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ABSTRACT

The Optimality and Overuse of Labour in Estonian Manufacturing Enterprises*

For transition economies labour market flexibility is necessary for successful restructuring and reallocation of labour force and for coping with the requirements of the European Monetary Union. In this paper we apply a novel approach to the issue of labour market flexibility in transition countries by studying the optimality and efficiency of labour usage among Estonian manufacturing enterprises. A dynamic model is employed where both the long run optimal level of employment and the speed at which actual employment is adjusted to the optimal are modelled as functions of several variables. Firm level panel data from 1995 to 1999 were used. The results showed that in the long run employment responds greatest to wages, followed by value-added and capital stock. Speed of adjustment and labour use optimality and efficiency show much greater variations over firms than over time. In the course of time there occurs both labour saving technical change and an increase in the efficiency of labour usage. On average there is shortage of labour compared to firms' own optimal level, while over use of labour compared to best-practice technology. Capital seems to be a binding constraint on the development of employment in the Estonian labour market.

JEL Classification: C23, J23, P23

Keywords: labour, efficiency, employment, flexibility, Estonia

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1 Introduction

In the last ten years severe shocks have occurred to the Estonian economy that have forced firms to reduce the amount of labour used. First, in the beginning of the transition processes firms faced the challenge of restructuring and shedding of excess labour. Under socialism there was constant excess demand for labour and widespread labour hoarding to cope with uncertainties in the delivery of inputs and to maximize subsidies for an enterprise (Campos and Coricelli 2002). Output drop and new market conditions forced firms to adjust the number of employees to the demand for their products considering the technological requirements and market circumstances.

Another shock to the economy was in the later period of transition due to the Russian crisis in the second half of 1998. The loss of competitiveness in the Russian market due to the devaluation of the rouble forced Estonian manufacturing industry to carry out extensive restructuring resulting in a significant reduction in employment. However, when the economy started to recover in 2000, labour market indicators did not show improvement. This was interpreted by Eamets, Varblane and Sõstra (2002) to be due to technological factors, when less (unskilled) labour using production technologies were taken into account (though this hypothesis was not tested on enterprise data).

Theoretically, the speed of adjustment in workforce at the firm level, as well as the incidence of excess labour, are related to the multidimensional concept of labour market flexibility and the functioning of the labour market during the transition period. Here we deal mostly with numerical (or external) flexibility, that is, the freedom of employers to expand or contract their workforce as they wish (Treu 1992). It has been argued that the labour market flexibility is high in Estonia compared with other Central and Eastern European (CEE) countries and that this is the key factor in a relatively fast labour reallocation process observed in Estonia (Eamets 2003). The rather high speed of restructuring in Estonia can be observed from the rates of job creation and destruction, which for 1994-1996 were remarkably higher compared to other CEE countries, though later job flows have somewhat decreased (Faggio and Könings 1999; Vodopivec 2003). It has been said that changes in employment structure that took place in Europe and Japan over 25 years, have occurred in Estonia over only four years. External factors like the Russian crisis and its influence on the Estonian economy, technological change and transformation of technology played an important role in the rapid changes.

An overview of studies on labour demand in CEE countries can be found in Svejnar (1999). Just to mention a few of them, Basu, Estrin and Svejnar (2000) estimated dynamic labour demand models for five CEE economies using data from pre-transition and early transition years. Konings and Lehmann (2002) estimated static labour demand equations for Russia for 1997. Brown and Earle (2001) studied whether job reallocation (job destruction) had any positive effect on productivity in Russia. Some papers have estimated dynamic labour demand equations on firm level data in order to test for defensive (cost reducing) restructuring (for example, Domadenik, Prašnikar and Svejnar 2002). However, these studies have not specified or estimated the target for optimal employment.

In this paper we follow a new approach to flexibility that studies transition economies labour markets. The aim of the paper is to estimate the optimality and efficiency of labour usage among Estonian manufacturing firms, together with the speed of adjustment at which firms attain their target level of employment and eliminate the gap between optimal and observed levels. Inability to adjust employed labour flexibly to changing market conditions leads to inefficiency in labour usage. We use two definitions of efficiency. First, efficiency of labour use is understood as the ratio of actual labour usage to optimal (desired) labour usage at the firm level. Labour hoarding may be the reason for the inefficiently high level of labour hired, that is, in the presence of labour adjustment costs firms lay off fewer workers than in the absence of adjustment costs and would carry excess labour through a slump period (Nickell 1986). Second, efficiency in the use of labour is estimated using a stochastic labour requirement frontier function. Inefficiency is defined as labour used in excess to that of the minimum amount required by the employed best practice technology.

An important feature of our approach is the flexible adjustment speed. Though the latter is often modelled as a constant parameter, this approach would not have good ground in the transition context where labour flexibility is likely to change over time (for example due to increasing administrative enforcement of labour laws) and vary over firms, for example state owned firms versus newly established firms may show different behaviour. In the empirical part of this study we use a database of about 430 firms observed in 1995-1999, compiled by the Statistical Office of Estonia.

This paper contributes to the labour literature concerning firms' adjustment in their labour demand towards an optimal level and analysis of Estonian manufacturing covering a rapid transition period. The main features are as follows. First, we want to investigate what the determinants of the efficiency of labour use are. Of particular interest are the determinants associated with firm, time and industrial sectors. For instance, is it the case that in more unionized industries there is more excess labour? Second, how firms responded to the Russian crisis in second half of 1998 and did the efficiency of labour usage diminished due to labour hoarding? Can we see signs in the data on labour saving technical change after the Russian crises, so that less labour was needed thereafter for the same purpose (as argued by Eamets, Varblane and Sõstra 2002)? Third, we are keen on the speed of adjustment, how it depends on factors like firm size, industry, and the degree of inefficiency. One possible definition for labour market flexibility is the speed of adjustment to external shocks and changes in economic conditions. Our interest is whether the speed of adjustment – labour market flexibility – has decreased over the time? One intuitive explanation for the latter may be that if the observance of the enforcement of labour regulations improves over time due to increased administrative capacity, then dismissing employees may become effectively more costly.

The rest of the paper is structured as follows. In section 2 aspects of the institutional environment of labour market relevant for our study are discussed. Section 3 describes our theoretical model. In section 4 we describe the particular database we are using along with some descriptive statistics. In section 5 the empirical model is presented and discussed. The next section, section 6, presents the empirical results and the last section concludes.

2 The Estonian labour market and economy

2.1 Labour market flexibility and reallocation

In this section some characteristics of the institutional environment of the labour market in Estonia are discussed. This information is essential for our study as institutions affect the speed and ease with which adjustment in the level of employment occurs. We describe the situation concerning labour market regulations, trade unions, labour policies, the evidence on micro-level flexibility (jobs flows) and also the underlying external causes.

We start with labour laws regulating dismissals, as those make dismissals more costly, give incentives to moderate adjustment to shocks and create labour hoarding. Though labour laws in Estonia follow the main international labour standards, the number of ratified ILO conventions (31) is well below the average numbers of both CEE (62) and EU (88) countries (ILOLEX 2003). The formal strictness of labour regulations against dismissals is usually measured by the OECD index. The index considers restrictions on individual dismissals, regulation of the usage of temporary forms of employment and additional restrictions applied for collective redundancies (OECD 1999). According to these measures the overall strictness of employment protection legislation in Estonia is even higher than the average of European Union countries. The values of an index that varies from 0 to 6 are 2.6 for Estonia and 2.5 for the EU (Eamets and Masso 2003). Both in Estonia and in CEE countries in general collective dismissals in particular are fairly heavily regulated, putting extra pressure on large firms. However, flexibility is increased by less strict restrictions on the use of temporary forms of employment.

An important factor affecting effectiveness and flexibility is poor law enforcement. Firms often violate state regulations in Estonia, for example in 1999 violations were detected in 46 per cent of enterprises inspected by labour inspectors (Labour Inspection 2001) and workers' allegations of violations of labour relations are rather frequently raised in labour dispute commissions (65 per cent of cases in 2000). The enforcement problems are important for transition countries generally, for example in a study in Hungary 85 per cent of private respondents reported they had no serious constraints in dismissing workers (Kuddo 1995). Altogether strict labour regulations increase the costs of hiring and firing workers and may generate labour hoarding and as a consequence lower labour use efficiency, while poor enforcement may counterbalance these negative effects.

Another important characteristic of the Estonian labour market is the rather modest role of trade unions, measured either by the rate of unionization (14.8 per cent in 1999-2001) or the coverage of collective agreements (15 per cent in the end of the 1990s) (Eamets, Kallaste, Masso and Rõõm 2003). While union density is low in CEE countries generally, in Estonia it is even smaller and has decreased over time. Due to low coverage by collective agreements, the majority of employees in the Baltic States rely on individual employment contracts. Very low minimum wages (in 1995 19 per cent, in 2001 29 per cent of average wage) compared with EU countries (34 to 57 per cent of average salary in manufacturing; Nobre 2001) may not have constrained wage flexibility, that is, the ability of wages (usually real wages) to response to economic fluctuations. So, inflexible institutions combinded with wage and strict dismissal regulations, may promote enterprises to adjust to decreased demand rather than by lowering wages or reducing employment. The empirical analysis on how wages adjusted during recession in 1999, triggered by the Russian crisis, showed that in the open sector especially wages were flexible (Vesilind and Rell 2000).

An important aspect of the labour market is the value of outside options for employees, for example, unemployment insurance and assistance systems. The ratio of fixed sum unemployment benefits to wage was in 2001 less than 10 per cent, and the maximum period the benefit is payable was rather short; only 180 days. Since 2002 a new unemployment insurance scheme was introduced, with a number of important features. First, both the employer and employee make contributions to the fund. Second, the duration of payment of benefit depends on insurance tenure subject to a maximum of 360 days. Finally, the size of insurance payment depends on the person's previous average wage or salary. Generally in CEE countries unemployment benefits are much higher than in former Soviet Union (FSU) countries. Boeri and Terrell (2001) argued that relatively high unemployment benefits in CEE countries created a floor for wages, for example making them rigid and thereby leading to dismissals of employees in old sectors and faster labour reallocation. In FSU countries due to much lower unemployment benefits the bulk of adjustment involved wages, with much less decline in employment and lower labour reallocation. Concerning labour reallocation Estonia is rather the exception among FSU countries and belongs to the group of CEE countries.

A question emerges, how have these institutions affected the flexibility at the firm level. The latter is often studied through job flows, that is job creation and destruction. The rate of job creation shows the number new jobs created in a period compared to the pool of existing jobs in the beginning of the period. Second, the rate of job destruction shows the number of closed jobs in comparison to the number of existing jobs (Davis, Haltiwanger and Schuh 1997). The higher the turnover of jobs, the more flexible the labour markets and the more quickly firms can respond to changed conditions of demand. The comparison of Estonia with other transition and developed European countries reveals that although job reallocation has decreased in Estonia, the value of job flow indicators are still higher than in other countries. Among European countries the United Kingdom has a high job turnover rate. From 1987 to 1995 the net reallocation rate was 9 per cent (average) in the United Kingdom, while in Estonia during 1996-1999 it was 10.2 per cent, in Rumania 7.4 per cent and Bulgaria 2.3 per cent (Eamets 2003). Faggio and Könings (1999) have previously done similar calculations for Estonia, where, for 1994-1997 the rate of job reallocation was even higher, 13.5 per cent.

An important determinant of labour market flexibility at the firm level is labour turnover costs, that is the costs associated with hiring new employees (search costs, training) and dismissing the present employees in the form of advance notice and severance pay requirements. Järve (2002) estimated econometrically that firing cost is about 25 per cent of annual labour costs, while the estimates of hiring costs were surprisingly negative.

Our subsequent empirical analysis follows a different approach to the studying of labour flexibility. The novelty is that quantitative estimates on the size of labour hoarding, that is, how much actual labour deviate from the long run optimum level. Higher flexibility should result in faster adjustment, less labour hoarding and improved productivity, profitability and survival of firms. The drawback of flexibility is primarily reduced job security for employees.

2.2 The state of the Estonian economy

We add to the discussion of flexibility some general background information on the performance of the Estonian economy after regaining independence. Table 1 presents some indicators of the dynamics of Estonian labour market and economy for the years 1992-2001.

Table 1. Selected indicators of Estonian labour market and economy, 1992-2001

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Job creation rate, %	8.10	10.98	10.25	6.94	7.88	8.13	4.96	6.00	-	-
Job destruction rate, %	13.62	13.24	9.36	6.28	8.11	7.10	7.46	8.12	-	-
Net employment change, %	-5.52	-2.25	0.89	0.66	-0.23	1.03	-2.51	-2.12	-1.38	0.26
Excess reallocation rate, %	16.2	22.0	18.7	12.6	15.8	14.2	9.9	12.0	-	-
Change in nominal wages, %	-	94	63	37	26	20	13	10	11	12
Change in real wages, %	-	-	10	6	2	8	4	7	6	6
Labour productivity growth, %			4	10	6	11	6	4	10	5
Unempl. Rate (annual average), %	3.74	6.67	7.72	9.74	10.01	9.81	9.98	12.43	13.85	12.78
Particip. Rate (annual average), %	75.11	73.61	73.77	72.60	72.16	72.35	71.67	70.31	70.44	70.06
GDP growth, %	-	-	-2.0	4.3	3.9	9.8	4.6	-0.6	7.1	5.0
Change in volume of industrial production, %	-36	-19	-3	2	3	15	4	-3	15	-
Capital intensity per employee	-	-	-	67.4	89.8	101.9	126.6	211.4	210.9	223.8
Investment share of capital, %	-	31	41	37	39	39	29	23	25	26
Wage share in value added, %	-	52	57	57	53	52	51	54	50	49
Export growth, %	-	-	-	22	12	49	19	-2	52	4
Import growth, %	-	-	-	36	26	41	13	-9	43	4
Share of foreign trade in GDP, %	-	-	120	114	107	126	126	114	147	138

Sources: Job flows (job creation rate, job destruction rate, net employment change): Estonian Labour Force survey data. Job creation rate is the sum of new jobs as a percentage of existing jobs in the beginning of period. Job destruction rate is the sum of employment losses as a percentage of existing jobs in the beginning of period. Excess job reallocation rate is the sum of creation and destruction rates minus absolute value of net employment change. Source of job flows data: Vodopivec (2003). Wages, unemployment rates, foreign trade and GDP: Statistical Office of Estonia. Capital intensity is defined as the ratio of capital to the number of employees. Capital is measured as the residual value of fixed assets in firms' balance sheets. Investments are the gross capital formation from SNA (System of National Accounts). Wages are deflated with consumer price index, other variables with the producer price index. All real variables are expressed in year 2000 prices.

The rate of GDP growth has been rather volatile: sharp recession in the beginning of the 1990s, in 1995 economic growth became positive, and in 1997 peaked almost 10 per cent. Though there was recession following theRussian crisis, later the growth rates have been impressive again. On the average Estonia has performed rather well compared to other CEE countries, whose average growth has been disappointing compared to the expectations prevailing in the beginning of transition (Campos and Coricelli 2002). However, in the literature it has also been suggested that in transition economies real growth rates may be underestimated as usual price indices may overestimate inflation (see Campos and Coricelli 2002; Djankov and Murrell 2002). The numbers on foreign trade follow the changes in economic activity we see in the GDP growth time series. Estonia is a rather open economy; the sum of imports and exports exceeds GDP. This is a reflection of the rapid transition of the economy and integration into the European market.

Concerning labour market indicators, we note once again the rather high rates of job creation and destruction that, however, follow a downward trend. Real wages have been growing throughout the period 6 per cent per year on average. There have been some concerns about wage growth exceeding the growth of productivity (the averages for 1994-2001 are, according to our calculations, 6.2 and 6.9 per cent). The share of wages in value added has been 53 per cent on average, though all CEE countries have shares of wages in value added lower than the average of EU member countries (Eamets, Kallaste, Masso and Rõõm 2003). The share of wages is argued to be a measure reflecting the power of trade unions in the economy and consequently the relative power of capital and labour.

The initially low unemployment rate started to grow from 1993. In 1999 the unemployment rate shot up due to the Russian crisis and only in 2001 can we see some improvement and stability in the labour market. Similar to the other transition economies, labour force participation rates have decreased since the beginning of transition. It is very unlikely that the rate of participation is being influenced by the very low coverage of social security system.

Investment activity has been rather high so that capital intensity measured per employee has grown over the years. Though compared with other transition countries aggregate investment rates have been quite high in the Baltic States: with the beginning of transition investment rates fell and capital shrunk (Campos and Coricelli 2002).

In general the above numbers show that the markets and economy have been rather dynamic during the period of this study, and important structural changes have taken place. High labour market flexibility has been argued to be an important and crucial factor enabling these positive developments.

3 The dynamic adjustment labour-use model

The continuous and rapid adjustment of the labour market in Estonia was a process of transformation of the market to an optimal one. The use of a static model assuming instantaneous adjustment is not consistent with reality. A partial adjustment model is a more appropriate method of modelling firms' behaviour. In our modelling approach we proceed from articles by Kumbhakar, Heshmati, Hjalmarsson (2002) on labour-use in Swedish banking, Kumbakhar and Hjalmarsson (1997) on labour-use in Swedish social insurance offices, Ncube and Heshmati (1998) on employment in Zimbabwe's manufacturing industries and Haouas, Yagoubi and Heshmati (2002) on Tunisian manufacturing industries. We use a model that allows for the inoptimality in the usage of labour. By inoptimality we mean deviations from the long run employment target, while inefficiency refers to the use of excess labour to that of the minimum amount required by the employed best practice technology to produce a given level of output. It means that sometimes too much labour is used. Inoptimality is due to costly adjustment; while inefficiency is due to the employed technology being relatively labour intensive compared to the best practice one. It is assumed that labour is the only variable input and capital is quasi-fixed after an investment decision is made (that is fixed in the short run and variable only in the long run).

The assumption in the above is best satisfied for services industries where labour is the dominant production factor and the amount of capital is basically proportional to labour, a fixed amount per employee and about the same standard. Although it is harder to motivate this assumption for the manufacturing data, the high rate of export dependency, the rapid renewal of technology in the beginning of the transition period, capital limitation due to financing (liquidity) constraints and the desire to avoid a high unemployment rate make the model suitable for application even to the type of data that we are using.

If we have the panel data, the frontier or optimal labour requirements function can be defined as follows:[3]

$$L_{it}^{*} = f\left(W_{it}, Y_{it}, Z_{it}, t : \beta\right) \qquad (1)$$

where L_{it}^{*} is the optimal or desired level of labour employment, Y_{it} is real value added, W_{it} is real wage, Z_{it} is a vector a variables characterizing the production process and environment, and β are unknown parameters that are associated with determinants of optimal labour-use. This Z vector includes quasi-fixed real capital, but also economic policy variables. Finally, variable t denotes time, by which we model changes in technology.

Kumbhakar and Hjalmarsson (1997) modelled the relationship between the actual labour used by firm *i* at time *t* (denoted as L_{it}) and the optimal amount of labour (L_{it}^{*}) as:

$$L_{it} = L_{it}^{*} e^{u_{it}} \qquad (2)$$

where $u_{it} \geq 0 \;\; \forall\, i$ and variable t was interpreted as technical inefficiency. The term $e^{u_{it}} = L_{it} / L_{it}^{*} \geq 1$ measures optimality or overuse of labour. A $u_{it} = 0$ implies that $L_{it} = L_{it}^{*}$, that is, there is no inoptimality in the use of labour. The model was estimated using standard stochastic frontier techniques in which distributional assumptions were made on the inoptimality (inefficiency) and random error terms.

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3 Diewert (1974) discusses the properties of an input requirement function.

The optimality ratio can also be simply defined $OR = (L_{it} / L_{it}^{*})$ for $\forall\, i$ and t. In this case no distributional assumptions on the inefficiency *u*-term is needed. It is to be noted that normally the optimality ratio is expected to be greater than 1. Ratio less than 1 is also possible in cases where an expansion of production is limited for instance by shortage of physical or human capital. In the following inoptimality and inefficiency are used interchangeably. The difference is that an inefficient unit is compared in the sample to best practice technology, while an inoptimal unit is compared with reference to its own optimal level.

Though Kumbakhar and Hjalmarsson (1997) did not suggest any adjustment mechanism in labour use, the followers have adopted a dynamic setting by modelling the adjustment speed with which inefficient units catch up with the frontier of optimal labour use (1), rather than measuring labour use efficiency *per se*. Usually adjustment is costly, for instance, in most countries labour codes impose costs on dismissals, concerning statutory severance payments, advance notice periods, etc. It is often modelled that the marginal adjustment costs are increased in the size of the adjustment, for example collective dismissals may be more heavily regulated. So a partial adjustment model is specified:

$$L_{it} / L_{i,t-1} = (L_{it}^{*} / L_{i,t-1})^{\delta_{it}} \qquad (3)$$

where $0 \le \delta_{it} \le 1$ is the firm- and time-specific speed of adjustment. Basically it measures the percentage of the difference between actual and optimal levels of labour that is eliminated during one period. If $\delta_{it} = 1$, then full adjustment of actual labour to its optimal level occurs within a single period. If $\delta_{it} = 0$, no adjustment occurs and labour is at the optimal level in a given period for a firm. Alternatively, no adjustment is possible for the reasons of capital and labour supply limitations mentioned above.

The important feature of the model is that adjustment is firm- and time-specific. In such a framework the rigidity of the standard partial adjustment model is dropped. In the latter convergence is asymptotic, it occurs only during a rather long period of time and rapid jumps are ruled out (that is $L_{it} \to L_{it}^{*}$, when $t \to \infty$ and $0 < \delta < 1$). In the flexible model, an inoptimal industry could reduce its inoptimality faster by adjusting some of the factors that affect δ. Also in reality different industries have been found to adjust their labour-use differently over time (Kumbakhar, Heshmati and Hjalmarsson 2002). Accordingly the speed of adjustment or catch-up is determined as follows:

$$\delta_{it} = g(M_{it}, t : \gamma) \qquad (4)$$

where M_{it} is a vector of determinants of speed of adjustment partly overlapping the *Z* vector, γ is the vector of fixed unknown coefficients associated with the determinants of adjustment, and variable *t* here represents the temporal patterns of adjustment. The flexible adjustment speed is found to be an appropriate way of modelling firms' behaviour at the presence of heterogeneity in the cost of adjustment. In modelling L_{it}^{*} by including variable *t* we allow for technological change.

Taking logs, rearranging (3) and appending an error term we can express the labour use model as

$$\ln L_{it} = (1-\delta_{it})\ln L_{i,t-1} + \delta_{it}\ln L_{it}^{*} + v_{it} \qquad (5)$$

where v_{it} is the independently and identically distributed error term with mean zero and constant variance. To sum up, the important features of the model is that it is dynamic, less restrictive, allows identifying the determinants of optimal level of employment and quantifying their impacts. Furthermore, we can investigate the variation in the level of the optimal and the adjustment speed and labour use efficiency in response to policy measures both over time and across firms.

4 The data and variables

The data used in this study has been collected and compiled by the Statistical Office of Estonia. The data set includes up to 70 distinct items from firm-level financial statements. The items also include some general information on the firms, like yearly average number of employees, form of ownership and industry classification. The data set includes 438 enterprises observed for the period 1995-1999, so the early transition period is not covered. For 119 firms we have four consecutive years and for 319 firms five consecutive years of data.[4]

The labour-use model is specified as a factor input requirement function, where labour is specified to be a function of independent variables like wages, output produced, quasi-fixed capital, technology, production environment and production process characteristics of firms. The dependent variable (*L*) is measured as the yearly average full time equivalent number of employees in a given firm. Unfortunately the data set does not include information on the quality of human capital like on the level of education and the number of employees across skill categories say, blue collar versus white collar workers. The production characteristics variables include export share (*XSHARE*), capital intensity, profitability, ownership and industrial sector. Capital intensity and profitability are defined as capital and profit per unit of labour.

Output (*Y*) can be represented as quantities of goods produced, sales or value added. In this paper we use value added calculated as sales minus costs of intermediate inputs (material and energy expenses). Our wage (*W*) variable is the average wage per employee in a given firm that is obtained from dividing total wages in each firm by the total yearly average number of workers in each firm. Capital stock (*K*) is measured as the average value of capital equipment (fixed assets). The average is taken from the values at the beginning and at the end of each year. Profit is measured as the net income after taxes. Originally wages, capital and value added are expressed in current thousands of Estonian kroons, but we converted these to real values by dividing each with the producer price index. All real values are expressed in 1995 prices. The producer price index of the Estonian Statistical Office for the manufacturing industry was used for deflating nominal values. Though the dynamics of producer prices vary over different

[4] It is not due to excluding firms with less than four years of data but such was the original data.

industries, the statistical office publishes it only for a few, not for all individual manufacturing industries.

The firms in the sample make up about 70 per cent of the total sales of the Estonian manufacturing industry. The total number of firms in the industry in this period was about 4500 (Statistical Yearbook of Estonia 2000), so including proportionally more large firms than small firms biases the sample representation of population. While there are very few micro firms with less than 10 employees, small and medium sized firms (those with up to 250 employees) constitute 93 per cent of all firms (see also Appendix 1). In order to capture the effect of firms' size on adjustment speed and long-run labour demand, we defined five dummies, respectively for observations with 5-49, 50-99, 100-249, 250-499, and 500+ employees. This classification is consistent with the firm size classification applied by the European Community (see for example, Enterprises in Europe 2001).

The firm's industry classification is determined according to the EMTAK code (Classification of Economic Activities of Estonia) that is based on the Statistical Classification of Economic Activities in the European Community (NACE). We grouped all the firms into 10 industries, and created respective dummy variables that were added into regressions. The industry structure of the sample is described in Appendix 2. Most frequently the firms of our sample belong to the food industry (20 per cent of observations), machinery (18 per cent), paper and pulp (17 per cent) and textile industry (15 per cent).

We also controlled for the type of ownership (Appendix 3). Three dummies were defined for the state owned (1.6 per cent of observations), private Estonian capital owned (77 per cent) and foreign capital owned firms (21 per cent). By the beginning of our sample period privatization of state owned enterprises was almost completed in Estonia. Djankov and Murrell (2002) after reviewing the available extensive literature on enterprise restructuring in transition economies found that privatization is strongly associated with more enterprise restructuring. For some other transition economies soft budget constraints are found to influence negatively the performance of state owned enterprises. This is interpreted as evidence that firms have no incentives to improve their efficiency due to state subsidies or loans from state owned banks (Djankov and Murrell 2002).

Table 2 presents some descriptive statistics. Wages and export share is the only variables with coefficient of variations (CV = standard deviation/mean) below 1. The highest CV ratio is associated with profitability. Capital intensity also shows a high degree of dispersion among Estonian firms. The pattern is consistent with the volatile and rapidly changing business environment. Though original data was in national currency, for the international reader the monetary values are expressed in euros. In respect to all variables there is significant heterogeneity across firms. The average wage of just 3100 euro (in 1995 prices) indicates to rather low labour costs. According to Eurostat, in 2000 the hourly labour cost in Estonian industry was 2.90 euro, while candidate countries average was 3.25 euro and the EU average was 23.00 euro (Clare and Paternoster 2002). Exports constituted 45 per cent of net sales on the average. For a small open economy like Estonia such a high percentage is rather normal. It is to be noted that the internal market is too small to exploit the economies of scale.

Table 2. Descriptive statistics of the Estonian data, 1995-1999

Variable	Definitions and measures	Mean	Std dev.	Coefficient of variation
Labour	Year average number of employees	166.00	222.00	1.34
Wages	Annual wage cost in euro	3100.30	1785.45	0.58
Capital	Capital Stock (‘000 euro)	1036.21	2458.58	2.37
Value added	Value added (‘000 euro)	879.22	1391.39	1.58
Sales	Sales (‘000 euro)	2958.81	4859.80	1.64
Profitability	Profit per employee in euro	277.79	3292.53	11.85
Capital intensity	Capital per employee (‘000 euro)	6.59	13.42	2.04
Export share	Share of exports in sales	0.45	0.37	0.81
No. of firms	Number of firms	438	-	-
No. of periods	Number of years	5	-	-
No. of observations	Observations	2071	-	-

Sources: Statistical Office of Estonia.

Note. Untill 1999 the Estonian kroon was fixed to the DEM at the exchange rate 1EEK=8DEM. Since 1999 the kroon is fixed to the euro, 1EEK=15.64464 euro.

The correlation matrix (see Table 3) shows that as expected, the number of employees is negatively correlated with wages, and positively with value added, capital, capital intensity, and export share. In general wages and value added per employee increase with the size of the firm. A positive relationship between value added per employee and the size of firm is an indication of economies of scale. However, the relationship may partly be driven also by the fact that in small firms wages might be paid unofficially in cash and underreported in official statistics to avoid taxes. Concerning wages, in the literature it has been observed for some time that there is a positive relationship between employers’ size and the wages paid to workers so called employer size–wage premium (Troske 1994). The neoclassical explanations of the phenomena include the costs of employee monitoring, capital-skill complementarity and the complementarity between labour skills and advanced technology capital. However, the exception from this tendency in our data are the firms with more than 500 employees that are characterized by relatively lower wages, high capital intensity and higher export orientation (61 per cent of sales). This class of firms might belong to a type of foreign owned firm involved in recent years with international outsourcing and relocation of production activities to places like Estonia with access to low cost and less skilled labour. The average size of firm has decreased from 178 employees in 1995 to 163 in 1999, reflecting possibly the continued downsizing due to transition from Soviet-time large-scale industry and the emergence of new greenfield (de novo) firms.

Table 3. Correlation matrix of the variables

Variable	Employee	Wages	Capital	Value added	Sales	Profit per employee	Capital per employee	Export share
Employees	1.00							
Wage	-0.03	1.00						
	(0.16)							
Capital	0.43	0.23	1.00					
	(0.00)	(0.00)						
Value added	0.71	0.30	0.68	1.00				
	(0.00)	(0.00)	(0.00)					
Sales	0.64	0.34	0.65	0.84	1.00			
	(0.00)	(0.00)	(0.00)	(0.00)				
Profit/employee	0.02	0.16	0.01	0.23	0.19	1.00		
	(0.36)	(0.00)	(0.61)	(0.00)	(0.00)			
Capital/employee	-0.02	0.34	0.55	0.23	0.27	-0.06	1.00	
	(0.35)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)		
Export share	0.12	-0.07	0.06	0.09	0.03	0.00	-0.01	1.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.22)	(0.87)	(0.78)	

Source: Authors' calculations, Statistical Office of Estonia.
Note: p-values are in parentheses; number of observations *N* = 2071.

The correlation between value added and capital is high, indicating the presence of collinearity between the two explanatory variables (Table 3). The relationship applies to sales as well. Hence, the two effects of output and capital might be difficult to separate from each other. However, sensitivity analysis showed that the explanatory power of the model was much better when using value added (as in this paper) to explain variations in employment at the firm level.

5 The empirical model

In the empirical estimation we exploited translog functional form for modelling labour requirements function, which can be viewed as a second order Taylor series approximation of an arbitrary, twice continuously, differentiable production function (Christensen, Jorgenson and Lau 1971). The model in (5) consisting of (6) and (7) is non-linear in parameters and is estimated simultaneously using the maximum likelihood estimation method. The unobserved optimal labour-use L_{it}^{*} in (5) specified in terms of observable variables is written as:

$$
\begin{aligned}
\ln L_{it}^{*} &= \alpha_0 + \alpha_K \ln K_{it} + \alpha_W \ln W_{it} + \alpha_Y \ln Y_{it} + \alpha_T t \\
&+ 1/2\left[\alpha_{KK}(\ln K_{it})^2 + \alpha_{WW}(\ln W_{it})^2 + \alpha_{YY}(\ln Y_{it})^2 + \alpha_{TT}(t)^2\right] \\
&+ \alpha_{KW} \ln K_{it} \ln W_{it} + \alpha_{KY} \ln K_{it} \ln Y_{it} + \alpha_{WY} \ln W_{it} \ln Y_{it} \\
&+ \alpha_{KT}(\ln K_{it})t + \alpha_{WT}(\ln W_{it})t + \alpha_{YT}(\ln Y_{it})t + \textstyle\sum_j \mu_j D_{jit} \\
&+ \eta_{PRIVATE} PRIVATE_{it} + \eta_{FOREIGN} FOREIGN_{it} + \eta_{XSHARE} XSHARE_{it}
\end{aligned} \qquad (6)
$$

where $\ln W$, $\ln Y$ and $\ln K$ are log of wages, output and quasi-fixed capital variables, respectively[5] and variable t denotes time trend capturing technological change.[6] The D_{jit} are the nine industry dummy variables, $PRIVATE$ is the dummy variable for firms controlled by private Estonian capital, $FOREIGN$ is the dummy for firms controlled by foreign capital and $XSHARE$ is the share of exports in net sales.[7] The later characteristic variables are both determinants of the optimal labour use and the speed of adjustment.

The speed of adjustment in the actual amount of labour used in production to its optimal level from (5) can be modelled as a function of firm characteristics or policy variables as follows:

$$
\begin{aligned}
\delta_{it} &= \delta_0 + \delta_1 DIST_{it} + \delta_2 XSHARE_{it} + \delta_3 \ln(K/L)_{it} \\
&+ \delta_{PRIVATE}\, PRIVATE_{it} + \delta_{FOREIGN} FOREIGN_{it} + \textstyle\sum_j \zeta_j D_{jit}
\end{aligned} \qquad (7)
$$

where $DIST = |\ln L_{it}^{*} - \ln L_{i,t-1}|$, is a distance variable, the absolute difference between optimal labour for firm i in period t and actual labour at period t-1. The distance variable, *DIST*, is calculated at each iteration while estimating the non-linear model. The larger deviation from optimal, the higher the speed of adjustment is expected to be. The absolute value is taken because δ_{it} should increase both with over and under use of labour, otherwise the impact of *DIST* depends on whether $L_{it} > L_{it}^{*}$ or vice versa. The (K/L) term is for the relative capital intensity of the production process. The intuition with inclusion of capital intensity is that capital-intensive firms could more easily substitute labour for capital. The alternative is that if there were already relatively few workers per unit of capital (high capital intensity), substitution of remaining excessive workforce will be possible only at a decreasing rate. Due to our specification the adjustment speed can change both over time and firms. We did not include time dummies in the final model, as due to the short period and a high degree of nonlinearity, estimation of the model would have become highly complicated.

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5 The price of the other factor of production, capital, is not included in the list of regressors due to the assumption of quasi-fixity of capital. It is also usually not easy to obtain the variable either.

6 The other possibility for considering time is to use the general index model of Baltagi and Griffin (1988), that is including time dummies for each period. We did not follow that approach due to the high degree of nonlinearity in our model.

7 The reference for ownership is public ownership by the state and municipalities.

Since the parameters (α's) of the translog function due to the presence of interaction and square terms do not have a direct interpretation, total elasticities of labour with respect to changes in the independent variables (wages, capital, and output) need to be calculated for making any economic inference. Inclusion of the lag value of labour allows distinction between short and long run elasticities. The long run elasticities are obtained from the following relations:

$$E_K = \partial \ln L_{it}^* / \partial \ln K_{it} = \alpha_K + \alpha_{KK} \ln K_{it} + \alpha_{KW} \ln W_{it} + \alpha_{KY} \ln Y_{it} + \alpha_{KT} t \quad (8)$$

$$E_W = \partial \ln L_{it}^* / \partial \ln W_{it} = \alpha_W + \alpha_{WW} \ln W_{it} + \alpha_{KW} \ln K_{it} + \alpha_{WY} \ln Y_{it} + \alpha_{WT} t \quad (9)$$

$$E_Y = \partial \ln L_{it}^* / \partial \ln Y_{it} = \alpha_Y + \alpha_{YY} \ln Y_{it} + \alpha_{KY} \ln K_{it} + \alpha_{WY} \ln W_{it} + \alpha_{YT} t \quad (10)$$

The short run elasticities are obtained by multiplying the long run elasticities with the speed of adjustment. The expected signs of wage and output elasticity are respectively negative and positive. Capital elasticity is positive if labour and capital are complements and negative when they are substitutes. The exogenous rate of technical change is obtained as:

$$TC = \partial \ln L_{it}^* / \partial t = \alpha_T + \alpha_{TT} t + \alpha_{KT} \ln K_{it} + \alpha_{WT} \ln W_{it} + \alpha_{YT} \ln Y_{it} \quad (11)$$

If the rate of technical change is positive, an upward shift in the labour requirement function indicates technical regress (more labour using technology is introduced). Contrary, negative technical change implies labour saving technical progress. The rate of technical change can be decomposed into pure, non-neutral and scale augmenting components. The pure (neutral) technical change derives as $PTC = \alpha_T + \alpha_{TT} t$. The non-neutral component derives as $NTC = \alpha_{KT} \ln K_{it} + \alpha_{WT} \ln W_{it}$. The scale augmenting component of technical change is $STC = \alpha_{YT} \ln Y_{it}$. It measures shifts in the labour-use over time due to changes in the scale of operation.

As mentioned previously, we use two definitions of optimality and efficiency. By our first definition, labour use is optimal if there is no overuse of labour, that is, when $L_{it} = L_{it}^*$. In earlier papers (Kumbakhar, Heshmati and Hjalmarsson 2002) it has been measured as:

$$OR_{it} = \left(L_{it} / L_{it}^* \right). \quad (12)$$

This ratio can be described as an optimality ratio, that is, how much (how many times) the actual amount of labour exceeds the optimal labour. For $L_{it}^* < L_{it}$ (for example, due to rigidities in institutions), labour use is suboptimal and there is labour hoarding. For $L_{it} = L_{it}^*$ labour is at its long-run optimal level. Finally, the case of $L_{it}^* > L_{it}$ has been neglected in previous studies (Kumbhakar, Heshmati and Hjalmarsson 2002 always found $L_{it}^* < L_{it}$ though their model did not constrain for that). Although firms minimize cost (here labour) such a case may appear for a number of reasons. First, it may be justified with an increasing cost of hiring and training and potential shortage of labour, that it becomes optimal to adjust labour to a higher optimal level over several periods. Second, the expansion might be limited by the lack of internal (or by difficulties in finding external capital) resources to reach an equilibrium level of employment. In transition economies the latter occurs due to the lending inexperience of the banking sector, firms lacking credit history, collateral, etc. (Pissarides 1998). A third explanation might be expected postive future demand after investment is made resulting in higher optimal employment.

It is to be noted that we may have observations with labour use efficiency both greater and smaller than 1. The intuition is that during the period when production is expanded, for a given capital intensity optimality is < 1 (new employees need to be hired), and during times of contracting production optimality is > 1 (part of the workforce is redundant and needs to be dismissed). So in order to obtain optimality always ≥ 1, the optimality ratio can be normalized with respect to the annual minimum optimality value in the sample:

$$OR_{it}^{N} = (OR_{it} \big/ \underset{i}{Min}\, OR_{it}) \,. \qquad (13)$$

Here the reference is allowed to change over time. Optimality scores are compared with the best optimal labour use technology among firms within a year.

In the second approach, estimation of labour use efficiency is based on the residual from the labour requirement model (5). Using FRONTIER 4.1 (Coelli 1996), and considering the residual plus intercept as a dependent variable, a labour requirement stochastic frontier model (see Battese, Heshmati and Hjalmarsson 2000) is estimated and efficiency point estimates for each observation computed. Formally, the estimable equation then becomes as

$$v_{it} = \alpha_0 + u_{it} + w_{it} \qquad (14)$$

where the random error term, w_{it}, are assumed to be *i.i.d.* normally distributed with $N(0, \sigma_W^2)$ and independent of the inefficiency u_{it}. The latter are non-negative that is random variables assumed to account for the inefficiency in labour use, given the levels of outputs and the quasi-fixed capital input, and are obtained as truncations at 0 of the $N(m_{it}, \sigma_u^2)$ distribution of v_{it}. The degree of overuse of labour is explained by a time trend, ownership and export orientation:

$$m_{it} = \xi_0 + \xi_1 t + \xi_2 PRIVATE_{it} + \xi_3 FOREIGN_{it} + \xi_4 XSHARE_{it} \,. \qquad (15)$$

It means that time, ownership and export share are the variables affecting the labour use efficiency of a firm. Here m_{it} is the average of the normal distribution truncated at 0; higher m_{it} means higher inefficiency. The frontier model based on (14) and (15) treated as an inverted factor requirement (cost) model is estimated by the method of maximum likelihood. The over use of labour is defined as:

$$OL_{it} = \exp(u_{it}) \,. \qquad (16)$$

The *OL* measure is > 1, where the amount of excess to 1 indicates percentage over use of labour. The main difference with previously defined optimality ratio, *OR* measure, is that *OL* is estimated by assuming distributional assumptions on the parameters of its distribution. However, *OL* can alternatively be estimated by using fixed or random effects (for example methods of moment) methods to obtain efficiency levels. It is based on the mean or mode of the conditional distribution of inefficiency *u* given the overall residual *v*. For details on the use of such methods see Kumbhakar and Lovell (2000).

6 Empirical results

We estimated two labour demand models. First a static time trend model was estimated where only the observed amount of labour used is modelled. This model serves as a benchmark model with which we compare the estimated dynamic flexible adjustment model. The time trend model has no difference between the optimal and actual labour use because there is full adjustment, that is, $\delta_{it} = 1$. So the estimable equation is written as follows:

$$\begin{aligned} \ln L_{it} = {} & \alpha_0 + \alpha_K \ln K_{it} + \alpha_W \ln W_{it} + \alpha_Y \ln Y_{it} + \alpha_T t \\ & + 1/2\left[\alpha_{KK}(\ln K_{it})^2 + \alpha_{WW}(\ln W_{it})^2 + \alpha_{YY}(\ln Y_{it})^2 + \alpha_{TT}(t)^2\right] \\ & + \alpha_{KW} \ln K_{it} \ln W_{it} + \alpha_{KY} \ln K_{it} \ln Y_{it} + \alpha_{WY} \ln W_{it} \ln Y_{it} \\ & + \alpha_{KT}(\ln K_{it})t + \alpha_{WT}(\ln W_{it})t + \alpha_{YT}(\ln Y_{it})t + \sum_j \mu_j D_{jit} \\ & + \eta_{PRIVATE} PRIVATE_{it} + \eta_{FOREIGN} FOREIGN_{it} + \eta_{XSHARE} XSHARE_{it} + v_{it}. \end{aligned} \tag{17}$$

Next a dynamic model is estimated assuming a flexible adjustment parameter, δ_{it}, that varies both over time and over firms (see equations 5, 6 and 7). The dynamic model is highly nonlinear and an iteration procedure was employed for estimating its parameters. Various tests indicated the lag coefficient being different than zero and not being constant across firms and over time as it is in traditional dynamic models.

Table 4. Parameter estimates of dynamic and static labour demand models

	Static model		Dynamic model	
Variables	Estimates	Standard error	Estimates	Standard error
Labour use function				
α_0	-0.4354	0.3899	1.4644*	0.8686
α_y	0.0876	0.0659	0.1033	0.0963
α_w	1.1817***	0.1585	0.8318***	0.2269
α_k	0.1718***	0.0502	0.1219	0.0779
α_t	0.0769	0.0627	-0.1934	0.1352
α_{yy}	0.1524***	0.0063	0.1617***	0.0079
α_{ww}	-0.1132*	0.0611	-0.0588	0.0820
α_{kk}	0.0361***	0.005	0.0383***	0.0096
α_{tt}	-0.1007***	0.0121	-0.1580***	0.0313
α_{yw}	-0.1517***	0.0211	-0.1892***	0.0265
α_{yk}	-0.0373***	0.0053	-0.0397***	0.0079

	Static model		Dynamic model	
Variables	Estimates	Standard error	Estimates	Standard error
α_{yt}	0.0418***	0.0080	0.0696***	0.0127
α_{wk}	-0.0182	0.0149	-0.0019	0.0245
α_{wt}	-0.0076	0.0175	0.0556*	0.0325
α_{kt}	-0.0050	0.0055	-0.0143	0.0104
$\eta_{private}$	-0.2198	0.0728	0.1692	0.5109
$\eta_{foreign}$	-0.3381***	0.0755	0.4981	0.5149
γ_{mining}	-0.0772	0.0677	-0.8055**	0.3561
γ_{food}	0.1842***	0.0691	-0.6958*	0.3566
$\gamma_{textiles}$	0.2474***	0.0805	-0.5268	0.3646
$\gamma_{leather}$	-0.0338	0.0680	-0.5349	0.3587
$\gamma_{paper\ and\ pulp}$	-0.0986	0.0707	-0.9149**	0.3576
$\gamma_{chemical}$	0.1101	0.0677	-0.6804*	0.3562
$\gamma_{maschinery}$	0.0697	0.0881	-1.0708***	0.3873
$\gamma_{transport\ equipment}$	0.0864	0.0711	-0.7992**	0.3572
$\gamma_{furniture}$	-0.1543*	0.0885	-1.0111***	0.3649
γ_{xshare}	-0.0247	0.0276	0.3038***	0.0568
Speed of adjustment function (coeff. of lag *L*)				
γ_0			-0.3466*	0.2014
γ_{dist}			0.2461***	0.0174
γ_{xshare}			-0.1828***	0.0313
$\gamma_{private}$			0.1709	0.1947
$\gamma_{foreign}$			0.0625	0.1970
γ_{food}			0.3035***	0.0895
$\gamma_{textiles}$			0.4885***	0.0918
$\gamma_{leather}$			0.4035***	0.0999
$\gamma_{paper\ and\ pulp}$			0.3013**	0.0915
$\gamma_{chemical}$			0.3756***	0.0917
$\gamma_{maschinery}$			0.3576***	0.0893
$\gamma_{transport\ equipment}$			0.3755***	0.1279
$\gamma_{furniture}$			0.4396***	0.0925
$\gamma_{services}$			0.6743***	0.1535
$\gamma_{klabour}$			-0.0001***	0.0000
N	2071		1633	
R^2 adjusted	0.7795		0.9391	
Root MSE	0.4025		0.2042	

Source: authors' calculations.

Notes: *** significant at 0.01 level; ** significant at 0.05 level; * significant at 0.10 level.

The parameter estimates associated with the two static and dynamic models are presented in Table 4. A striking result is the improvement in the goodness of fit (R^2) due to the inclusion of lagged dependent variable in the dynamic formulation from 78 per cent to 94 per cent. It may be regarded as partial evidence in favour of a model that considers dynamics adjustment. That improvement could not to be seen in papers by Haouas, Yagoubi and Heshmati (2002) and Ncube and Heshmati (1998), that are based on aggregated (industry level) data. Due to aggregation, industry level data may hide some of the heterogeneous dynamics present at the firm level. While rapid changes may be observed at the firm level, the aggregate time series are likely to produce much more smooth results. In the static model 52 per cent of the parameters are statistically significant while in the dynamic model we may say so of about 71 per cent of the parameters; favouring the dynamic model over the static one. Frontier estimation results based on equations (14) and (15) are given in Table 5.

Table 5. Parameter estimates of stochastic labour use frontier model

Variable	Coefficient	Standard error	t-ratio
Labour use model			
α_0	0.050	0.004***	13.583
Inefficiency (over use) model			
γ_0	-1.122	0.412**	-2.726
γ_t	-0.077	0.013***	-6.039
$\gamma_{private}$	1.234	0.398***	3.097
$\gamma_{foreign}$	1.197	0.396***	3.026
γ_{XSHARE}	-0.065	0.027**	-2.439
Variance parameters			
γ^2	0.035	0.004***	8.195
γ	0.817	0.029***	27.936
Log likelihood function			1342.252
LR test of the one-sided error			155.26

Source: authors' calculations.

Note: The labour model parameters are estimated using non-linear regression method. Here the dependent variable is the residual (plus intercept) calculated from the labour model parameters.

6.1 Elasticities

Since the parameters of a translog function give little information that can directly be interpreted economically, inferences will be drawn based on calculated elasticities at each data point. The calculated elasticities are presented in Table 6 (elasticities from static model) and Table 7 (long run elasticities from dynamic model). The short run elasticities are simply the long run elasticities multiplied by the speed of adjustment. The latter at the sample mean are presented in Table 8. The inferences hereby will be mostly based on long-run elasticities from the dynamic model.

Table 6. Mean elasticities from the static time trend model by year and various firm characteristics

Characteristics	Value added	Wages	Capital	Technical change	Returns to scale
Mean by year					
1995	0.655	-0.685	0.073	0.277	1.564
1996	0.620	-0.703	0.068	0.167	1.656
1997	0.668	-0.757	0.062	0.072	1.527
1998	0.696	-0.789	0.061	-0.027	1.446
1999	0.725	-0.819	0.059	-0.127	1.381
Mean by firm size (number of employees)					
5-49	0.536	-0.526	0.072	0.085	1.852
50-99	0.627	-0.675	0.063	0.035	1.599
100-249	0.710	-0.816	0.061	0.085	1.413
249-499	0.803	-0.987	0.069	0.106	1.260
500+	0.899	-1.093	0.067	0.163	1.123
Mean by ownership					
State owned	0.677	-0.740	0.080	0.246	1.521
Municipality owned	0.672	-0.671	0.082	0.170	1.489
Private Estonian capital	0.673	-0.725	0.062	0.068	1.515
Foreign capital	0.668	-0.845	0.073	0.071	1.523
Mean by industry					
Mining	0.674	-0.759	0.052	0.128	1.511
Food	0.707	-0.847	0.075	0.089	1.457
Textiles	0.697	-0.651	0.049	0.063	1.454
Leather	0.683	-0.654	0.053	0.060	1.516
Paper and pulp	0.612	-0.733	0.075	0.051	1.615
Chemical	0.678	-0.84	0.074	0.076	1.493
Machinery	0.664	-0.725	0.055	0.067	1.549
Transport equipment	0.711	-0.884	0.066	0.110	1.450
Furniture	0.688	-0.752	0.066	0.058	1.505
Services	0.564	-0.546	0.064	0.117	1.726
Overall sample mean	0.672	-0.751	0.065	0.071	1.516
Std dev.	0.153	0.256	0.051	0.146	0.291

Source: authors' calculations

Table 7. Mean long-run elasticities, inoptimality ratio, and speed of adjustment by year, and various firm characteristics calculated from the dynamic model parameter estimates

Characteristics	Value added	Wages	Capital	Technical change	Speed of adjust-ment	Optimality ratio(OR)	Normal-ized OR	Returns to scale	Over use of labour
Mean by year									
1996	0.625	-0.946	0.058	0.186	0.201	0.964	1.737	1.650	1.105
1997	0.689	-0.906	0.043	0.035	0.206	0.963	1.735	1.490	1.112
1998	0.743	-0.871	0.035	-0.116	0.182	0.962	1.733	1.362	1.082
1999	0.801	-0.837	0.025	-0.268	0.179	0.996	1.795	1.266	1.064
Mean by firm size (number of employees)									
5-49	0.569	-0.679	0.048	-0.069	0.256	0.901	1.623	1.777	1.110
50-99	0.666	-0.788	0.038	-0.082	0.196	0.942	1.697	1.522	1.093
100-249	0.750	-0.958	0.037	-0.017	0.178	0.997	1.796	1.354	1.083
249-499	0.844	-1.127	0.047	0.016	0.169	1.027	1.850	1.204	1.076
500+	0.950	-1.279	0.045	0.083	0.162	1.005	1.811	1.067	1.108
Mean by ownership									
State owned	0.596	-0.916	0.058	0.130	0.045	1.039	1.872	1.686	1.013
Municipality owned	0.679	-0.901	0.065	0.156	0.070	0.885	1.595	1.472	1.020
Private Estonian capital	0.716	-0.863	0.037	-0.049	0.209	0.981	1.768	1.437	1.090
Foreign capital	0.716	-0.984	0.051	-0.021	0.136	0.907	1.634	1.443	1.083
Mean by industry									
Mining	0.691	-0.920	0.034	0.046	0.157	0.843	1.519	1.486	1.035
Food	0.736	-0.977	0.053	-0.014	0.266	0.992	1.787	1.403	1.076
Textiles	0.753	-0.809	0.019	-0.069	0.215	0.959	1.728	1.368	1.133
Leather	0.734	-0.801	0.022	-0.069	0.162	0.949	1.710	1.411	1.106
Paper and pulp	0.662	-0.857	0.051	-0.062	0.187	0.927	1.670	1.536	1.084
Chemical	0.713	-0.969	0.053	-0.027	0.177	0.983	1.771	1.435	1.078
Machinery	0.703	-0.858	0.029	-0.045	0.181	0.996	1.795	1.461	1.077
Transport equipment	0.741	-1.018	0.048	0.021	0.227	1.044	1.881	1.392	1.054
Furniture	0.740	-0.891	0.038	-0.059	0.443	0.978	1.762	1.404	1.103
Services	0.603	-0.759	0.044	-0.012	0.192	0.979	1.764	1.687	1.128
Overall sample mean	0.715	-0.890	0.040	-0.042	0.192	0.965	1.739	1.439	1.091
Std dev.	0.147	0.245	0.054	0.190	0.117	0.098	0.177	0.300	0.071

Source: authors' calculations.

Table 8. Overall means and standard deviations of short-run elacticities calculated using the dynamic model parameter estimates

Variable	Value added	Wages	Capital	Technical change
Overall mean	0.136	-0.164	0.007	-0.009
Std dev.	0.087	0.105	0.015	0.045

The signs of the mean values of elasticities are consistent with economic theory: wage elasticity is negative, output elasticity positive and capital elasticity also positive. The positive (though in absolute value small) capital elasticity indicates that labour and capital are complements and labour productivity increases with capital. The responsiveness is highest to wages, followed by output and capital.

The mean value of wage elasticity of labour demand is fairly high, -0.89 in dynamic model. The estimate of Järve (2002) for Estonian firms on the subset of our data set was -0.32. Concerning other CEE economies, estimated wage elasticities have been as follows:

> Konings and Lehmann (2002) obtained -0.18 for Russia,
>
> Basu, Estrin and Svejnar (2000) obtained estimates of short term elasticities in the range of 0.14 for Russia to -0.96 for the Czech Republic and for the five CEE economies (Slovakia, Czech Republic, Hungary, Poland, Russia) during 1992-1993,
>
> Körösi (1997) obtained -1.6 for Hungary,
>
> Domadenik and Vehovec (2002) obtained -1.0 for Croatia.

So in respect to wage elasticity Estonia belongs rather to the group of central European countries. Concerning estimates reviewed in Hamermesh (1986), our long run elasticity estimates fall on the upper side of those presented.

It means that despite relatively strict job security regulations in place in Estonia (above EU average level), employers adjust their workforce rather strongly to increases in labour cost. Also, the results reflect that in the middle of the 1990s market incentives shaped the behaviour of Estonian firms. However, there is some decrease in the absolute value of elasticity over time (from -0.95 to -0.84). The possible interpretation could be that initially very high labour market flexibility is decreasing. However, the elasticity from static model changes from -0.68 in 1995 to -0.82 in 1999. The elasticities are fairly stable across industries; lowest responsiveness to wages is in services (-0.76) and the highest in transport equipment production (-1.02).

The mean output elasticity, 0.72, is again close to the range obtained for other CEE countries by Basu, Estrin and Svejnar (2000), whose long run values ranged from 0.84 to 0.89. From both the static and dynamic model we see that these elasticities are growing over the time. Our short-term elasticity estimate, 0.14 is lower than those obtained by Basu, Estrin and Svejnar (2000), but rising also a little over time. Basu, Estrin and Svejnar (2000) noticed that short-term labour demand elasticities rose in central European countries after the start of the transition.

The mean capital elasticity is 0.04 with a standard deviation of 0.054. The elasticity is lowest in textiles (0.019) and highest in the food industry and chemical industry (0.053). Capital elasticity estimates are decreasing rather rapidly over time, from 0.058 in 1996 to 0.025 to 1999, so less jobs are created due to capital accumulation and the production process becomes more capital intensive (that is also seen from the growing amount of capital per labour over time).

The estimate of returns to scale is 1.44 on average. It is declining over time from 1.65 to 1.27 indicating lowering sub-optimal production processes over time. Less labour intensive technologies are taken into use over time. In all years and groups of firms we observe increasing returns to scale. We may wonder whether that points to the suboptimal size of many small firms. Indeed, returns to scale decreases continuously with firm size from 1.78 to 1.07 reflecting optimal development in resource utilization, learning by doing, and development of institutions.[8] The entrepreneurs of small and medium sized firms in transition economies have indicated the output growth to be an objective aside to profit maximization; researches have argued that this may sign the presence of obstacles to firm growth (Pissarides 1998; Pissarides, Singer and Svejnar 2000). Another side of the story is the emergence of many new firms at the start of the transition that have not yet achieved optimal scales of operations.[9] Maybe it is interesting to note that though returns to scale measures has decreased over the years, the average size of firms has not increased. The explanation could be that new technologies are adopted that make production more efficient at lower scales. The production of small firms may also be underreported in official statistics for tax evasion that may have some impact on the results.

6.2 Technical change

The mean rate of technical change is -4.2 per cent: on average one year later the same amount of output can be produced with 4.2 per cent less labour. The rate influenced by the time trend representative of technology is switching from a technical regress (+18.6 per cent) in 1996 to technical progress (-26.8 per cent) in 1999. The major changes are a reflection of the magnitude of the restructuring the industry and inflow of labour saving capital investment and outflow of goods produced. As we saw in 1995-1999 output per employee rose by 16 per cent. The reason that technical regress (in 1996-1997) was replaced with technical progress (in 1998-1999) could also be that economic recession following the Russian crisis forced enterprises to restructure by adopting new and more productive production technologies using less unskilled labour.

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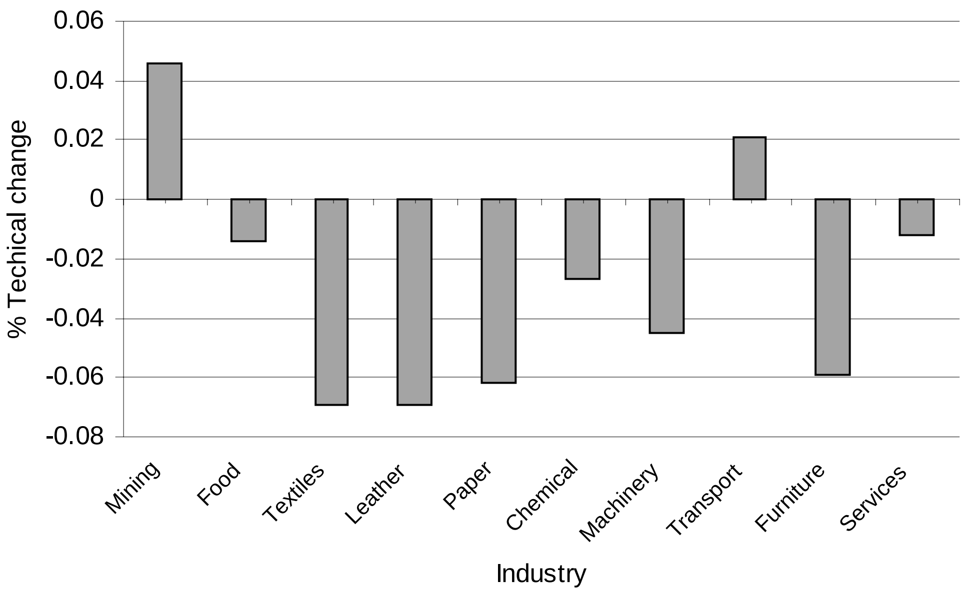
8 Ideally these measures should be weighted using for instance each categories share of the total value added as shares.

9 For a comprehensive analysis of small and medium enterprises in transitional economies, their growth, finance and survival, see McIntyre and Dallago (2003).

Concerning industries, we see mostly technical progress except in mining and the production of transport equipment. The highest rates of labour saving technical change can be observed in the textiles and leather industries, where strong competitive pressure has emerged from countries with cheap labour, like Pakistan and China. The presence of labour using technical change among state enterprises (13 per cent a year) could be due to lack of competitive pressure and the build up of public services as tax revenues increase.[10] Finally, small firms have experienced technical progress while large firms experience technical regress. Is it again differences in flexibility in adjustment and the competitive pressures that effect firms' labour demand and employment behaviour?

Figure 1. Mean period rate of technical progress (negative sign is labor saving) by industries from the dynamic model



Decomposition of technical change shows that neutral technical change is strongly labour-saving, though output and employment expanded over time, and the non-neutral change is labour-intensive due to low wages. Scale augmenting technical change is labour intensive because the returns to scale measure decreased from 1.65 in 1996 to 1.27 in 1999. Concerning the bias in technical change, the time and capital interaction term is negative, which may indicate that there is capital intensive technical change for given labour input. So we might consider it as evidence that over time labour is replaced with capital in Estonian industry. However, the parameter is not statistically significant. Furthermore, capital and labour were complements during the process of industrial development.

10 Though in the literature of transition, state owned enterprises receive a lot of attention, here we do not discuss the results as our sample includes only a few (1.55 per cent) such enterprises.

6.3 Labour use optimality

As mentioned above we base our analysis on two different definitions of optimality or efficiency in the use of labour. In the first case, labour use optimality can be defined as the ratio of actual labour (L_{it}) to the firm's long-run optimal labour (L_{it}^{*}). An optimality ratio > 1 can be interpreted as overuse of labour for a given level of output produced.

The optimality results are reported in Table 7. The sample mean optimality is 0.965 with standard deviation of 0.098. Optimality ratio varies in the interval 0.555 and 1.623. It means that for firms close to mean on the average the optimal amount of labour would be 3.5 per cent higher than the actual level. In the first sight it may be surprising: in earlier studies this ratio has always been found > 1 so that usually too much labour is used. We also estimated our model with more simple functional forms for the labour requirements function to see whether the translog functional form may cause the optimality ratio on average to be < 1 as it fits the data rather well. So we also used the Cobb-Douglas and generalized Cobb-Douglas, that is the Cobb-Douglas model augmented with squared terms of independent variables. However, these modifications did not change the patterns of the optimality ratio much, neither did it solve the problem of the optimality ratio smaller than 1.

However, our results can be clarified as follows. During the periods when an enterprise needs to expand activities, labour in period *t*, L_{it}, exceeds the labour in period L_{it-1}, so that for speed of adjustment $0 < \delta_{it} < 1$, the optimality ratio will be higher than 1. On the other hand, if the amount of labour is to be reduced following for example economic recessions or problems specific to enterprise, L_{it} will be smaller than L_{it-1} so that the optimality ratio will be less than 1. Aggregate employment in Estonia decreased during 1992-1993. It expanded during the recovery period of 1994-1997, followed by another contraction period of 1998-2000 (recall Table 1).

One key factor distinguishing the Estonian manufacturing from others is that Estonia has gone through a comprehensive restructuring of industry in a relatively short time period. After the collapse of the Soviet market production capacity was reduced and it took time to create a stable investment environment, attract foreign investors, go through reorientation of trade to western markets and economic recovery. The rapid restructuring process has caused imbalances between capital and labour causing disruption in the flow of output. The imbalances are due to the limitation of capital to meet a growing demand for good produced using a low paid labour force. The lack of capital together with restrictive labour market regulations has made labour hoarding and an optimal level of labour permanently exceeding the observed level possible. Shortage of capital combined with an increasing marginal cost of adjustment kept the observed level below the optimal level.

For the unexpected range of optimality ratio, in Table 7 we also present the values of the optimality ratio, standardized in respect to the minimum value of the optimality, 0.555. The average of the standardized value is 1.739 with a standard deviation of 0.177. It should be noted that the distribution is very sensitive to the extreme nature of the minimum and maximum values.

The mean labour use optimality is < 1 for all years, and slightly higher in 1999. An explanation could be that in 1999 economic recession in Estonia caused by the Russian crisis generated labour hoarding, widespread dismissals and unemployment to grow. However, while on the whole manufacturing industrial production dropped by 6 per cent in current prices and 2.5 per cent in real terms, employment decreased by 7 per cent. There was also a drop in labour productivity, in 1999 the value of industrial output per employee dropped by 3 per cent (Statistical Office of Estonia). The variation in labour use optimality is more noticeable over firms. The optimality is lowest in the mining and highest in the transport equipment and food industries. The mean optimality is < 1 in groups of firms with up to 250 employees but > 1 among firms with more than 250 employees. The list of explanations includes higher unionization rates among large firms; extra regulations on collective (large-scale) dismissals present in Estonia; employment protection rules are less enforced in small establishments, etc. Cazes and Nesporova (2001) showed that employees in larger establishments in transition economies have significantly longer job tenure in comparison to employees in smaller establishments, probably due to larger job flows in the latter. Finally, state owned firms show a slightly higher normalized optimality compared to firms owned by Estonian private capital (1.76) or foreign capital (1.63).

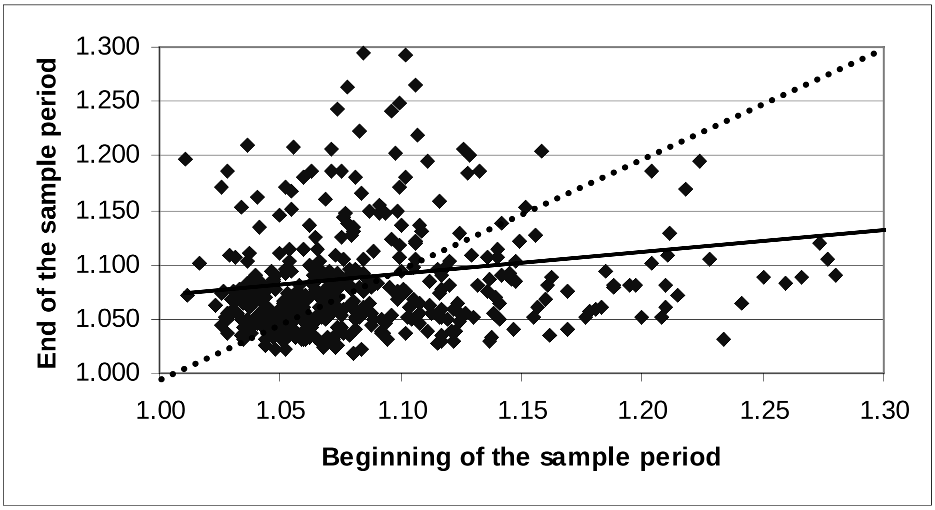
6.4 Overuse of labour

According to the second definition, Estonian manufacturing has on average used 9.1 per cent labour in excess of the best practice technology in production of a given level of output. The standard deviation is 7.1 per cent. The period mean firm level overuse of labour ranged from 1.03 to 1.37. The parameter estimates of stochastic labour use frontier model can be found in Table 5.

The degree of overuse of labour is declining over time from 10.5 per cent in 1996 to 6.4 per cent in 1999. The level of overuse of labour is negatively correlated with the size of firms, except for firms with more than 500 employees. State owned and municipality owned firms are more efficient than private and foreign owned. However, as there are few state owned firms we do not emphasize these results much. There is evidence of large variations in overuse of labour by industrial sector. Mining (textile) is the most (least) efficient industrial sector. We also see that export orientation increases efficiency in the use of labour, possibly due to stronger competitive pressure.

Finally we note that though generally research findings refer to a high level of efficiency persistence among firms, and also for some transition economies (see Funke and Rahn 2000 for East and West German manufacturing), that does not appear in our results: the Spearman rank correlations are only 0.24. The end and beginning of the sample period values of efficiency vis-à-vis are plotted in Figure 2. The efficiency improvements are below the 45-degree line; while the efficiency deterioration are above the 45-degree line. The rather flat regression line shows that convergence is quite small. The biggest efficiency improvements can be seen in food and chemicals industries, while smallest in mining and services.

Figure 2. The dynamics of overuse of labour



Source: authors' calculations.

6.5 Speed of adjustment

The estimates of the speed of adjustment can be found in Table 7. The sample mean is 0.192 and standard deviation 0.117. The point estimate means that industries close to mean adjust 19 per cent of their deviations off the equilibrium during one year. In regard to previous studies this estimate is of average size. Earlier estimates range from 7.1 per cent (Haouas, Yagoubi and Heshmati 2002) to 33 per cent (Ncube and Heshmati 1998) per year. The median lag length is 3.25 years or 13 quarters.[11] It means that it takes 13 quarters for employers to move half way to the eventual equilibrium in response to a shock in labour demand. Considering the results of studies reviewed in Hamermesh (1993), it is a fairly large number. The result is somewhat surprising, as other studies referred in our paper have indicated to the rather high flexibility of the Estonian labour market. The speed of adjustment is very much determined by the credit market and inflow of foreign direct investment (that is, supply of capital).

The adjustment speed has somewhat decreased over time (from 20 per cent to 18 per cent). Though that may in principle imply decreasing labour market flexibility, the change is rather modest. Much more noticeable is the variation over firms. The adjustment speed is highest in services (44 per cent), followed by textiles (26 per cent), furniture (23 per cent) and leather (22 per cent). The far lowest speed of adjustment is found for mining (over 5 per cent). That evidence is in line with western studies. In services the production is less capital intensive and labour is relatively unspecialized and needs relatively little training and a higher share of temporary forms of employment (fixed-term contracts, temporary work, agency employment) may be the reason. In services also the influence of unions is probably much weaker due to the higher share of

[11] The median lag length t^* derives from the formula $(1-\delta)^{t^*} = 0.5$ (Hamermesh 1993: 248).

small size firms. In mining industry the trade unions have usually much more power that prevents adjustments by means of dismissals and production is capital intensive.

State owned enterprises are much slower adjusters of excess workforce, their catch up speed is 4.5 per cent a year compared with 20 per cent in Estonian private firms and 14 per cent in foreign owned firms. Commenting on the difference between Estonian and foreign owned firms, Hannula and Tamm (2003) argued that domestically owned enterprises use rather defensive restructuring by being more focused on cutting costs through reducing the number of employees while foreign owned firms use rather strategic restructuring activities (focused on increasing revenues). Unsurprisingly also small firms are more flexible, and the size of the adjustment parameter declines continuously with firms' size class.

Our results also show that there is a positive relationship between the gap between current and optimal labour and the speed of adjustment (see Table 5). Firms less efficient (further away from the labour requirements function) are expected to adjust faster. We also see statistically significant and negative impact of capital intensity on adjustment speed. The intuition for the relation could be that capital is a binding factor for adjustment in labour. More capital-intensive firms have less labour, so the possibilities to adjust the stock of employees downwards are rather limited. Finally export intensity is slows down the adjustment speed as well. The explanation could be that if fluctuations in export markets are more likely to be considered temporary compared to changes in the domestic market, it is less necessary to adjust to the former.

The correlation matrix concerning the adjustment speed, current and optimal levels of labour and optimality ratio and their relation with time are presented in Table 9. As we see, adjustment speed is positively correlated with the optimality ratio, implying that with faster adjustment there is less labour hoarding and actual labour is closer to optimal. There is a statistically significant, though numerically small, decrease in adjustment speed over time. Adjustment speed decreases with both optimal and actual labour due to the effect of firm size.

Table 9. Correlation between time and various parameters of the dynamic adjustment model

	Time	Adjustment speed	Optimality ratio	Actual labour (L)	Optimal labour (L^*)
Time	1.00				
Adjustment speed	-0.09	1.00			
	(0.00)				
Optimality ratio	-0.13	0.13	1.00		
	(0.00)	(0.00)			
Actual labour	-0.01	-0.18	0.36	1.00	
	(0.83)	(0.00)	(0.00)		
Optimal labour	-0.07	-0.25	-0.19	0.84	1.00
	(0.01)	(0.00)	(0.00)	(0.00)	

Source: authors' calculations.

7 Summary and conclusions

The purpose of this study is to model labour demand in Estonian manufacturing in a dynamic fashion, by deducing quantitative estimates on labour use optimality and labour hoarding, and the size of adjustment speed in attaining the optimal level of employment. The long run labour demand is represented by the labour requirements function. Short run labour demand depends also upon the last period labour and adjustment speed were allowed, on several determinant factors. Thus employers choose their own individual adjustment paths to catch up with the labour requirements frontier.

For the purposes of sensitivity analysis, both dynamic and static models are estimated. The models perform well and explain a high proportion of variations in labour use. The results are found to be consistent with the theoretically expected ones. Concerning results of the dynamic model, long run employment responds greatest to wages, followed by value added and capital stock. The mean elasticity of labour demand is fairly high in international comparison, so employers adjust their workforce rather strongly to increases in labour cost. Capital elasticity estimates are decreasing rather rapidly over time, so that fewer jobs are created due to capital accumulation and the production process becomes more capital intensive.

Technical change is generally labour saving. The initially positive rate (regress) of technological change has become negative (labour saving) partly probably due to the effects of the Russian crisis. The highest rates of labour saving technical change can be observed in textiles and leather industries more imposed to external competition. While pure technical change is labour saving, the non-neutral change is labour using, to a large extent due to labour using scale biased technical change. In all years and groups of firms we observe increasing returns to scale that may indicate the suboptimal size of many small firms. However, the degree of sub-optimality in the scale of operation is declining over time as a result of learning by doing and comprehensive restructuring process.

The mean optimality ratio shows that optimal labour is larger than actual by 3.5 per cent and by the second efficiency measure overuse of labour is 9.1 per cent on the average. According to the first (second) measure the degree of overuse of labour has slightly increased (decreased) over time. It means, that due to adjustment of labour and technological changes employed labour has increased to catch up with the firms own optimal level and labour overuse compared to best practice technology, that has decreased. The optimality ratio is lowest in the mining and highest in the transport equipment, textiles and food industries. According to the first measure the mean optimality is < 1 in groups of firms with up to 250 employees but > 1 in groups of firms with more than 250 employees. According to the second measure overuse of labour is negatively correlated with the size of firms, except for firms with 500+ employees. Export orientation increases efficiency in the use of labour.

The estimates of adjustment speed show that industries close to mean adjust 19 per cent of their deviations off the equilibrium during one year. It also means that it takes about 13 quarters for employers to move half way to the eventual equilibrium in response to a shock in labour demand. The adjustment speed is surprisingly low compared to other studies' findings of an indication of the high flexibility in the Estonian labour market. The adjustment speed is highest in services and textiles and lowest in mining.

So all in all, though some of our results have indicated high flexibility (high wage elasticity of labour demand) in some sectors, others have indicated modest flexibility (relatively modest size of adjustment speed). Considering that, and the limitations of our data, future studies or expansion of the current study of Estonian industries may need to make some developments in a few directions. First, our industry coverage is mostly limited to manufacturing firms, while results for other areas like service sectors may be quite different. Second, the adjustment of low and high skilled workforce is probably rather different; with the latter the adjustment should probably be more costly. A decomposition of labour into high and low skilled categories would be benefitial. The other improvement for having data by educational categories would be that the nature of skill biased technical progress could be analyzed more thoroughly.

Appendix 1. Distribution of observations across firm size classes

Size class	Number of employees	Frequency	Percent
1	5-49	291	14.05
2	50-99	862	41.62
3	100-249	584	28.20
4	250-499	200	9.66
5	500+	134	6.47

Appendix 2. Distribution of observations across industries

Number	Description	3-digit EMTAK Code	Frequency	Percent
1	Mining	100-140	40	1.93
2	Food	150-159	417	20.14
3	Textile	170-183	325	15.69
4	Leather	190-193	72	3.48
5	Paper and pulp	200-222	357	17.24
6	Chemicals	240-268	205	9.90
7	Machinery	270-333	372	17.96
8	Transport equipment	340-351	46	2.22
9	Furniture	360-366	190	9.17
10	Services	370-	47	2.27

Appendix 3. Distribution of observations across firms with different types of ownership

Number	Ownership type	Frequency	Percent
1	State owned enterprise	32	1.55
2	Municipality owned enterprise	1	0.05
3	Enterprise with majority owned by private domestic capital	1598	77.16
4	Enterprise with majority foreign ownership	440	21.25

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