at a 10% level
** - significant at a5% level
Standard errors in parentheses
Sample size = 7653 obs.

Table 9: Dynamic Labor Demand Equation, 1992, Sales And Output Used As IV

(Dependent Variable = change in log of labor at t,
all right hand side variables are changes in logs)

	other industrial averages, sales	other industrial averages, output variables, sales	retraining, foreign industrial averages, predet'd variables, other industrial averages, sales
$labor_{t-1}$	.041949 (.096140)	-.056490 (.085126)	.104812** (.053398)
$labor_{t-2}$	.131679 (.102923)	.040386 (.118823)	.291734** (.068907)
$output_t$	.039615** (.007877)	.035917** (.007307)	.037145** (.007632)
$output_{t-1}$	.021551** (.010284)	.018510** (.005277)	.016386** (.008120)
$wage_t$	-.154937** (.045516)	-.152414** (.042243)	-.078814** (.026069)
$wage_{t-1}$	-.083176 (.056434)	-.079116 (.053292)	-.047345 (0.031166)
Long-term elasticity of output	.074017** (.018831)	.053564** (.012914)	.088709** (.024847)
Long-term elasticity of wages	-.288143** (.109509)	-.227861** (.084795)	-.209063** (.086674)
Adj. R^2	0.03	0.03	0.02

* - significant at a 10% level
** - significant at a 5% level
Standard errors in parentheses
Sample size = 7653 obs.

Table 10: Hausman Test Against Industrial Averages, 1993, 2 Lags

(Table and Column in parentheses denote compared estimates)

Exogenous by assumption	Other Industry Averages (Table 8, Column 3)				
Test of exogeneity of	retraining, predet'd vars. (Table 8, Column 1)	retraining (Table 8, Column 2)	sales (Table 9, Column 1)	output variables, sales (Table 9, Column 2)	retraining, foreign industrial averages, predet'd variables, sales (Table 9, Column 3)
$X^2(12)$	0.18 [$X^2(3)$]	0.13 [$X^2(3)$]	1.98	0.03	0.26 [$X^2(3)$]
P-value	0.98	0.98	1.00	1.00	0.97

* - significant at a 10% level

** - significant at a 5% level

Sample size = 7653 obs.

Table 11: Hausman Test Against Industrial Averages, 1993, 2 Lags

(Table and Column in parentheses denote compared estimates)

Exogenous by assumption	Foreign Industry Averages (Table 8, Column 5)		
Test of exogeneity of	retraining, predet'd variables (Table 8, Column 4)	other industrial averages (Table 8, Column 3)	retraining, predet'd variables, other industrial averages, sales (Table 9, Column 3)
$X^2(3)$	0.09	0.23	0.16
P-value	0.99	0.97	0.98

* - significant at a 10% level

** - significant at a 5% level

Sample size = 7653 obs.

Table 12: Dynamic Labor Demand Equation, 1993, 2 Lags, Sales Not Used As IV

(Dependent Variable = change in log of labor at t,
all right hand side variables are changes in logs)

Instruments	retraining, other industrial averages, predet'd variables	retraining, other industrial averages	other industrial averages	retraining, foreign industrial averages, predet'd variables	foreign industrial averages
$labor_{t-1}$	.193411** (.056030)	.098956* (.060956)	.053983 (.076495)	.193349** (.053894)	-.018289 (.076219)
$labor_{t-2}$	.061588 (.048330)	-.000152 (.056554)	-.093667 (.065074)	.055065 (.046749)	-.020509 (.063143)
$output_t$	.027037** (.007033)	.031273** (.005268)	.037888** (.006165)	.026482** (.005922)	.038170** (.004905)
$output_{t-1}$	.004401 (.004745)	.011873* (.005623)	.010456 (.007262)	.005373 (.004057)	.015291** (.006310)
$wage_t$	-.035437** (.012558)	-.036175** (.013301)	-.028042* (.017561)	-.032514** (.011830)	-.020884 (.016703)
$wage_{t-1}$	-.002458 (.016769)	-.012398 (.016537)	-.016221 (.017683)	-.003347 (.014709)	-.022711 (.020200)
Long-term elasticity of output	.042199** (.012395)	.047877** (.010526)	.046499** (.010653)	.042385** (.009804)	.051464** (.008557)
Long-term elasticity of wages	-.050866* (.029700)	-.053898** (.028600)	-.042574* (.028066)	-.047715 (.027556)	-.041967 (.031193)
Adj. R^2	0.03	0.04	0.03	0.03	0.03

* - significant at a 10% level
** - significant at a 5% level
Standard errors in parentheses
Sample size = 9935 obs.

Table 13 Dynamic Labor Demand Equation, 1993 Sales And Output Used As IV

(Dependent Variable = change in log of labor at t,
all right hand side variables are changes in logs)

Instruments	other industrial averages, sales	other industrial averages, output variables, sales	retraining, foreign industrial averages, predet'd variables, other industrial averages, sales
$labor_{t-1}$	.056722 (.076284)	.019525 (.077362)	.269892** (.066650)
$labor_{t-2}$	-.063564 (.065648)	-.116171** (.066367)	.028244 (.055312)
$output_t$	.020398** (.005345)	.019701** (.003707)	.027605** (.006747)
$output_{t-1}$	.013340** (.003021)	.013756** (.002570)	-.002257 (.005765)
$wage_t$	-.025819 (.017052)	-.030950* (.017073)	-.038109** (.015094)
$wage_{t-1}$	-.011585 (.017584)	-.021214 (.017294)	-.009706 (.017519)
Long-term elasticity of output	.033508** (.006764)	.030509** (.004921)	.036115** (.013140)
Long-term elasticity of wages	-.037150 (.028449)	-.047567* (.026301)	-.068126** (.032973)
Adj. R^2	0.04	0.03	0.02

* - significant at a 10% level
** - significant at a 5% level
Standard errors in parentheses
Sample size = 9935 obs.

Table 14 Hausman Test Against Industrial Averages, 1993, 2 Lags

(Table and Column in parentheses denote compared estimates)

Exogenous by assumption	Other Industry Averages (Table 12, Column 3)				
Test of exogeneity of	retraining, predet'd vars. (Table 12, Column 1)	retraining (Table 12, Column 2)	sales (Table 13, Column 1)	output variables, sales (Table 13, Column 2)	retraining, foreign industrial averages, predet'd variables, sales (Table 13, Column 3)
$X^2(3)$	0.15	0.04	0.04	0.00	3.07
P-value	0.98	1.00	1.00	1.00	0.31

* - significant at a 10% level

** - significant at a 5% level

Sample size = 9935 obs.

Table 15: Hausman Test Against Industrial Averages, 1993, 2 Lags

(Table and Column in parentheses denote compared estimates)

Exogenous by assumption	Foreign Industry Averages (Table 12, Column 5)		
Test of exogeneity of	retraining, predet'd variables (Table 12, Column 4)	other industrial averages (Table 12, Column 3)	retraining, predet'd variables, other industrial averages, sales (Table 13, Column 3)
$X^2(3)$	0.18	0.07	0.17
P-value	0.98	1.00	0.98

* - significant at a 10% level

** - significant at a 5% level

Sample size = 9935 obs.

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