Estimating the Demand for Heterogeneous Labor in Hungary During the Pre-Crisis and Crisis Periods

By

Vahe Krrikyan

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Supervisor: Professor John S. Earle

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Abstract

In this thesis I study the demand for heterogeneous labor in Hungary in the last decade. Using a linked employer-employee database of Hungarian firms belonging to retail trade, food, textile and electronics manufacturing industries for the years from 2000 to 2009 I investigate whether the demand for unskilled, medium-skilled and high-skilled labor has been influenced by the economic developments in the pre-Crisis period and during the Crisis. I estimate the dynamic and static demand for heterogeneous labor and find that while the short-run elasticity of demand for unskilled labor was unresponsive to wages in the period from 2003 to 2007, the long-run elasticity hadn't changed since 1999. At the same time both the short-run and long-run elasticities of demand for medium-skilled and high-skilled employment decreased in absolute value. The estimation results also show that both the short-run and long-run elasticities of demand for all skill types of labor (except for the short-run elasticity of demand for high-skilled) have increased in absolute value during the Crisis, implying that the financial constraints of firms caused by the decline of effective demand for products and services have made firms more responsive to wage changes. The long-run elasticities are higher than the short-run elasticities in both periods meaning that firms incur adjustment costs when changing the employment of all skill types.

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1. INTRODUCTION

The Hungarian economy witnessed several fundamental developments during the last decade. In the first half of the decade Hungary was on the path of constant growth, the real GDP increased by 4% on average annually (see Table A.1) attracting high inflows of foreign direct investment, the unemployment rate was low and the wages were growing constantly. However, the steady economic development didn't last long. In order to satisfy the Maastricht Criteria the Hungarian Government was forced to implement austerity measures, which resulted in substantial economic contraction.

Still not revived from the tightening fiscal and monetary policies, the Hungarian economy was struck by the Global Financial Crisis in 2008, which caused a sharp decline in the real GDP of the country, the net foreign direct investments to GDP ratio shrunk dramatically from 47.03% in 2008 to only 3.26% of GDP in 2009, reaching the lowest level since 1991. The employment rate decreased to the lowest level in the region at around 55% (Hars, 2012).

In this thesis I analyze heterogeneous labor demand in Hungary with a focus on whether the reaction of employment to wages has changed during the last decade and if the responses differ with different skill types. I study the demand for heterogeneous labor during the pre-Crisis period when the Hungarian economy was growing steadily and in the Crisis. I suspect the elasticity of demand for heterogeneous labor has changed since 1999 which is the last year for which the demand elasticity for labor of different skill types was estimated in Hungary (Kertesi and Köllö, 2002). In particular, several factors could influence the demand for labor of different skill types during the pre-Crisis period. One source of influence can be considered the real minimum wage which has increased by approximately 92 percent[1] since 2000 in Hungary, reaching from 33,909 HUF in 2000 to 58,377 HUF in 2007 and 57,661 HUF in 2009 expressed in 2005 constant prices. I expect this has led to an increase in the wages of unskilled labor which caused the substitutability of unskilled with other factors of production to change forcing an increase in the elasticity of demand for unskilled labor.

Another factor that has possibly influenced the elasticity of demand for labor during the first half of the 2000s is the skill-biased technological change. As Acemoglu (2002) highlights, the technological development in the last decades has been biased towards high skilled labor leading the productivity of this factor of production to increase and raising the demand for high-skilled. I suspect the skill biased technological change increased the elasticity of demand for unskilled labor by raising the substitutability between capital and unskilled. I also expect that the elasticity of demand for high-skilled either decreased or didn't change during the first half of the 2000s as I assume that due to the technical development the substitutability between high skilled-labor and medium-skilled has decreased.

The high FDI inflows to the country during the period from 2000 to 2007 (see table A.1) can be considered as another source of influence on the demand for heterogeneous labor. Specifically two main streams of influence can be distinguished through which the FDI inflows have affected the demand for labor. The first is through an increase in competition in the products market and the second is through the increase in the share of foreign multinational firms in the domestic economy. I address the upper mentioned sources of influence in more detail in the next chapter.

[1] The real minimum wage in Hungary increased by almost 72% during the period from 2000 to 2007 and by approximately 92% from 2000 to 2012 (66.7% from 2000 to 2010) according to the OECD Statistical Database.

In the thesis I also investigate whether the decrease in effective demand for goods and services due to the Financial Crisis has influenced the demand for heterogeneous labor. In particular I suspect that the decline in demand for products and services increased the price elasticity of demand for goods causing the elasticity of demand for unskilled and medium-skilled workers to increase in absolute value.

The answers to these questions are very important for the economic literature in the following respects. First of all estimating labor demand elasticities for workers of different skill groups is crucial for being able to anticipate future developments in the labor market and foresee the possible trends of different population groups' welfare. The responsiveness of employers to wages of different skill groups is needed in forecasting future changes in employment and unemployment using macro models. On the other hand it is important in designing equality aimed labor market policies and anticipating the effects of policy implementation. Studying the change in labor demand due to the consequences of the Crisis is also interesting in a sense that it helps us to answer whether the adjustment of firms during different periods of the economic cycle is the same or it varies during booms and recessions, and if there is divergence in responses to changes in wage level, which skill groups are worse off and which are better off.

In order to answer the research questions I estimate static and dynamic labor demand models using a linked employer-employee dataset (LEED) of Hungarian firms for the periods from 2003 to 2007 and the year 2009. This framework will help me estimate the demand for heterogeneous labor just before the Crisis, in the period of economic development of the country and during the Crisis. The estimation results will show the demand for which type of labor was affected more by the Crisis and in which direction.

The thesis is organized as follows. In the second chapter I present the review of relevant literature and give theoretical motivation for suspecting possible changes in the elasticity of demand for labor of different skill types, chapter 3 describes the short- and long-run labor demand elasticities and summarizes the estimation methodologies, in chapter 4 I describe the data set and data preparation needed for the estimations, chapter 5 presents the estimation results. I summarize the findings in the Conclusion.

2. LITERATURE REVIEW AND MOTIVATION

2.1 Review of Previous Literature

The requirements for a research in the field of labor demand are quite challenging due to the lack of firm-level data describing the characteristics of individual workers (Hamermesh, 1993). This is the reason why the topic has gained little attention in the academic world. In particular there are very few studies of labor demand in the Central and Eastern European countries and most of them date back to the 1990s. One study by Basu *et al.* (2005) analyzes the firm behavior in the Czech Republic, Hungary, Poland and Slovakia during the last years of Communism and in the first years of transition. Using a partial adjustment dynamic labor demand model and data on industrial enterprises in the four countries, the authors estimate the wage and sales elasticity of labor demand for each year in the period from 1988 to 1992. They find that the adjustment of firms' employment behavior was very fast after the collapse of the Soviet Union, highlighting that the Hungarian firms were substantially reformed in the beginning of transition, and also they find no evidence of labor hoarding during the transition period. The authors report the estimates of short- and long-run own wage labor demand elasticity in Hungary to be -0.829 and insignificant -5.023 respectively for the year 1991-92, though they admit that the data set of Hungarian firms was constructed mostly from large industrial firms.

In another paper Gabor Körösi (1997) estimates the short-run labor demand elasticity for Hungarian firms for the period from 1985 to 1995 using a dynamic labor demand model and data on medium and large exporter firms but unfortunately omitting, as the author suggests, a crucial part of the labor market, that is, the new small firms. The estimated wage elasticities of labor demand vary from -0.825 in 1991 to -0.440 in 1993 during the transition period, and for the last year of the sample the estimated elasticity is -0.584. Explaining the high divergence of the estimates during the 1991-1995 period, the author suggests that the high volatility in estimates is due to the fact that the labor market hadn't yet stabilized after the collapse of the Communist Regime.

Kertesi and Köllö (2002) study the demand for heterogeneous labor during the period from 1992 to 1999. They use a data set consisting of firms that have at least 30 workers and they group individual workers into the following groups: unskilled, young skilled and older skilled. The authors use a translog cost function approach and estimate the long-run wage elasticities of labor demand to be -1.768, -0.647 and -0.997 for unskilled, young skilled and older skilled workers respectively. At the same time the authors suspect that during the 1990s the estimated firm level prices of capital might be severely biased as for the estimation they use the annual depreciation levels of the firms and during 1990s small firms tended to report very high depreciation rates. Kertesi and Köllö also show that skilled and unskilled labor are p-complements while younger and older skilled are p-substitutes.

Table A.2 summarizes the results of labor demand estimates in CEE countries. As we can see, out of three studies of labor demand in Hungary only one addresses the demand for heterogeneous labor, the other two treat the Hungarian labor force as homogeneous, whilst this approach won't help a lot in predicting the developments in the labor market for workers of different skill levels. My main motivation to use the cost function approach for estimating the long-run demand elasticities is to get results comparable with those by Kertesi and Köllö (2002).

The economic literature suggests high divergence between labor markets in Europe and the United States. Specifically in their study Konya and Krause (2011) show that wages in existing employment relationships are more rigid in Euro Area than in the US. In another study Nickell

(1997) argues that high unemployment levels in Europe are mainly due to the high unemployment benefits compared to that in the United States, if the unemployed are not forced to find a job, high unionization and low cooperation among unions in Europe and high overall taxes. At the same time he mentions strict employment protection legislation in Europe as another source of labor market rigidity. Among many other differences between labor markets of the US and Europe Wasmer (2002) also adds the low mobility of labor in Europe explaining this phenomenon with diverse nature of human capital investments. Relying on the facts highlighted in these studies, I mainly concentrate on the past research in Europe as labor markets of the European countries have similar characteristics with the Hungarian labor market.

Using the data from German LIAB, Addison *et al.* (2005) estimate the long-run labor demand elasticity for unskilled and skilled workers in the manufacturing industry. Their results suggest that technological progress and trade don't have a negative impact on unskilled employees, and structural changes even have positive effect on employment of unskilled. The reported elasticities of labor demand are also interesting in a sense that they contradict the theory, in particular, the authors report the following estimates of own-wage labor demand elasticities: -0.496, -1.051 and -0.600 for unskilled, skilled and highly skilled employees respectively. As these results show, the estimated elasticities predict that the demand for skilled workers is more sensitive to wage shocks than that of unskilled but Hamermesh (1993) argues that the short-run elasticity of demand for a particular skill group is lower if the adjustment costs of hiring are higher, suggesting that the demand elasticity for skilled workers must be lower in absolute value than that of unskilled workers given that the hiring costs of skilled are higher.

Several studies of in Germany report labor demand estimates that are positive, which contradicts the labor demand theory (e.g. Falk and Koebel, 2001). In another paper Freier and

Steiner (2007) use a translog cost function approach to estimate the long-run static demand elasticities for different labor groups in the whole German economy. The authors estimate the own wage elasticity of demand both for labor and for hours worked and find that in both cases the elasticity is higher in absolute value for unskilled compared to skilled labor, though in case of the hours worked the elasticity differential is lower. The authors also estimate the labor demand for the Western and Eastern parts of Germany separately and find that the elasticities in the Eastern part are much lower in absolute value than that of the West. The own-wage elasticity of demand for male employees in the Eastern part is estimated to be -0.30 and -0.11 for low skilled and high skilled respectively. It is worth noting that the firm behavior in the East German labor market can be considered closer to the firm behavior in Hungarian labor market connected with common past Communist regime.

In their study of German labor market Lichter, Peichl and Siegloch (2012) estimate the short- and long-run own wage labor demand elasticities for unskilled, medium skilled and high skilled labor using static and dynamic labor demand models and find the median adjustment time to be 5.25 quarters[2]. With the Arellano-Bond Difference GMM approach they estimate the short-run own wage elasticities to be -0.536, -0.298 and -0.318, and the estimated long-run own wage elasticities are -1.05, -0.37 and -0.56 for unskilled, medium-skilled and high-skilled workers respectively. The authors also find medium-skilled and unskilled workers to be p-substitutes the same way as high-skilled and medium-skilled workers, while-high skilled and unskilled workers are estimated to be p-complements, although the cross wage elasticity is close to zero. Estimating the short-run labor demand elasticities of different types of workers Jacobi and Schaffner (2008) find similar results. Using data for the period from 1976 to 1995 Falk and Koebel (2001)

[2] They estimate the coefficient on the lagged employment parameter to be 0.590.

estimate the short-run labor demand elasticities to be -0.20, -0.05 and 0.01 and long run elasticities - -0.21, -0.10 and -0.20 for low, medium- and high-skilled employment respectively. It's noteworthy that the short-run own-wage demand elasticity for skilled workers is positive. Using data on Colombian manufacturing firms Roberts and Skoufias (1997) estimate the short-run own-wage labor demand elasticities to be -0.650 and -0.423 for unskilled and skilled workers respectively. In most of these studies the elasticity of demand for unskilled workers is higher in absolute value than that for skilled workers as suggested by the theory. Given the estimates of the studies I expect the short-run elasticities of labor demand be in the range from -0.5 to -0.1 and the long-run elasticities be between -1.8 and -0.20, I also expect the elasticity of demand for the unskilled be higher in absolute value than that of high-skilled both during the Crisis and pre-Crisis periods.

In recent years many researchers have concentrated on studying the effects of FDI on the labor demand. Scheve and Slaughter (2003) identify several theoretical reasons for how the FDI can increase the labor demand elasticity in the domestic labor market; they highlight increased competition in the product market and globalization of production as two main sources influencing the labor demand elasticity. The authors add that another source of influence can be the fact that Multinational Establishments (MNE) are more likely to shut down their plants than domestic firms (e.g. Fabrri, *et al,* 2003). Bruno, Crino and Falzoni (2012) study the impact of FDI on labor demand in the Czech Republic, Hungary and Poland and find the effect of FDI on non-manual workers share in the wage bill to be positive for Hungary, insignificant for the Czech Republic and negative for Poland. The authors argue that the divergence of effects is connected with different shares of low-skilled workers in the labor force in these countries, Poland having the largest share. They also find that the increase in exports of final goods decreases the relative demand for skilled workers in all three countries. Li and Girma (2006) find that MNEs adjust to optimal employment level much faster than domestic firms in the UK manufacturing sector, and in another study of UK MNEs Godart, *et al* (2012) find that foreign MNEs tend to have higher labor demand elasticity than domestic MNEs. These studies provide evidence that the high level of FDI in Hungary during the years from 2000 to 2007 should have increased the elasticity of labor demand.

Several papers analyze the impact of the Global Financial Crisis on labor demand. In particular Babecky, *et al* (2011) study the short- and long-run labor demand elasticities in the Czech Republic before and after the Crisis. They use a partial adjustment labor demand model as the baseline and using a panel data set of Czech manufacturing firms with 50 and more employees for the period from 2000 to 2009 they find that during the Crisis both the short- and long-run own wage labor demand elasticities increased. They estimate the short- and long-run elasticities to be equal to -0.532 and -0.936 for the period from 2002 to 2007 and -0.901, -1.586 for 2008-09 period respectively. They argue that the increase in elasticities is due to the fact that firms became demand constrained. The authors also use the Hausman test to check the exogeneity of real sales and find that though in the short run real sales are exogenous in the long run firms can affect the market. In another paper Bohachova, Boockmann and Buch (2011) try to explain the phenomenon of Germany during the Crisis, where the GDP contracted by almost 5% while the unemployment rate declined. The authors estimate a dynamic labor demand model for the period from 2000 to 2009 and use the difference of predicted and actual employment levels in 2009 as a measure of labor hoarding. They find a significant evidence of labor hoarding during the Crisis. Another finding is that firms that were using time accounts had more persistent employment levels. They find the labor demand elasticity equal to -0.08 which is insignificant for the 2000-08 period. Given the finding by Babecky, *et al* (2011) I treat sales as exogenous in estimating the short-run elasticities of demand for unskilled, medium- and high skilled labor in Hungary.

2.2 Possible influences on the labor demand in Hungary during the 2000s

As mentioned in the previous sections the economic developments in Hungary during the last decade changed the firm behavior. Specifically, as highlighted in the literature review, many studies have addressed the effect of FDI on labor demand, at the same time the rate of foreign direct investments has been high in Hungary during the last decade (Table A.1). Summarizing the results one can distinguish two main sources of impact on labor demand elasticity. One source is the increased competition due to creation of new firms and plants. Increased competition implies that the demand for products becomes more elastic as it becomes easier to substitute the appreciated product with another and the first Hicks-Marshall law of derived demand suggests that in this case the own-wage labor demand elasticity will increase. The other source of influence is connected with the increase in the share of foreign multinational firms in the Hungarian economy due to high levels of FDI while foreign affiliates are shown to have higher in absolute value labor demand elasticity (Godart *et al.*, 2012). Skill biased technological change can be considered another source of influence on labor demand of Hungarian firms. Acemoglu and Autor (2010) suggest that the relative demand for skilled workers may have risen because of the technological change while the substitutability between unskilled labor and capital may have increased as well, leading to higher elasticity of demand for unskilled labor[3] which can be the case in Hungary. In other words, the increase in substitutability between unskilled labor

[3] This is suggested by the second Hicks-Marshall law of derived demand

and capital could cause the Hungarian firms to substitute unskilled workers with capital as a response to an increase in wages, which means that the elasticity of demand for unskilled labor may have increased. Another factor affecting the hiring behavior of Hungarian firms could have been the increase in real minimum wage by almost 67% during the period from 2000 to 2007. As Hamermesh (1981) shows in his study, the increase in the minimum wage resulted in a decline of other factors' substitutability with young labor force during the 1954-1978 period. Neumark and Wascher (1992) get similar results; they show that a 10% increase in the minimum wage lowers the employment of young adults by approximately 1.5-2%. It is possible that the change in real minimum wage affected some part of the unskilled workers in Hungary by increasing the price of unskilled labor force and making them more substitutable with capital.

The Global Financial Crisis hit Hungary mainly through national currency depreciation which resulted in soaring of housing loans' local currency values, as almost 63 percent were in foreign currency (Egedy, 2012). As a consequence the effective demand shrunk and the industrial production fell by 18%, businesses faced financial shortages and the economic activity slowed down (Egedy, 2012). FDI inflows declined dramatically (Table A.1). All this led to increased unemployment; the participation rate didn't change as those who lost their jobs, didn't go out of the labor market, though total hours worked declined by less than the GDP resulting in a labor hoarding (Kierzenkowski, 2012). Kierzenkowski (2012) also highlights that the participation rate of those with less than upper secondary education remained the lowest among all other education groups (Figure A.1).

Summarizing all the upper mentioned factors, I expect that the elasticity of demand for unskilled workers has increased during the last decade due to the skill biased technological change and the increase in the minimum wage rate, while the elasticity of demand for skilled workers has either decreased or didn't change. At the same time the developments during the Crisis have led the effective demand in the goods market to decline. Given this I suspect that the own-price elasticity of goods has increased during the Crisis causing the elasticity of demand for labor of different skill types to increase as suggested by the first Hicks-Marshall law of derived demand. The Crisis also caused the Hungarian firms to be more financially constrained and in a situation of rigid wages firms have to adjust to changes in wage via adjustment of employment of different skill types. I suspect this has made firms substitute appreciated factors of production with other substitutable factors leading the elasticity of demand for heterogeneous labor to increase during the Crisis.

3. EMPIRICAL METHODOLOGY

3.1 Short-run Labor Demand Elasticity

As discussed in Hamermesh (1993) the adjustment of labor demand to an exogenous shock is costly for firms. In particular Hamermesh (1993) distinguishes the types of costs into explicit and implicit[4]. The implicit costs are difficult to calculate as they include the overall costs incurred from hiring and firing workers. Due to the adjustment costs it takes time for firms to fully adjust to the new economic situation and if assuming quadratic costs of adjustment, in each time period they adjust their employment levels to the profit maximizing equilibrium only partially.

To take into consideration the role of adjustment costs of hiring and firing on firms' response to exogenous wage shocks, I use the partial adjustment labor demand model to estimate the short-run labor demand elasticity of Hungarian firms. The model relies on several assumptions such as convex adjustment costs, stochastic exogenous shocks and rational expectations of the firms (Hamermesh, 1992). Convex adjustment costs imply a continuous adjustment path of firms to the new profit maximizing equilibrium level of employment, as large changes in employment are connected with high costs, although it is worth mentioning that the researchers haven't yet come to a consensus about the nature of adjustment costs (Lichter, *et al,* 2012) and the recent research shows the nature of adjustment costs to be a mixture of convex, linear and fixed costs (e.g. Nilsen, *et al,* 2007). The assumption of stochastic exogenous shocks implies that firms don't have perfect foresight about future developments. The rational expectations assumption implies that firms' expectations are based on present and past information.

[4] By explicit costs the author means those costs that can be illustrated in the income or expenditure statements of a firm, such as costs for advertisements, interviews etc, whilst by implicit costs he means those that cannot be measured explicitly, such as the costs incurred from lower than average productivity of newly employed workers or from the time of experienced workers spent on training the newcomers.

The partial adjustment model assumes that the current employment level L_t is not equal to its profit maximizing level L_t^* because of the convex adjustment costs. Following Lichter, *et al* (2012) and Sargent (1978) the change in employment from t-1 to t can be represented as a portion of the desired change:

$$\Delta L_t = \lambda(L_t^* - L_{t-1}) \text{ or}$$

$$L_t = \lambda L_t^* + (1-\lambda)L_{t-1} \qquad \textbf{(1)}$$

Assuming a Cobb-Douglas production function, (1) can be represented in logarithms (Nickell, 1986) as presented in (2) where L_t^* is the profit maximizing employment level and can be presented as a function of real wage w_t, the level of output Y_t and the real price of capital k_t as shown in (3).

$$\ln(L_t) = \alpha_1 \ln(L_t^*) + \alpha_2 \ln(L_{t-1}) + \mu_t \qquad \textbf{(2)}$$

$$L_t^* = L(w_t, k_t, Y_t) \qquad \textbf{(3)}$$

Specifying (3) in a log-linear form and plugging it into (2) we can get the relationship presented in equation (4):

$$\ln(L_t) = \gamma + \alpha_2 \ln(L_{t-1}) + \beta_1 \ln(w_t) + \beta_2 \ln(Y_t) + \beta_3 \ln(k_t) + \mu_t \qquad \textbf{(4)}$$

Following Lichter, *et al* (2012) I add the lags of the explanatory variables in the model and choose the number of lags of the dependent variable in the right-hand side of the model empirically, following Godart, *et al* (2012). I approximate k_t by the amortization rates of the firms. I also add time dummies to control for time fixed effects δ_t and also control for firm-specific effects by including ν_i. making all these changes I arrive to the following estimation model:

$$\ln(L_{it}^{x}) = \sum_{s=1}^{n} \alpha_2^s \ln(L_{t-s}) + \sum_{s=0}^{1} \{\beta_{1,x}^{s} \ln\left(w_{i,t-s}^{x}\right) + \beta_2^s \ln\left(Y_{i,t-s}\right) + \beta_3^s \ln\left(k_{i,t-s}\right)\}$$

$$\theta_{1,y} \ln\left(w_{i,t-s}^{y}\right) + \theta_{2,z} \ln\left(w_{i,t-s}^{z}\right) + \delta_{\ t} + \nu_i + \varepsilon_{i,t} \quad \textbf{(5)}$$

where $w_{i,t-s}^{x}$, is the real wage level for unskilled, medium- and high-skilled labor respectively and $\beta_{1,x}^{0}$ represents the own-wage demand elasticity for type X labor. $w_{i,t-s}^{y}$ and $w_{i,t-s}^{z}$ are the real wages of the other skill types, $\varepsilon_{i,t}$ is zero mean disturbance term assumed to be serially uncorrelated.

3.2 Estimation of the Short-Run Labor Demand Elasticity

As the dynamic partial adjustment labor demand model assumes that the lagged values of the explained variable, the logarithm of employment, have explanatory power and must be included in the right-hand side of the model, doing so and estimating the model with an OLS estimator will cause a dynamic panel bias, as $\ln(L_{i,t-s})$ is correlated with the error term which includes firm fixed effects ν_i. So the coefficient on the lagged employment level will be biased upward (Roodman, 2009). The fixed effects estimator won't solve the problem either, as the transformed $\widetilde{\ln(}L_{it-s})$ will still be correlated with $\tilde{\varepsilon}_{it}$ - the transformed error term (Roodman, 2009). The difference and system GMM estimators solve the endogeneity problem by using the previous lags of the variables as instruments for them so they are consistent in this case (Arellano and Bond (1991), Blundell and Bond (1998)). The difference GMM estimator first differences the dynamic model and uses the lagged levels of each endogenous variable as instruments for the transformed one whilst the system GMM estimates the level equation and uses the differenced lags of the variable as instruments for it. But as Blundell and Bond (1998) argue, if the autocorrelation coefficient of the dependent variable $\ln(L_{i,t})$ is close to 1, in other words if the variable follows a Random Walk process, then the lagged levels ($\ln(L_{i,t-s})$) of the dependent variable will serve as weak instruments for the differenced right-hand side variable $\Delta\ln(L_{i,t-1})$. In this respect the system GMM estimator is preferred.

The two-step Difference and System GMM estimators estimate the optimal weighting matrix in the first step and then use it in minimizing the quadratic expression with respect to the corresponding sample moments (Roodman, 2009). The one-step estimators are used in the case when the idiosyncratic errors are assumed to be homoscedastic (Bond, 2002). I estimate (5) using both two-step System and Difference GMM estimators as the comparison of the results will serve as a robustness check. Roodman (2009) also notes that as the OLS and within-group estimates of the lagged dependent variable's parameter are biased in different directions, the true value must lie in between the two estimates. This fact can serve as an indicator of the performances of the System and Difference GMM estimators.

3.3 Long-run Labor Demand Elasticity

The long-run or static labor demand elasticity helps to predict the equilibrium adjustment of labor demand to a change in wages. In particular it shows the overall change in the employment scheme of a firm as a result of a wage shock. The static labor demand framework also helps us to find the relationships between the unskilled, medium- or high skilled labor and the change in wages of one of these groups; it helps to determine which skill groups can be considered as p-substitutes and which ones can be considered as complements. Taking this into account I estimate the static labor demand for workers of different skills just before and during the Crisis. The comparison of the own and cross-wage elasticities will help to find the skill groups that suffered the most during the Crisis in Hungary and it will also help to construct policies aimed at assisting specific skill groups.

To estimate the static own- and cross-wage labor demand elasticities for different skill groups in the Hungarian labor market I use the transcendental logarithmic functional form which is a second order approximation of an arbitrary cost function. I follow the methodology described by Freeman (1979) and Hamermesh (1993). The logarithmic minimum cost (C^*) function has the following representation:

$$lnC^* = \gamma_0 + \gamma_1 lnY + \sum_{i=1}^{4} \theta_i lnw_i + \frac{1}{2}\sum_{i=1}^{4}\sum_{j=1}^{4} \beta_{ij} lnw_i lnw_j + \sum_{i=1}^{4} \beta_{iy}\, lnw_i lnY + R_m \quad \textbf{(6)}$$

where Y is the output produced using capital and three types of labor, and X_i and w_i are the demand for factors of production and their prices respectively. The cost function in (6) is subject to the following constraints implied by the equality of the cross-derivatives and the cost function's homogeneity of degree one in prices:

$$\beta_{ij}=\beta_{ji}, \quad \sum_{i=1}^{4} \beta_{ij} = 0, \quad \sum_{i=1}^{4} \beta_{iy} = 0 \quad \textbf{(7)}$$

Taking a derivative of (6) with respect to lnw_i and using the Shephard's lemma we can come to the following cost share equations:

$$\frac{\delta \ln C^*}{\delta lnw_i} = \frac{w_i X_i}{\sum_i^4 w_i X_i} = s_i = \theta_i + \sum_{j=1}^{4} \beta_{ij} lnw_j + \beta_{iy} lnY \text{ where i=1,...,4} \quad \textbf{(8)}$$

3.4 Estimation of the Long-Run Labor Demand Elasticity

Using the parameters of (8) it is possible to calculate own- (ε_{ii}) and cross-wage (ε_{ij}) elasticities of labor demand using the following methods:

$$\varepsilon_{ii} = \frac{\beta_{ii} - s_i + s_i^2}{s_i} \quad \textbf{(9')} \quad \varepsilon_{ij} = \frac{\beta_{ij} + s_i s_j}{s_i} \quad \textbf{(9'')}$$

Following Kertesi and Köllö (2002) the parameters for calculating the elasticities in (9'), (9'') can be estimated using the following system of equations:

$$s_{1n} = \theta_1 \sum_{j=1}^{4} \beta_{1j} lnw_{jn} + \beta_{1y} lnY_n + \beta_{1f} F_n + \vartheta_{1n}$$

$$s_{2n} = \theta_2 \sum_{j=1}^{4} \beta_{2j} lnw_{jn} + \beta_{2y} lnY_n + \beta_{2f} F_n + \vartheta_{2n}$$

$$s_{3n} = \theta_3 \sum_{j=1}^{4} \beta_{3j} lnw_{jn} + \beta_{3y} lnY_n + \beta_{3f} F_n + \vartheta_{3n} \quad \textbf{(10)}$$

Where F_n controls for non-neutral efficiency differences. The system is subject to the following constraints: $\beta_{12} = \beta_{21}, \beta_{13} = \beta_{31}, \beta_{23} = \beta_{32}$. I use a dummy variable whether a firm is exporter as a proxy for F_n. The subscripts 1,2,3 of the variables denote the skill levels and 4 denotes capital. The parameters of the fourth equation can be recovered from (7) as the equation is linearly dependent from the system of equations (10). I follow Lichter, *et al* (2012) and estimate the system of equations (10) using the method of Seemingly Unrelated Regressions (SURE) as it is more efficient estimator than the OLS.

4. DATA DESCRIPTION

I conduct the estimations using a linked employer-employee data set (LEED) of Hungarian firms belonging to the retail trade, food, textile and electronics manufacturing industries for the period from 2000 to 2009. The data set includes information both for employers and employees making it possible to estimate the labor demand for workers of different skill levels. It was constructed using two different sources. One is the Hungarian National Tax Authority which provides data on every formal sector employer if the company is of limited liability and on almost 80% of partnerships. This database includes firms' balance sheet and income data, also such variables as the sales level per year, employment, the location of the firm and its industrial affiliation.

The second source is the Hungarian Wage Survey (hosted by the National Employment Office). The Survey collects data on employees starting from 1992. This database includes information on firms with equal to or more than 5 employees[5]. Production workers are selected into the database if they were born on the 5th or 15th day of any month, and non-production workers are included if they were born on the 5th, 15th or 25th day of any month. From 2001 the Hungarian Wage Survey started to include all employees of firms with equal or less than 50 workers. The difference in methodologies for including production and nonproduction workers in the Survey has resulted in a disproportional representation of two types in the sample. Therefore, within firm individual weights were calculated for each employee using the number of employees of two types in the population and in the within firm sample. Another problem in the database arises when a firm doesn't have employees born on the upper mentioned dates. In this case the firm is dropped out of the sample. To make the database representative for the

[5] The sampling threshold was different before 2000.

whole industry, company weights were calculated for each firm and they vary with the size, as a bigger firm has higher probability of being included in the sample. In other words the individual weights describe how many workers an individual worker in the sample represents within a firm, and the company weights show how many firms in the economy a single firm represents.

Due to the high level of information coverage by the two databases it was possible to link the Wage Survey and the data from the National Tax Authority and create a linked employer-employee database of Hungarian firms. Though the data doesn't allow us to follow individuals in time, it helps to follow the firms for a long period. The database also helps to disaggregate the firm level characteristics such as wage bill and the number of employees among different types of labor. This makes it possible to analyze the labor demand for different types of labor during time and to estimate the own- and cross-wage elasticities of labor demand.

The data set that I am using in my thesis contains unweighted data on 6,238 firms for the period from 2000 to 2010 though it is not balanced; it includes observations on 1,230 firms in 2009 and 1,664 firms in 2008 (Figure A.2). Overall the data set consists of 18,993 firm-years and if using company weights the number of firm-years becomes equal to 281,813 (see Figure A.3). Using the individual level data I calculated the firm level wage bills and number of employees for workers with different skill levels. I divided the labor force by skills into three groups: unskilled, medium-skilled and high-skilled workers. In the unskilled group I included workers who finished only primary school by the definition of the Hungarian educational system, which means workers with at most eight years of education are included. In the medium-skilled group I included workers that obtained high-school diploma, vocational education or two more years of specialized post-secondary education. This means workers in this skill group have from 10 to 12 years of schooling. In the high-skilled group I included workers with college or university degree, according to the Hungarian educational system workers in this group have on average 16 years of schooling.

After weighting the data set I deflated the sales, wage bills, tangible assets and amortization levels of each firm using the harmonized consumer price index for Hungary provided by the OECD statistical service. I use the discount rate of each firm in each year as a proxy for firm-level price of capital following Kertesi and Köllö (2002). I calculated the discount rates by dividing firm-level amortization by tangible assets in each year. In order to estimate the long-run labor demand elasticities I calculated the firms' total costs by summing the weighted total wage bill and monthly amortization of each firm and then I got the cost shares for each skill type by dividing the wage bill for particular skill type in the firm by its total costs.

5. EMPIRICAL RESULTS

5.1 Short-run Estimation Results

To estimate the short-run labor demand elasticities for the Hungarian labor I use several specifications of model (5) and estimate them using OLS, Fixed Effects, System and Difference GMM estimators.

In particular I estimate several specifications of the model using firm level data for all full-time employees and for different periods to find whether the Crisis has had any influence on the labor demand decisions of Hungarian firms. For this purpose I use the data on firms that belong to retail trade, food, textile and electronics manufacturing industries. The estimation results are presented in Tables 1 and 2.

In the tables $ltotwnum_{t-1}$ and $ltotwnum_{t-2}$ are the first and the second lags of the dependent variable which is the logarithm of individual and company level weighted number of employees per firm, $Lrwavg_t$ and $lrwavg_{t-1}$ stand for the present and lagged logarithm of individual and company level weighted real average wages, lry_t and lry_{t-1} represent the present and lagged log of individual and firm level weighted real sales of the firm, and $lramort_t$ and $lramort_{t-1}$ are the level and first lagged values of the annual amortization of the firms used as a proxy for the price of capital per firm.

Table1. Estimation results of different specifications of Model (5) using OLS, Fixed Effects, Difference and System GMM estimators for the years 2003-2007[6].

Dep. Var: Firm level employ-ment	**OLS**		**Fixed Effects**		**Diff. GMM**		**Sys. GMM**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$ltotwnum_{t-1}$	0.723***	0.504***	0.124***	0.071***	0.327***	0.396***	0.822***	0.673*
	(0.007)	(0.014)	(0.014)	(0.018)	(0.047)	(0.047)	(0.139)	(0.353)
$ltotwnum_{t-2}$	--	0.259***	--	0.086***	--	0.173***	--	0.140
	--	(0.013)	--	(0.018)	--	(0.058)	--	(0.261)
Lrwavg	**-0.142*** **	**-0.119*** **	**-0.104*** **	**-0.099*** **	-0.084**	-0.062	**-0.123*** **	**-0.103*** **
	(0.018)	(0.022)	(0.023)	(0.027)	(0.038)	(0.052)	(0.029)	(0.040)
$Lrwavg_{t-1}$	0.079***	0.017	0.028	-0.039	0.026	-0.022	0.067	0.018
	(0.017)	(0.021)	(0.022)	(0.026)	(0.033)	(0.040)	(0.025)	(0.042)
Lry	0.130***	0.099***	0.130***	0.081***	0.109***	0.162***	-0.120	**-0.078*** **
	(0.008)	(0.010)	(0.011)	(0.014)	(0.029)	(0.030)	(0.083)	(0.026)
Lry_{t-1}	**-0.072*** **	**-0.042*** **	0.043***	0.049***	0.011	-0.009	0.190**	-0.034
	(0.008)	(0.010)	(0.012)	(0.014)	(0.021)	(0.025)	(0.096)	(0.042)
$Lramort_t$	0.166***	0.123***	0.137***	0.122***	0.156	0.134***	0.160***	0.130***
	(0.008)	(0.011)	(0.011)	(0.014)	(0.027)	(0.029)	(0.020)	(0.028)
$Lramort_{t-1}$	**-0.133*** **	**-0.096*** **	-0.018	-0.013	-0.033	-0.041	**-0.137*** **	**-0.109*** **
	(0.008)	(0.011)	(0.012)	(0.014)	(0.022)	(0.026)	(0.027)	(0.042)
Num. of Obs.	8388	4612	8388	4612	4610	2901	8388	4612
R-squrd	0.737	0.765	0.541	0.575	--	--	--	--
AR(1) Test	--	--	--	--	-6.1	--	-5.11	- 1.79
AR(2) Test	--	--	--	--	-1.59	--	1.87	0.24
Hansen Test	--	--	--	--	240 (0.00)	114 (0.00)	2.65 (0.754)	3.39 (0.416)
Nb. Of Gr.	--	--	--	--	1656	1050	3489	1657
Nb. Of inst.	--	--	--	--	34	32	19	18

Standard errors are presented in parentheses. The values of Arellano-Bond AR tests represent the t-statistic of the hypothesis of no autocorrelation in differenced errors. The p-values are presented in the parentheses of the Hansen test. Diff. and Sys. GMM are estimated using robust standard errors. Two step Sys. GMM estimator is used. (***), (**) and (*)-significant at 1%, 5% and 10% level respectively.

In tables 1 and 2 the specifications denoted by odd numbers include only one lag of the dependent variable and those denoted with even numbers have two lags on the right-hand side of the model. When estimating model (5) using the System GMM estimator I consider lagged and

[6] I estimate model (5) using the data set for the years from 2000 to 2007.

level values of wages, sales and amortization as exogenous following Lichter *et al.* (2012) and Babecky *et al.* (2011).

We can see from the results in both tables that all the estimated elasticities of labor demand are negative and most of them are highly significant. At the same time the coefficient on the sales (*Lry*) variable is positive and highly significant except for the cases when using the System GMM estimator for the period 2003-2007. The low coefficients of the sales variable imply that the firms have decreasing returns to scale. The Arellano-Bond AR tests in specifications (7) and (8) indicate that in order to prevent the bias caused by the autocorrelation in differenced errors the dependent variable must be included in the model with two lags. The Hansen tests for the System GMM in both tables have high p-values, which means that the hypothesis of overidentifying restrictions cannot be rejected. In other words, the instruments for the System GMM estimator are not correlated with the error term and don't cause a biased estimator. As already mentioned in the previous chapters, the OLS and Fixed Effects estimators are biased and the biases have opposite directions making the interval between estimated parameters by the two estimators a benchmark to evaluate the preciseness of Difference and System GMM estimators. Using this it is easy to see that, in table 2, specification (8), the parameter on the lagged dependent variable estimated using the System GMM estimator lies within the interval of the two parameters estimated by the OLS and Fixed Effects. In contrast to this, table 1 shows that when estimating labor demand before the Crisis the estimated parameter of the first lag of employment using Difference GMM also lies between the estimates by OLS and Fixed Effects. However it is worth mentioning that as the Hansen test results show for the Diff. GMM estimator, the hypothesis of overidentifying restrictions is rejected with p-value 0.00 meaning that the

Table 2. Estimation results of different specifications of model (5) using OLS, Fixed Effects, Difference and System GMM estimators for the year 2009[7].

Dep. Var: log of firm level employment	OLS		Fixed Effects		Diff. GMM		Sys. GMM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Totwnum_{t-1}$	0.647***	0.605***	-0.054	-0.036	**-0.245*** **	-0.141	0.803***	0.687
	(0.018)	(0.026)	(0.036)	(0.042)	(0.070)	(0.104)	(0.170)	(0.697)
$Totwnum_{t-2}$	--	0.213***	--	-0.084**	--	-0.094*	--	0.116
	--	(0.025)	--	(0.041)	--	(0.054)	--	(0.653)
Lrwavg	**-0.346*** **	**-0.297*** **	**-0.432*** **	**-0.397*** **	**-0.347*** **	**-0.365*** **	**-0.276*** **	**-0.273*** **
	(0.049)	(0.049)	(0.067)	(0.060)	(0.069)	(0.077)	(0.053)	(0.072)
$Lrwavg_{t-1}$	0.152***	0.137***	-0.089	-0.102	**-0.222*** **	**-0.116** **	0.086	-0.076
	(0.046)	(0.048)	(0.068)	(0.065)	(0.054)	(0.054)	(0.555)	(0.110)
Lry	0.392***	0.273***	0.449***	0.360***	0.283***	0.331***	0.264***	0.246***
	(0.008)	(0.018)	(0.026)	(0.027)	(0.039)	(0.037)	(0.045)	(0.063)
Lry_{t-1}	**-0.162*** **	**-0.146*** **	0.112***	0.226***	0.157***	0.181***	-0.091*	-0.087
	(0.019)	(0.019)	(0.032)	(0.031)	(0.031)	(0.035)	(0.053)	(0.083)
$Lramort_t$	0.339***	0.352***	0.399***	0.391***	0.386***	0.329***	0.303***	0.311***
	(0.018)	(0.019)	(0.026)	(0.029)	(0.039)	(0.040)	(0.043)	(0.068)
$Lramort_{t-1}$	**-0.295*** **	**-0.321*** **	-0.025	**-0.087*** **	0.045	0.032	**-0.261*** **	**-0.270*** **
	(0.019)	(0.020)	(0.032)	(0.033)	(0.032)	(0.037)	(0.046)	(0.081)
Num. of Obs.	3011	2893	3011	2893	2890	2575	4126	2893
R-squrd	0.840	0.840	0.687	0.660	--	--	--	--
AR(1) Test	--	--	--	--	-2.783	-2.265	-4.23	-0.97
AR(2) Test	--	--	--	--	0.144	-0.874	3.98	0.31
Hansen Test	--	--	--	--	415 0.00	398 0.00	21.23 (0.069)	11.30 (0.503)
Nb. Of Groups	--	--	1654	1401	1399	857	2001	1401
Nb. Of Inst.	--	--	--	--	37	42	25	25

Standard errors are presented in parentheses. The values of Arellano-Bond AR tests represent the t-statistic of the hypothesis of no autocorrelation in differenced errors. The p-values are presented in the parentheses of the Hansen test. Diff. and Sys. GMM are estimated using robust standard errors. Two step Sys. GMM estimator is used. (***), (**) and (*)-significant at 1%, 5% and 10% level respectively.

[7] The data from the years 2006-2008 are used as instruments for the endogenous right-hand side variables in the model when using two lags of the dependent variable in the right-hand side. When estimating the model with System GMM I use firm level data for the years from 2005 to 2009.

instruments are correlated with the error term so there is a high risk that the estimates using the Diff. GMM estimator are biased. Based on what has been discussed here, in further analyses I concentrate on the results by the System GMM estimator.

We can see from table 1 that the own-wage elasticity of demand for homogenous labor for the period from 2003 to 2007 is estimated to be -0.123 or -0.103 depending on the specifications, using the System GMM estimator. Although the skill biased technological change, the high FDI inflows during the 2000s and other factors indicated in the previous chapter suggest that the wage elasticity of labor demand should have increased in absolute value, the estimation results show that it decreased in the Hungarian labor market during the first half of the 2000s in comparison to the elasticity of labor demand in the period during the 1990s estimated by several researchers (e.g. Körösi (1997), Kertesi and Köllö (2002), and Basu, *et al.* (2005)). This statement is partially correct, as in estimating the labor demand elasticity for the period from 2003 to 2007 I use data only for Hungarian firms belonging to retail trade, food, textile and electronics manufacturing industries[8] (see figure A.5).

Table 2 illustrates the estimation results of the elasticity of labor demand in the year 2009 using OLS, Fixed Effects, Difference and System GMM estimators. We can see that the estimated labor demand elasticities are much higher than during the pre-Crisis period. The estimated elasticity varies from highly significant -0.432 to -0.273 and the System GMM estimates the parameter to be from -0.276 to -0.273 depending on the specification used. Both estimates are highly significant. The parameters predict that a one percent increase in average wage level will lead to a decrease in employment by around 0.275 percent. The evidence that

[8] Low elasticities of labor demand can be explained with the fact that the retail trade and electronics manufacturing sectors may have lower than average elasticities, as the former belongs to the service sector having a low elasticity of substitution between labor and capital and the latter may have high ratio of high skilled workers the elasticity of labor demand for which is low as shown in the thesis.

during the Crisis the demand for labor has increased in absolute value means that Hungarian firms have become more responsive to changes in factor prices. This can be explained by the fact that firms have become more financially constrained due to the decline in effective demand. The pessimistic expectations of the employers during the Crisis can be considered as another reason for the high elasticities. At the same time the coefficient on the sales variable varies from 0.246 to 0.449 and all the estimates are highly significant implying larger adjustment of employment to sales than in the pre-Crisis period.

The estimates of own-wage elasticity of labor demand for the whole labor force tell very little about the demand for labor of different skill levels. Even if the short-run elasticity of labor demand for the whole labor force has increased during the Crisis, it may have had different effects on the demand elasticity for different types of labor. In order to evaluate the consequences of the Crisis on particular groups of the Hungarian labor force I also estimate the demand for heterogeneous labor before and during the Crisis. The estimation results are illustrated in tables 3 and 4 for pre-Crisis and Crisis periods respectively. In order to estimate the labor demand elasticity for different types of labor before the Crisis I use the data set of firms covering the period from 2000 to 2007. I estimate model (5) for unskilled, medium- and high-skilled workers separately using the System GMM estimator. In the medium-skilled group I include those employees with vocational or high school education which is equal to 10-12 years of schooling. I estimate the labor demand elasticities during the Crisis using the data set of firms for the years from 2006 to 2009 and the System GMM estimator.

Table 3. Own-wage labor demand elasticity for different types of labor for the period from 2003 to 2007. The model is estimated using two-step System GMM estimator.

Dep. Variable: log of firm level employment	Unskilled	Medium-Skilled	High-Skilled
	(1)	(2)	(3)
$Employment_{t-1}$	0.222	-0.159	0.472*
	(0.341)	(0.510)	(0.283)
$Employment_{t-2}$	-0.028	0.939	0.658
	(0.209)	(0.678)	(0.458)
$Wage_t$	0.069	-0.230***	-0.185***
	(0.099)	(0.076)	(0.054)
$Wage_{t-1}$	-0.230***	-0.013	0.090
	(0.082)	(0.090)	(0.058)
$Wage1_t$	-0.014	-0.025	0.056
	(0.089)	(0.074)	(0.074)
$Wage2_t$	0.070	0.022	-0.020
	(0.048)	(0.038)	(0.075)
$Sales_t$	0.091*	0.059	-0.005
	(0.049)	(0.061)	(0.087)
$Sales_{t-1}$	0.025	0.010	-0.030
	(0.061)	(0.061)	(0.060)
$Capital_t$	0.107**	0.072	0.325***
	(0.050)	(0.047)	(0.085)
$Capital_{t-1}$	0.028	-0.047	-0.325***
	(0.085)	(0.057)	(0.087)
Nb. Of Obs.	2250	4410	2065
AR(1) Test	-1.37	-0.71	-1.02
AR(2) Test	-0.11	-1.40	-0.77
Hansen Test	16.79 (0.158)	4.10 (0.392)	3.27 (0.514)
Nb. Of Groups	872	1592	796
Nb. Of Inst.	28	20	20

Standard errors are presented in parentheses. The values of Arellano-Bond AR tests represent the t-statistic of the hypothesis of no autocorrelation in differenced errors. The p-values are presented in the parentheses of the Hansen test. The two-step System GMM is estimated using robust standard errors. (***), (**) and (*)-significant at 1%, 5% and 10% level respectively.

The estimation results for the pre-Crisis and Crisis periods are presented in tables 3 and 4 respectively, where *employment*$_{t-1}$ and *employment*$_{t-2}$ are the first and second lags of the dependent variable, the logarithm of employment level of a particular skill type (e.g. medium-skilled) in the firm, *wage*$_t$ and *wage*$_{t-1}$ are the log and lagged log of the average wage for that skill type (medium-skilled), $wage1_t$ is the log of real or fitted[9] (if missing) wage of lower skilled group (in this example unskilled), $wage2_t$ is the log of real or fitted (if missing) wage of higher skilled group (in this example high-skilled), $sales_t$ and $sales_{t-1}$ are the log and the first lag of the log of the firm's annual sales, $capital_t$ and $capital_{t-1}$ are the log and the lagged log of annual amortization level of the firm as a proxy for the price of capital.

As we can see from tables 3 and 4 in all the estimations the p-value of the Hansen test is above 0.1 which means we can reject the hypothesis of overidentifying restrictions using a 10% confidence interval for all estimations. With this it is clear that the instruments used in the System GMM are not correlated with the error term so the estimates are not biased. The Arellano-Bond AR tests indicate that in all specifications except for specification (2) in Table 4 there is no second order autocorrelation in the differenced errors. Given this, the estimate of the short-run elasticity of labor demand for the medium-skilled workers for the Crisis period must be considered with caution.

Table 3 presents the estimated labor demand elasticities for the pre-Crisis period. The coefficients on the lagged employment variables show signs of employment persistence though it varies with skill types and periods. Specifically in the pre-Crisis period, the employment of medium- and high skilled workers was more persistent than that of unskilled, as suggested by the theory, although the coefficients on lagged employment are mostly insignificant. The same pattern is obvious for the period during the Crisis and one can notice that the aggregate employment has become more persistent for medium-skilled workers and has decreased for the

[9] In order not to lose observations in case if a firm is not represented by a particular skill type in the sample, I predict the missing values of average wages of other skill groups using OLS and industry, region and year dummies.

high-skilled workers. This evidence shows that the labor hoarding is stronger for medium- and high-skilled workers in comparison to unskilled.

Table 4. Own-wage elasticity of labor demand for heterogeneous labor for the year 2009[10]. The models are estimated using two-step System GMM estimator.

Dep. Variable: log of firm level employment	**Unskilled**	**Medium-Skilled**	**High-Skilled**
	(1)	(2)	(3)
$Employment_{t-1}$	0.163	-0.233	0.744**
	(0.248)	(0.297)	(0.296)
$Employment_{t-2}$	0.106	1.280***	-0.059
	(0.227)	(0.359)	(0.267)
$Wage_t$	-0.271**	-0.314***	-0.170*
	(0.124)	(0.084)	(0.092)
$Wage_{t-1}$	--	-0.051	0.127
	--	(0.106)	(0.092)
$Wage1_t$	0.049	-0.075	0.025
	(0.109)	(0.078)	(0.105)
$Wage2_t$	0.087	0.041	-0.081
	(0.060)	(0.039)	(0.076)
$Sales_t$	0.364***	0.188***	0.307***
	(0.058)	(0.045)	(0.109)
$Sales_{t-1}$	-0.202***	-0.027	-0.099
	(0.056)	(0.052)	(0.124)
$Capital_t$	0.340***	0.303***	0.455***
	(0.058)	(0.044)	(0.104)
$Capital_{t-1}$	-0.257***	-0.280***	-0.419***
	(0.074)	(0.048)	(0.112)
Nb. Of Obs.	1374	2774	1425
AR(1) Test	-1.95	-2.89	-2.06
AR(2) Test	-0.37	-3.07	0.98
Hansen Test	27.68 (0.117)	7.82 (0.779)	10.51 (0.571)
Nb. Of Groups	717	1355	713
Nb. Of Inst.	34	27	27

Standard errors are presented in parentheses. The values of Arellano-Bond AR tests represent the t-statistic of the hypothesis of no autocorrelation in differenced errors. The p-values are presented in the parentheses of the Hansen test. The two-step System GMM is estimated using robust standard errors. (***), (**) and (*)-significant at 1%, 5% and 10% level respectively.

[10] *The data set used to estimate the models includes also the years 2006-2008 in order to use these years' data as instruments for the estimation procedure.*

Considering the elasticities of demand we can see that in the pre-Crisis period the demand elasticity for the unskilled labor is estimated to be positive and insignificant indicating that the short-run demand for unskilled was almost unresponsive to changes in the wage of unskilled during the period from 2003 to 2007. The demand for high-skilled (-0.185) is less elastic than the demand for medium-skilled (-0.230) which is in-line with theory. I also estimate the elasticity of unskilled labor for the whole sample of firms including all industrial branches using the same specification and instrument set and still the elasticity of demand for unskilled labor is close to zero and insignificant.

Table 4 presents the estimation results of the elasticity of demand for different types of labor for the Crisis period. The medium-skilled group has the highest elasticity of demand equal to -0.314, the elasticity of demand for unskilled labor is -0.271 preceding the demand elasticity for the high-skilled labor (-0.170). Although the difference is small, it reveals that during the Crisis the demand for unskilled labor is more responsive to changes in wage level than that of high-skilled workers as shown in previous literature (e.g. Lichter *et al.*, 2012, Roberts and Skoufias, 1997, Kertesi and Köllö, 2002 and Riberio and Jacinto, 2008); Riberio and Jacinto (2008) get a similar pattern of elasticities studying the labor demand in Brazil. In particular they show that the demand for medium-skilled workers is the most elastic and the demand elasticity of unskilled workers is higher than that of high-skilled. It is also interesting to note that the Crisis resulted the short-run elasticity of demand for unskilled and medium-skilled workers to increase whilst the elasticity of demand for high-skilled labor has declined in absolute value, suggesting that the Crisis didn't have negative consequences on the high-skilled labor in Hungary from the point of view of labor demand. The evidence that the elasticity of demand for medium-skilled workers is the highest in both periods can be explained with the fact that medium-skilled labor is substitutable both with unskilled labor and capital, and given that the unskilled labor is much cheaper factor of production, it can be possible that during the Crisis the medium-skilled workers have been substituted with unskilled labor. And the increase of both own-wage and sales elasticities of demand for unskilled and medium-skilled labor during the Crisis suggest that firms have become financially constrained due to the decline in effective demand for goods and services.

Given the estimation results it is worth mentioning that although using the individual and company weights mitigates the problem of selection bias discussed in the data description section, it cannot remove the bias completely.

In order to check the robustness of the results I also estimate the short-run elasticity of demand for the three types of labor substituting $wage1_t$ and $wage2_t$ in the model with the average wage of the other two skill types in the firm. The estimated elasticities are only slightly different from those in tables 3 and 4 and the patterns don't change. Changing the instrument sets doesn't affect the results much as well suggesting that the original estimation results are robust to instrument sets and specifications.

5.2 Long-run estimation results

As mentioned in the previous chapter, the study of long-run demand for labor helps us to estimate the equilibrium adjustments of labor demand made by firms as a response to exogenous wage shocks (Hamermesh, 1984). In other words, the static labor demand theory allows us to predict the possible overall changes in the economy-level employment if there is a change in wages. In order to estimate the long-run own- and cross-wage demand elasticities for different skill types I use the Translog specification and follow Freeman (1979) and Hamermesh (1993) in deriving model (8). I estimate the system of equations (10) for the years 2007 to 2009 using the Seemingly Unrelated Equations method and present the estimation results in tables A.4a-A.4c. I choose these years in order to see whether the long-run elasticity of demand for different labor types has been influenced by the Crisis.

I present the test statistics of the models and the mean cost shares of unskilled, medium- and high-skilled workers in table A3 in the Appendix. Using equations (9) and (9') I calculate the long-run own- and cross-wage elasticities of demand for labor of different skills for the years from 2007 to 2009 and present the results in table 5. I present the demand for labor of specific skill type in the vertical axis and the wages in the horizontal axis. For example, the estimation results predict that a one-percent change in the wages of unskilled workers would increase the demand for medium-skilled in the long-run by 0.046 percent in 2007. The long-run own-wage labor demand elasticities are presented with bold numbers.

However, those firms that have missing data for employees of a particular skill type because of the sampling methodology are dropped during the estimation process. This may lead to a sample selection bias when estimating long-run elasticities, as big firms have higher probability to be represented by all skill types in the sample[11]. In order to mitigate the possible effects caused by this caveat I weight the firms by individual and company weights to make the sample representative for the whole industry, although the risk of sample selection bias doesn't disappear.

[11] Firms, that have more than 5 and less than 50 employees are fully represented in the database.

The long-run own-wage elasticities are the highest in absolute value for the unskilled labor force in every year. Surprisingly, the estimate for 2007 (-1.83) is very close to the results by Kertesi and Köllö (2002) for the year 1999; the authors predict the long-run elasticity of demand for skilled labor[12] to be in the interval from -0.5 to -1 while I estimate the long-run elasticities for skilled to be in the interval between -0.35 and -0.6 in 2007.

Table5. Own and Cross-wage elasticities of unskilled, medium- and high-skilled workers in Hungary in the years 2007-2009

	Unskilled	**Medium-skilled**	**High-skilled**
		2007	
Unskilled	**-1.83**	0.131	-0.090
Medium-skilled	0.046	**-0.596**	0.057
High-skilled	-0.096	0.173	**-0.342**
		2008	
Unskilled	**-5.392**	0.370	0.086
Medium-skilled	0.125	**-0.804**	0.066
High-skilled	0.079	0.182	**-0.758**
		2009	
Unskilled	**-5.607**	0.278	-0.070
Medium-skilled	0.091	**-1.105**	0.094
High-skilled	-0.058	0.240	**-0.822**

This can be a result of skill biased technological change although the assumption is not based on empirical evidence. The elasticity of demand for medium-skilled is higher than that for high-skilled in 2007 and the pattern doesn't change in the following years. Similar to the short-run labor demand elasticities, from table 5 we can notice that the long-run demand elasticities also have increased in absolute value during the Crisis. The long-run elasticities of labor demand are higher than the short-run estimates. This means that in the short-run firms adjust to wage shocks only partially and full adjustment occurs only in the long run proving the fact of the existence of adjustment costs and labor hoarding (Lichter, *et al.*, 2012). In contrast to the short-run results, the

[12] Kertesi and Köllö (2002) divide the labor force into unskilled, young-skilled and older-skilled groups when estimating the long-run elasticities, thus the comparison of results cannot be straightforward.

long-run estimates show that the unskilled and high-skilled workers in Hungary have suffered more from the Crisis than the medium-skilled workers due to the increase in the elasticity of labor demand. The highest increase in the elasticity of demand has occurred for the unskilled workers. The estimates of long-run cross-wage elasticities show that the demand for unskilled and high-skilled labor has become more responsive to the wages of medium-skilled during the Crisis. This can serve as evidence that during the Crisis medium-skilled labor has become more substitutable with unskilled and high-skilled labor. We can also notice that although the short-run demand elasticity for high-skilled labor has declined, the long-run estimate has increased during the Crisis. This fact implies that though the short-run response of firms to changes in the wage of high-skilled workers hasn't been influenced much during the Crisis, the long-run adjustment of the employment level of high-skilled has increased.

6. CONCLUSION

Using a linked employer-employee database of Hungarian firms belonging to the retail trade, food, textile and electronic manufacturing industries for the period from 2000 to 2009, in the thesis I have estimated the short- and long-run demand elasticities for heterogeneous labor for the periods before the Global Financial Crisis and during the Crisis. I have contributed to the labor demand literature by updating the estimates of short- and long-run demand elasticities for different types of labor in Hungary, and I have also showed that both the short- and long-run elasticities of demand for heterogeneous labor (except for the short-run elasticity of demand for high-skilled) has increased due to the Crisis. This evidence suggests that during the Crisis firms have become more financially constrained.

Using the Blundell and Bond (1998) System GMM estimator and partial adjustment dynamic labor demand model I have found that during the period from the 2003 to 2007 the short-run elasticity of demand for medium-skilled labor was the highest in absolute value (-0.230) and the elasticity of demand for unskilled was almost irresponsive to wage shocks. With the data set including the period from 2006 to 2009 I have estimated the elasticity of demand for heterogeneous labor in 2009, where the data for 2006-08 period served as instruments for the variables. The findings show that the short-run elasticity of demand for unskilled and medium-skilled labor has increased during the Crisis, whilst the elasticity for high-skilled workers hasn't changed. The evidence of high elasticity of demand for medium-skilled during both pre-Crisis and Crisis periods can be explained with the fact that medium-skilled labor can be substituted with capital and unskilled labor. And during the Crisis the elasticity of demand for medium-skilled may have increased, because firms became more financially constrained and given the wage rigidities, they had to substitute medium-skilled labor with cheaper unskilled labor. In support for this statement, table 5 presents evidence that the long-run medium-skilled wage elasticity of demand for unskilled labor is positive and has increased during the Crisis, implying higher substitutability between unskilled and medium-skilled labor, although this evidence is weak. In order to check the robustness of the results I have also estimated the model for both periods using the average wage of other skill types in a firm as a control instead of imputing fitted average wages, and the patterns of elasticities didn't change.

I have estimated the long-run elasticities of demand for heterogeneous labor for the years 2007 to 2009 using a translog cost function and found that the long-run elasticities have also increased due to the Financial Crisis. The estimated long-run elasticities are higher than the short-run elasticities, indicating the existence of adjustment costs and labor hoarding both during the Crisis and before. However, it must be noted that the estimates of the long-run elasticities could have been affected by the sample selection bias discussed in the previous chapter.

Despite this caveat, the estimation results suggest that the long-run elasticities of demand for medium- and high-skilled workers decreased in absolute value during the first half of 2000s in comparison to the results by Kertesi and Köllö (2002) for 1999 while the elasticity of demand for unskilled didn't change, which can be a result of skill biased technological change. The increase in long-run elasticities of demand for labor of all skill types during the Crisis can be explained by the decrease in the effective demand for products and services which could cause financial shortages for firms as highlighted by Hars (2012). For further research in the field it would be interesting to study whether the financial constraints have been the main reason for the increase in the elasticities of labor demand or other factors have influenced the firms' behavior too.

Appendix

Table A.1. Macroeconomic indicators of Hungary for the years 2000-2010.

Variable	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Emp. Rate	56.2	56.2	56.2	57.0	56.8	56.9	57.3	57.3	56.7	55.4	55.4
Part. Rate	49.2	48.9	48.9	49.7	49.6	50.1	50.5	50.3	50.0	50.0	50.6
Real GDP Growth	4.2	3.7	4.5	3.9	4.8	4.0	3.9	0.1	0.9	-6.8	1.3
Net FDI-GDP Ratio	5.97	7.48	4.54	2.61	4.20	6.91	17.35	52.05	47.03	3.26	-32.87
Net Migr. Over 1,000 Population	0.73	0.74	0.76	0.78	0.86	0.86	0.86	0.86	0.86	0.87	1.4
Average Monthly Wages†	181396.4	193920.7	209925.1	225246.7	236777.2	244001.7	249131.9	247404.1	252091.6	244022.3	235150
Unemp. Rate	6.26	5.57	5.58	5.74	6.06	7.17	7.46	7.39	7.80	10.01	11.16
Real Min. Wage*	33,909.57	48,721.07	57,870.37	55,248.62	54,862.42	57,000	60,153.99	58,377.9	57,983.19	57,661.29	56,538.46
Imports**	36.4	6.6	0.4	10.2	12.8	8.1	22.4	8.3	7.1	-16.1	17.0
Exports**	33.7	10.2	1.4	8.7	15.0	11.3	25.1	11.4	7.2	-10.1	18.7

*†-Average monthly wages are presented in 2011 forints. *-Real minimum wage is presented in 2005 forints, 2005=100, **-Imports and Exports are presented as a percentage increase from the previous period. Sources: OECD Statistics.*

Table A.2. Summary of studies of labor demand in the Central and Eastern European countries

Country	Estimation period	Short-run Elasticity	Long-run Elasticity	Study
Czech Rep.	1989-90	-0.39	--	Basu, *et al.* (2005)
Czech Rep.	1990-91	Insign.	-1.19	Basu, *et al.* (2005)
Czech Rep.	1991-92	-0.96	Insign.	Basu, *et al.* (2005)
Czech Rep.	1992-93	-0.61	Insign.	Basu, *et al.* (2005)
Czech Rep.	1992-93	-0.07- -0.04	-0.11- -0.07	Singer (1996)
Czech Rep.	2002-07	-0.53	-0.94	Babecky, *et al.* (2011)
Czech Rep.	2008-09	-0.90	-1.60	Babecky, *et al.* (2011)
Hungary	1986-89	-0.56	--	Köllö (1998)
Hungary	1986-89	-1.41--0.50	-1.88 - -1.61	Körösi (1997)
Hungary	1988-89	Insign.	--	Basu, *et al.* (2005)
Hungary	1989-90	Insign.	Insign.	Basu, *et al.* (2005)
Hungary	1989-92	-0.17	--	Köllö (1998)
Hungary	1990-91	Insign.	-4.76	Basu, *et al.* (2005)
Hungary	1990-95	-1.07- -0.44	-2.62 - -1.60	Körösi (1997)
Hungary	1991-92	-0.83	-5.02	Basu, *et al.* (2005)
Hungary	1992-93	-0.25	--	Köllö (1998)
Hungary	1992-99	--	-1.76 – 0.80	Kertesi & Köllö (2002)
Hungary	2000-07	-0.230- 0.069 (ins.)	-1.83 - -0.34	Own study
Hungary	2009	-0.314- -0.170	-5.6- -0.82	Own study
Poland	1988-89	-0.40	--	Basu, *et al.* (2005)
Poland	1988-89	-0.22	-0.7*	Basu, *et al.* (1997)
Poland	1989-90	-0.48	-0.51	Basu, *et al.* (2005)
Poland	1989-90	-0.41	-1.00*	Basu, *et al.* (1997)
Poland	1989-90	-0.03	--	Grosfeld & Nivet (1997)
Poland	1990-91	-0.57	-0.70	Basu, *et al.* (2005)
Poland	1992-93	-0.29	-0.71*	Basu, *et al.* (1997)
Poland	1992-94	-0.13	--	Grosfeld & Nivet (1997)
Slovak Rep.	1989-90	-0.33	--	Basu, *et al.* (2005)
Slovak Rep.	1990-91	0.40	Insign.	Basu, *et al.* (2005)
Slovak Rep.	1991-92	-0.25	--	Basu, *et al.* (2005)
Slovenia	1995-2000	-0.47	-0.40	Domadenik & Vohovec (2003)

Source: Babecky *et al.*, 2011 and author's updates.

Table A3. Test Statistics of SURE equations subject to constraints $\boldsymbol{\beta_{12}} = \boldsymbol{\beta_{21}}, \boldsymbol{\beta_{13}} = \boldsymbol{\beta_{31}}, \boldsymbol{\beta_{23}} = \boldsymbol{\beta_{32}}$ in model (10)

Equations	Nb. Of Obs.	RMSE	R-squrd	Mean and Standard Deviation of the dependent variable
		2007		
Unskilled	542	0.128	0.086	0.156 (0.005)
Med.-skilled	542	0.172	0.129	0.445 (0.007)
High-skilled	542	0.093	0.262	0.147 (0.004)
		2008		
Unskilled	581	0.114	0.047	0.148 (0.004)
Med.-skilled	581	0.171	0.098	0.438 (0.007)
High-skilled	581	0.100	0.226	0.160 (0.004)
		2009		
Unskilled	488	0.121	0.061	0.137 (0.005)
Med.-skilled	488	0173	0.072	0.417 (0.008)
High-skilled	488	0.107	0.241	0.164 (0.005)

Source: Own calculations

Table A.4a. Cost share estimation results using SUR model for the year 2007. Model (10) is estimated subject to constraints $\boldsymbol{\beta_{12} = \beta_{21}, \beta_{13} = \beta_{31}, \beta_{23} = \beta_{32}}$.

Variables	Estimated Coefficient	Standard Error
Unskilled		
Lrwelem (w_1)	0.087***	0.022
Lrwms (w_2)	-0.049**	0.021
Lrwuni (w_3)	-0.037***	0.010
Ldeprate (w_4)	-0.001	0.007
Lry (Y)	-0.023***	0.006
Expting (F)	0.024**	0.012
Constant	0.518***	0.171
Medium-skilled		
Lrwelem (w_1)	-0.049**	0.021
Lrwms (w_2)	0.129***	0.031
Lrwuni (w_3)	-0.040***	0.013
Ldeprate (w_4)	-0.012	0.009
Lry (Y)	-0.041***	0.007
Expting (F)	-0.052***	0.017
Constant	0.589***	0.219
High-skilled		
Lrwelem (w_1)	-0.037***	0.010
Lrwms (w_2)	-0.040***	0.013
Lrwuni (w_3)	0.118***	0.009
Ldeprate (w_4)	0.007	0.005
Lry (Y)	0.001	0.004
Expting (F)	-0.016*	0.009
Constant	0.326***	0.109

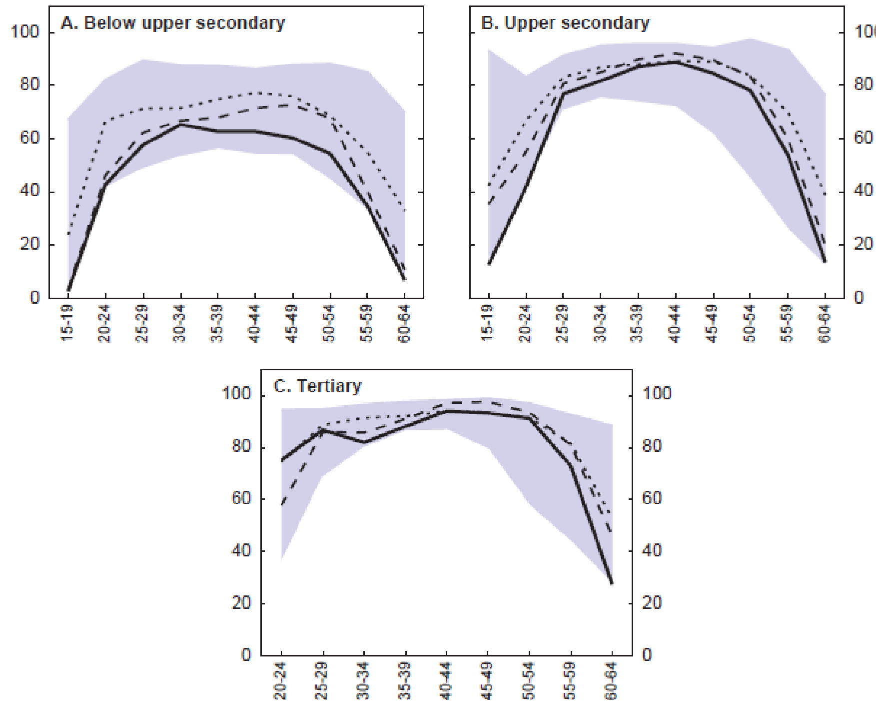
Table A.4b. Cost share estimation results using SUR model for the year 2008. Model (10) is estimated subject to constraints $\boldsymbol{\beta_{12} = \beta_{21}, \beta_{13} = \beta_{31}, \beta_{23} = \beta_{32}}$.

Variables	Estimated Coefficient	Standard Error
Unskilled		
Lrwelem (w_1)	0.008	0.020
Lrwms (w_2)	-0.010	0.020
Lrwuni (w_3)	-0.011	0.009
Ldeprate (w_4)	-0.006	0.006
Lry (Y)	-0.018***	0.004
Expting (F)	0.007	0.010
Constant	0.565***	0.154
Medium-skilled		
Lrwelem (w_1)	-0.010	0.020
Lrwms (w_2)	0.092***	0.032
Lrwuni (w_3)	-0.041***	0.014
Ldeprate (w_4)	-0.008	0.009
Lry (Y)	-0.038***	0.006
Expting (F)	-0.025	0.016
Constant	0.543**	0.220
High-skilled		
Lrwelem (w_1)	-0.011	0.009
Lrwms (w_2)	-0.041***	0.013
Lrwuni (w_3)	0.115***	0.009
Ldeprate (w_4)	0.007	0.005
Lry (Y)	-0.004	0.003
Expting (F)	-0.009	0.009
Constant	-0.523***	0.113

Table A.4c. Cost share estimation results using SUR model for the year 2009. Model (10) is estimated subject to constraints $\beta_{12} = \beta_{21}, \beta_{13} = \beta_{31}, \beta_{23} = \beta_{32}$.

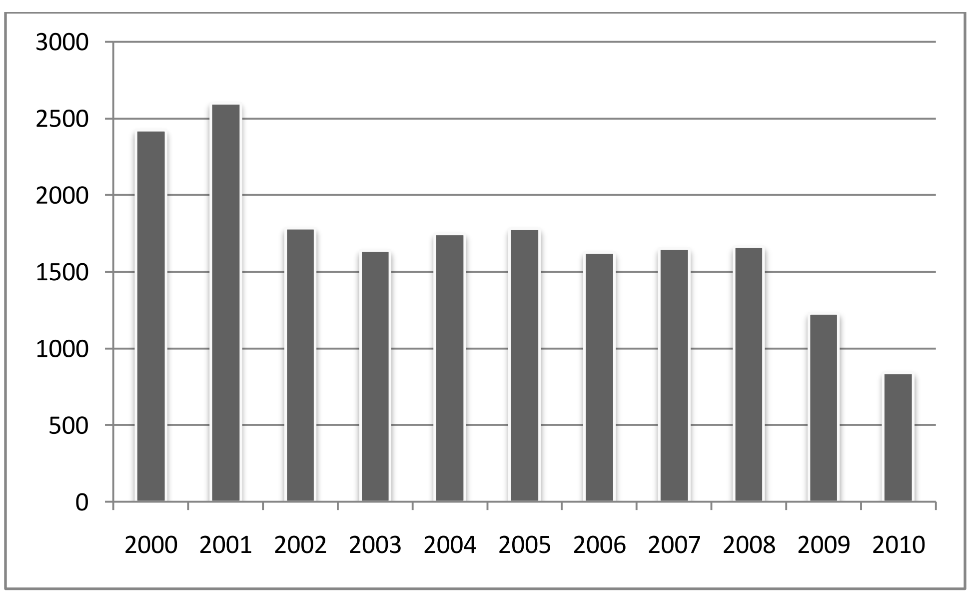
Variables	Estimated Coefficient	Standard Error
Unskilled		
Lrwelem (w_1)	0.013	0.026
Lrwms (w_2)	-0.019	0.023
Lrwuni (w_3)	-0.032***	0.010
Ldeprate (w_4)	-0.0001	0.007
Lry (Y)	-0.004	0.003
Expting (F)	-0.053*	0.032
Constant	0.733***	0.205
Medium-skilled		
Lrwelem (w_1)	-0.019	0.023
Lrwms (w_2)	0.051	0.035
Lrwuni (w_3)	-0.029**	0.014
Ldeprate (w_4)	-0.025**	0.009
Lry (Y)	-0.016***	0.004
Expting (F)	0.011	0.046
Constant	0.541***	0.263
High-skilled		
Lrwelem (w_1)	-0.032***	0.010
Lrwms (w_2)	-0.029**	0.014
Lrwuni (w_3)	0.115***	0.010
Ldeprate (w_4)	0.0001	0.005
Lry (Y)	0.004	0.002
Expting (F)	-0.045	0.028
Constant	-0.423	0.132

Figure A.1. Labor force participation rates by age and education level in 2009



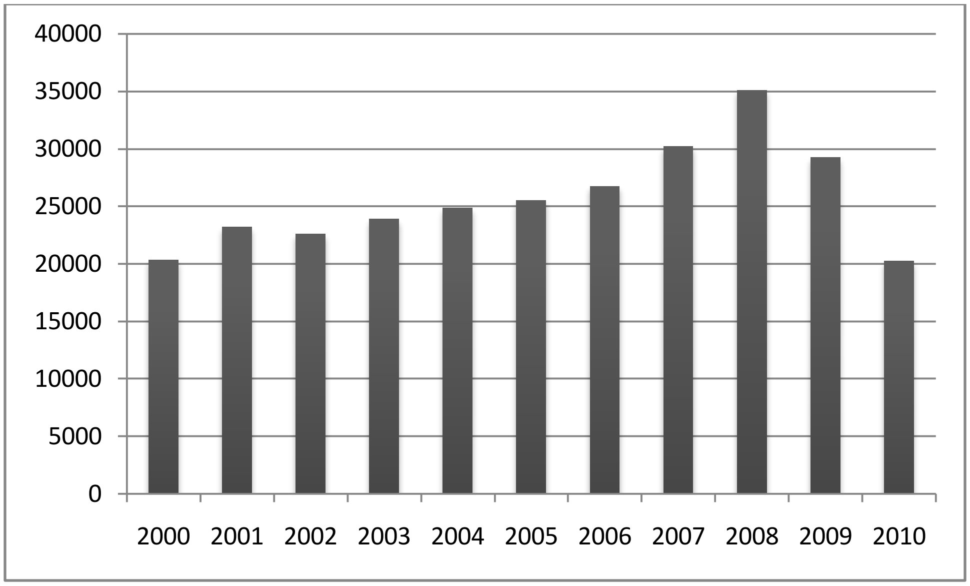
—Hungary, ---CEE countries, …-OECD median, shaded area-OECD range.
Source: Kierzenkowski, 2012.

Figure A.2. The number of firms in the sample in each year



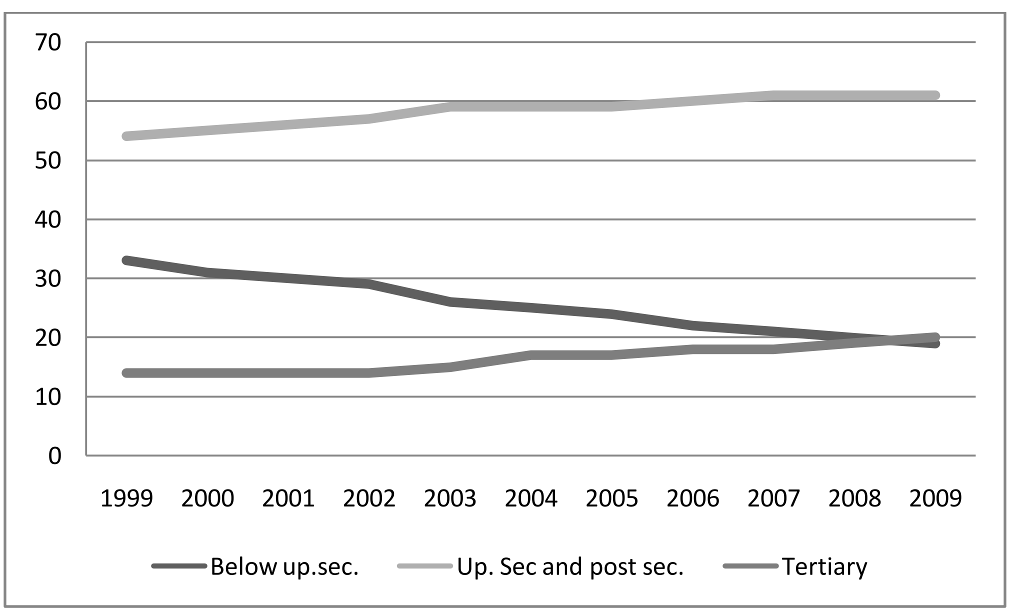
Firms that belong to the retail trade, food, textile and electronics manufacturing industries are included. The two-digit NACE codes for the industries are: 10-15, 26-28 and 45-47. Source: Own calculations

Figure A.3. The weighted number of firms in the data set



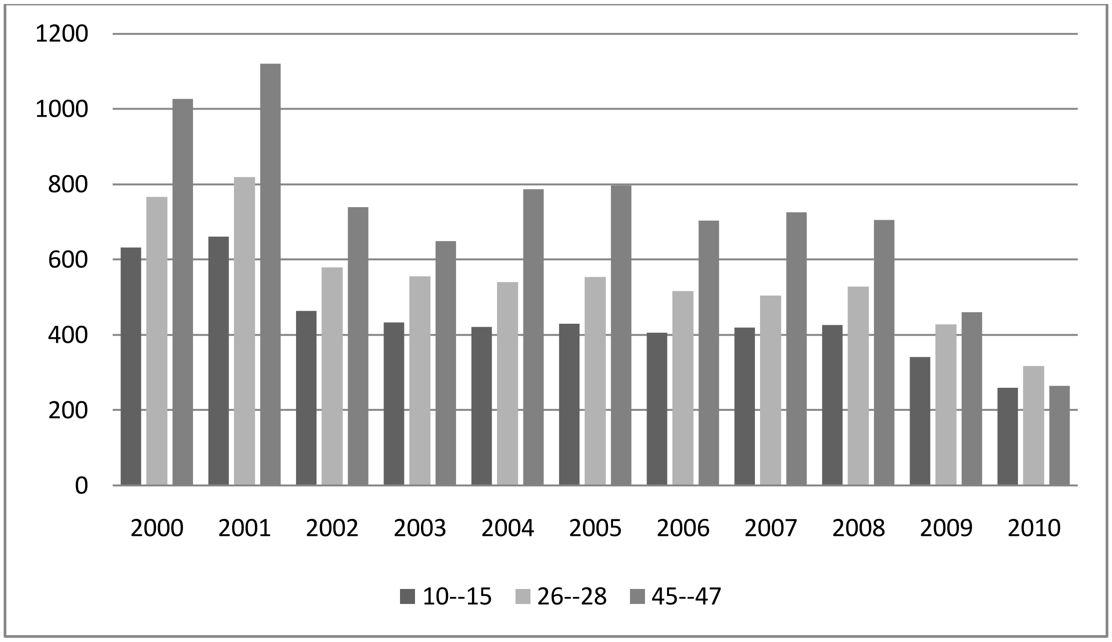
Firms that belong to the retail trade, food, textile and electronics manufacturing industries are included. The two-digit NACE codes for the industries are: 10-15, 26-28 and 45-47. Source: Own calculations

Figure A.4. The distribution trend of the Hungarian labor force by education level for the period 1999-2009



Source: OECD (2011)

Figure A.5. The distribution of firms among industries during the years from 2000 to 2010



The firms are aggregated into three industrial groups: 10-15, 26-28 and 45-47 using NACE two-digit industry codes. Source: own calculations

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