# Skill upgrading of occupations and college-degree supply: the case of the Czech Republic

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**Abstract**

There is much research on skill-biased changes in labor demand and the simultaneous growth in the number of college graduates. A key questions is whether the two proceed in a balanced fashion. In this paper, I apply the technique developed by Gottschalk and Hansen (2003) to identify the skill requirements of occupations and to study the share of college graduates in noncollege occupations in a country experiencing a dramatic expansion of higher education: the Czech Republic. Comparing districts with different education structure of population suggests that the higher is the stock of graduates, the better is the efficiency of matching them with college occupations. Nevertheless, no such effect has been found for within-districts changes in the amount of graduates, possibly due to short time span of data used. These findings are consistent with skill-complementing capital locating in places relatively abundant in skills, which effet needs time to be realized. It suggests that supply of college seats should not only be a response to the observed level of demand for skills but also a tool for attracting technologically advanced industries and improving the employment situation of skilled labor in the long term. This has strong implications for further expansion of the Czech state-funded higher education system.

# 1 Introduction

It is generally accepted that the recent decades were characterized by strong skill biased technological change (SBTC), which is responsible for the growth of demand for college-educated workers both in the United States and Europe (e.g., Gottschalk and Smeeding 1997, Katz and Autor 1999, Acemoglu 2002, Gottschalk and Hansen 2003). While this phenomenon is common for the developed economies, countries differ in their preparation to meet the growing demand for skills. The United States have prepared the ground for increased demand for college graduates by liberalizing and expanding the higher education system long in advance. Many European countries, however, face a need to reform their higher education systems in order to enhance production of more college graduates. This is why the European Union adopted the Lisbon strategy in 2000 with the aim to increase the education attainment of its citizens.

Following the adoption of Lisbon strategy and the observation of growing demand for college graduates, many European countries have taken policy steps towards expanding their higher education systems. An important question faced by them is how much to expand in order to meet the prevailing labor market conditions. To inform these decisions one would ideally like to know not only the current but also future extent of skill biased technological change that will determine the demand for highly educated workers. This knowledge is unavailable and thus enrollments, which level in many European countries is determined by public funds devoted to higher education, are driven by predictions. This could result in over- or undershooting which, among others, results in worsening or improvement of the situation of college graduates in the labor market.

To facilitate the decision making concerning the extent of provision of higher education it would be useful to know how the overall supply of college graduates corresponds to their situation in the labor market. This could answer a question whether the production of highly educated workers should only respond to the exogenous changes in the demand for them or maybe the presence of many college graduates additionally fosters this demand. In the search for this relationship, much research has focused on the relative wages of college and high-school educated. A less studied but also important measure is the fraction of college

graduates working in occupations not requiring a college degree. A decreasing (increasing) extent of such occupational mismatch implies that the growth in supply of highly educated workers is lower (higher) than the growth in demand for them.

As mentioned above, the consequences of SBTC and higher education expansion on (relative) wages of college graduates have been widely studied. The discussion about the role of SBTC in the changes of college-high school wage gap has started in the early 1990's with publications by Katz and Murphy (1992) and Bound and Johnson (1992). These papers analyze why, although the substitution effect predicts that growth in the relative supply of college graduates reduces their relative wages, in the 1980's both the relative college supply and relative wages increased. The conclusion is that there must have happened a SBTC significantly shifting the demand for educated labor. Since the publication of these seminal papers there have appeared many other studies analyzing the evolution of college wages. However, the first study of occupational mismatch appeared as late as in 2003 when Gottschalk and Hansen presented an economic-model-based analysis of the skill requirements of occupations.[1] These authors find that the level of mismatch in the graduate labor market, i.e. the share of college graduates working in "noncollege" occupation, decreased in the U.S. during the 1983-1994 period. The same analysis is performed for a European country – Portugal – by Cardoso (2007). She reaches a conclusion that in Portugal in the period 1986-1999, the fraction of college graduates working in "noncollege" occupations decreased, similar to the U.S. evolution. My analogous analysis of the Czech graduate labor market in the recent decade also reveals similar patterns.

When related to the significant growth in the number of college graduates in the American, Portuguese and Czech populations during the analyzed periods,[2] these results suggest

[1] In 1992 Hecker published a paper analyzing the kind of occupations that college grduates take. He uses individuals' assesment about the education requirements of the performed occupation and keeps the classificaion into "college" and "noncollege" occupations constant over time. In this way he does not account for skill upgrading of occupations.

[2] In the U.S. the average growth between mid 80's and mid 90's exceeded 30%, while in Portugal it reached 50%. A graph presenting correlations between the fraction of college graduates working in "noncollege" occupations and the relative supply of college graduates in the U.S., Portugal and the Czech Republic is

that growth in demand for college graduates exceeded growth in the supply of them in both countries. Nevertheless, these studies do not investigate a causal relationship between the extent of higher education expansion and the level of occupational mismatch, neither on national nor regional level. Thus, we do not know whether the changing situation of college graduates in the labor market is it purely driven by exogenous demand shifts or whether it is also endogenously improved.

Only recently there have appeared studies analyzing the direct consequences of higher education expansion in the U.S. states. Using the cross-state variation, Bound et al. (2004) show that the production of college graduates does not correspond to their stock because of a significant level of migration. On the other hand, Moretti (2004) finds that a high concentration of college-educated workers in a city population has a positive effect on wages of all education groups in that city. This finding implies the existence of positive productivity spillovers from spacial concentration of skills and suggests that a high supply of college graduates can trigger a shift in demand for them. Similar conclusions are reached by Acemoglu (2002, 2003) in his theoretical analyses of the demand for and supply of skills. These results together with the SBTC hypothesis can explain the findings by Gottschalk and Hansen (2003) and Cardoso (2007). It could be the case that the growing demand for college graduates, both caused by the SBTC and triggered by higher supply of them, more than matches the increased production of skills.

A somewhat different conclusion is reached by Fortin (2006). She shows that an increasing production of college graduates in a given state lowers the college-high school wage gap, which could be interpreted in the way that increase in the supply of college graduates does not trigger enough growth in the demand for them to compensate for the substitution effect. Nevertheless, this finding is not contradictory to the earlier research. Growing supply of college graduates can result in worsening of their relative position in the labor market, but at the same time their absolute standing might be better. My research investigates the latter phenomenon in more details.

Europe has not been analyzed as intensively as the U.S. Recently only Borghas and de

presented in the Appendix.

Grip (2000) and Cardoso (2007) have analyzed the situation of college graduates in single European countries. In a related line of work, Jurajda and Terrell (2007) look for explanations behind significant differences in unemployment rates across regions of post-communist economies. They find out that these differences can be to a large extent explained by variations in the local human capital endowment. Finally, Brunello et al. (2000) investigate the sources of differing patterns in college - high school wage premia among 10 European countries using a methodology based on Bound and Johnson (1992). It is found that in all European countries the college wage premium grew between the 1980's and 1990's, and this growth is "*negatively correlated with changes in relative supply* [of college graduates] *and positively correlated with the index of between industry demand shocks*". Nevertheless, to my best knowledge, a causal relationship between higher education expansion and labor market situation of college graduates has not been performed.

Research of the labor market outcomes of college graduates is developing together with higher education expansion. Its results are important sources of information for public authorities deciding on the shape of policies affecting higher education. From such a policy perspective, a regional analysis of the kind of occupations that college graduates take would be very useful. First of all, the occupational matching is a good measure of college skills usage, as opposed to skills' price, describing efficiency of higher education system. Moreover, this approach allows for investigation of the outcomes of higher education expansion within a country with homogenous demand conditions.

This paper performs such an analysis by comparing the propensity of a college graduate to be employed in a "noncollege" occupation across regions with different scale of higher education expansion. I analyze the situation in the graduate labor market of the Czech Republic. Having less than 10% of highly educated people in total population while being exposed to a world-wide SBTC this country faced an obvious skill shortage in the end of 20th century. The proceeding rapid expansion of the almost exclusively publicly funded higher education system has, however, worsened graduates' position in many Czech regions. This has triggered a natural question whether the growth in college supply is not too fast. I am addressing it by comparing the employment situation of college-educated workers in Czech

regions experiencing different rates of change in the provision of college education. The results presented in this paper shed a light on the relationship between the local educational policies and the degree of occupational mismatch in the labor market.

My analysis is based on the methodology developed by Gottschalk and Hansen (2003). The basic idea is to evaluate the situation of college graduates in the labor market by finding out what fraction of them is employed in the so called "noncollege" occupations. Such a measure is often referred to in the literature as the extent of overeducation. There have been developed several approaches towards measuring the extent of overeducation (see McGuiness, 2006 for a review), however the Gottschalk and Hansen (2003) idea has an advantage of being purely based on economic outcomes. These authors propose to distinguish between "college" and "noncollege" occupations by finding what wage premium each occupation pays to highly educated workers. It is argued that occupations paying high college wage premiums (above 10% as defined by Gottschalk and Hansen) can be classified as "college" ones. In the case when there is a significant disproportion between employees with and without a college diploma in a given occupation, it is classified as "college" or "noncollege" based on the fraction of workers with a given education level. Using this measure of occupational mismatch, I further relate it to the changing supply of college graduates to find out that an increased amount of them in the local population is able to attract technologically advanced firms and thus improve graduates' employment possibilities.

The rest of this article is organized in the following way. The next section describes the higher education organization in the Czech Republic. Then, the theoretical and empirical models used in the analysis are described. The data description section proceeds. Finally, I present and discuss the estimation results. The last section concludes.

# 2 The Czech Republic

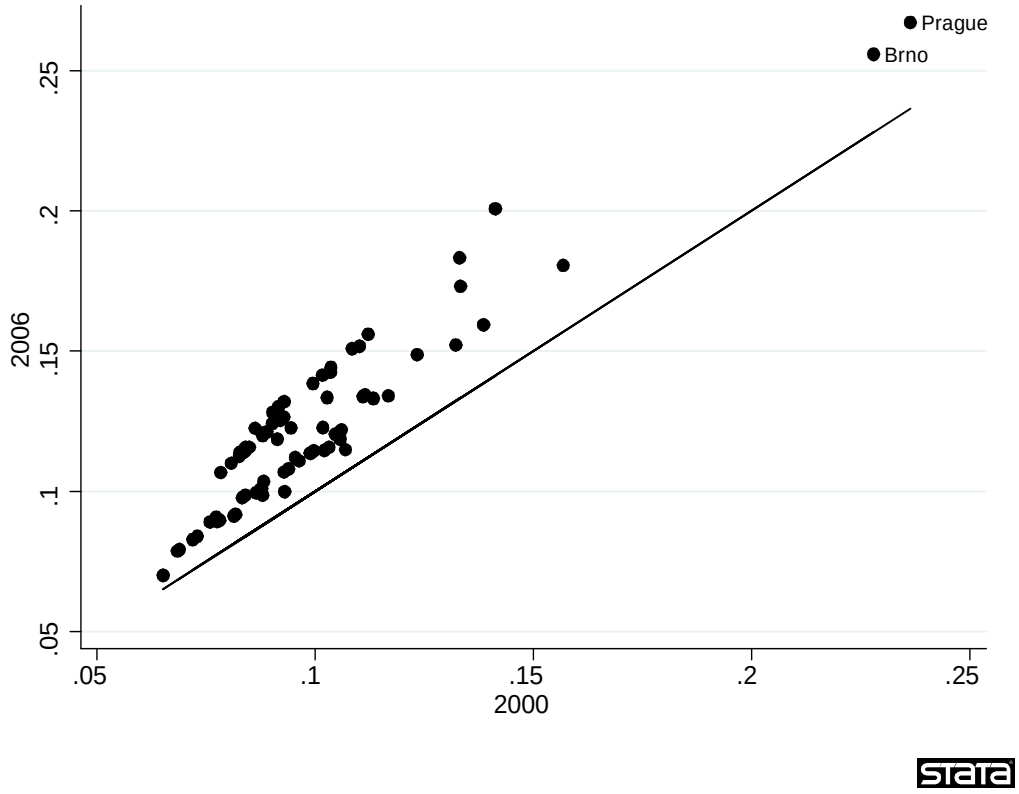
The analysis presented in this paper focuses on employment of college graduates in the Czech Republic. This country is particularly interesting because of several aspects concerning the organization of tertiary education there. The majority of Czech public universities have been

established during the communist times and their restructurization has started only in the 1990's. This is visible not only in the significant increase in enrollment rates in the last decade but also in the structure of study fields offered (CSO, 2008). The restructurization of higher education system has not, however, dealt with the sources of universities financing. Tertiary education in the Czech Republic is still fully state-funded.

The growth in college enrollment and the resulting increased inflow of graduates to the labor market is changing the educational structure of the labor force. The fraction of college graduates in adult population has grown from 10% in 1998 to 13% in 2006 with an average annual growth rate of over 4% (Eurostat, 2008). Despite these changes, the fraction of adult population with higher education is still very low in the Czech Republic as compared to other OECD countries. The OECD average fraction of college graduates among adult population was 18% in 2006 with the highest number coming from the U.S. (30%). International comparison suggests that the Czech Republic will be undergoing further expansion of higher education in the following years in order to catch up with other countries. Thus, it is important to know how efficient the country has been in its recent actions to help design the future policies.

Another interesting characteristic of the Czech Republic is the cross-district (NUTS-4) diversity in the educational structure of its population. There are significant differences in the fraction of adult population with tertiary education. This measure ranged from 7.1% in the district of Sokolov to 20.4% in the district of Hradec Kralove in 2006. Not surprisingly, the capital city hosts the largest proportion of highly educated in population, 27.2%. Also the rates of change in the fraction of highly educated adult population vary a lot across the Czech regions. In the time period analyzed in this article (2000-2006), this measure has ranged from -0.1% in the districts of Zapadocesky kraj to 5.8% in the districts of Vysocina The changes in fractions of college-educated population in Czech districts are presented in Figure 1.

Figure 1: Changes in fraction of college graduates in districts population togather with a 45-degree line.




Source: Own calculations based on 2001 Census (CSO, 2008) and the Czech Labor Force Survey.

As already mentioned, tertiary education in the Czech Republic is in great majority state funded. Supply of places in tuition free colleges (which is significantly lower than the demand for them) is determined by the funds allocated by the policy makers. In other words, enrollments to higher education institutions and thus the future amount of graduates in the labor market, constitute a public policy decision. The close relationship between higher education policies and the educational structure of local population is owed to low cross-district economic-incentives-based migration in the Czech Republic (Fidrmuc, 2004).

Focusing on a country with significant district-level differences in the educational structure of population driven by public policy decisions one can investigate how these decisions influence the situation of graduates on the labor market. It would be especially interesting

to see whether in the districts where higher education is expanding more rapidly, it is easier or more difficult for college graduates to find employment taking advantage of their skills. This analysis is of particular policy interest, because it reveals whether expansion of higher education can trigger improvement in employment possibilities of college graduates (and thus their skill usage) or whether it should be just a reaction to observed changes in demand for skills.

# 3 Theoretical framework

In this paper I estimate the influence of varying stock of college graduates on their allocation across different types of occupations. In line with the existing literature on the topic, I identify two main forces that determine this relationship. First is the substitution effect which causes a decrease of college graduates' wages when their amount in a given type of occupations (say, the technologically advanced ones) increases. This, in turn, makes other occupations more attractive, what finally results in reallocation of college graduates across occupations. The second force is a productivity spillover from having many highly educated workers. Such productivity spillovers have been already identified in the literature (Moretti 2004, Acemoglu and Angrist 2000), but never in the context of allocation of workers across occupations. The spillover idea is the following. The presence of many college graduates in the labor market makes it possible for them to cooperate and thus take advantage of each other skills, what increases their overall productivity. Alternatively, the presence of many college graduates attracts technologically advanced firms because it is easier for them to find employees that they need among the pool of highly educated. This also results in higher overall productivity of college graduates. Higher productivity of college graduates in technologically advanced occupations increases their wages and thus attracts more highly educated workers to work there, what is an opposite reallocation than the one described before.

In this section I model the channels through which the amount of college graduates in the labor market influences their allocation across occupations using a simple demand-supply

framework for a closed competitive economy. Further on, I extend my theoretical analysis to allow for a set of economies across which labor and capital are free to move. This leads me to formulation of an econometric model which I estimate in a further section.

## 3.1 Single closed economy model

This section's analysis bases on Gottschalk and Hansen (2003) model used to recognize which occupations require higher education and which do not. Following these authors, I assume that there are two sectors in the economy: a "college" sector and a "noncollege" sector. Firms in both sectors produce the same uniform good and they have the following production functions:

$$Q_1 = F_1(\alpha_{C1}L_{C1} + \alpha_{N1}L_{N1}) \tag{1}$$

$$Q_2 = F_2(\alpha_{C2}L_{C2} + \alpha_{N2}L_{N2}), \tag{2}$$

where $L_{Cj}$, $L_{Nj}$ is the amount of college- and high school-educated labor in sector $j$, and $\alpha_{ij}$ are the productivities of labor type $i$ in sector $j$. The important properties of these production functions are the following:

$$\frac{\partial F_j}{\partial L_j} > 0 \text{ and } \frac{\partial^2 F_j}{\partial L_j^2} < 0, \quad \text{where } L_j = \alpha_{Cj}L_{Cj} + \alpha_{Nj}L_{Nj} \tag{3}$$

$$\alpha_1 \equiv \frac{\alpha_{C1}}{\alpha_{N1}} > \frac{\alpha_{C2}}{\alpha_{N2}} \equiv \alpha_2. \tag{4}$$

Condition (3) describes the decreasing marginal product of labor in each sector and condition (4) says that in sector 1 college-educated labor is relatively more productive than high school-educated labor as compared to sector 2. That is why I call sector 1 the "college" sector.

Firms profit maximization under the price of output normalized to unity and labor input prices being $w_{C1}$, $w_{C2}$, $w_{N1}$and $w_{N2}$, respectively, gives the following conditions:

$$w_{C1} = \alpha_{C1}\frac{\partial F_1}{\partial L_1} \tag{5}$$

$$w_{C2} = \alpha_{C2}\frac{\partial F_2}{\partial L_2} \tag{6}$$

$$w_{N1} = \alpha_{N1} \frac{\partial F_1}{\partial L_1} \tag{7}$$

$$w_{N2} = \alpha_{N2} \frac{\partial F_2}{\partial L_2}. \tag{8}$$

An important property of the model is that

$$\frac{w_{C1}}{w_{N1}} = \frac{\alpha_{C1}}{\alpha_{N1}} \equiv \alpha_1 \quad \text{and} \quad \frac{w_{C2}}{w_{N2}} = \frac{\alpha_{C2}}{\alpha_{N2}} \equiv \alpha_2, \tag{9}$$

what combined with (4), implies

$$\frac{w_{C1}}{w_{N1}} > \frac{w_{C2}}{w_{N2}}, \tag{10}$$

i.e. wages of college graduates relative to high school graduates are higher in sector 1, the "college" sector. This property is used by Gottshalk and Hansen (2003) to distinguish between "college" and "noncollege" occupations.

Let me note that equations (5) - (8) form a set of demand equations from which a demand for each type of labor in each sector can be derived. To complete the model, supply of different labor types to both sectors needs to be specified. Following Gottschalk and Hansen (2003), I assume that workers in a pool of all college and high school graduates decide to work in either sector "*based on their heterogenous preferences and the relative wages available to them across sectors*". In the original model, the relationship between the shape of supply functions and the total amount of college and high school graduates in the market is not explicitly shown.[3] The authors do not need to model this, because they do not analyze the link between the structure of labor force and the allocation of workers across occupations. In my version of the model it is assumed that the total supply of a given labor type to a given sector is a proportion of all workers of this type in the population. This allows for direct analysis of the influence of changes in the total supply of labor on the market equilibrium. The assumed supply functions are the following:

$$L_{C1}^S = \mathcal{L}\left(\beta_C + \lambda_C \frac{w_{C1}}{w_{C2}}\right) L_C \tag{11}$$

[3] The original supply functions of college and high school graduates to the "college" sector are the following: $L_{C1}^S = \beta_C + \lambda_C \frac{w_{C1}}{w_{C2}}$ and $L_{N1}^S = \beta_N + \lambda_N \frac{w_{N1}}{w_{N2}}$. Note that they do not explicitely account for the total amount of college- and high school-educated labor in the economy.

$$L_{C2}^S = L_C - L_{C1}^S \tag{12}$$

$$L_{N1}^S = \mathcal{L}\left(\beta_N + \lambda_N \frac{w_{N1}}{w_{N2}}\right) L_N \tag{13}$$

$$L_{N2}^S = L_N - L_{N1}^S, \tag{14}$$

where $\mathcal{L}$ is a logistic function used to keep proportion between 0 and 1, and $\beta_i$ and $\lambda_i$ are the aggregate preference parameters of workers of type $i$.

Together, equations (5) - (8) and (11) - (14) determine the equilibrium allocation of workers in this model given the value of parameters $L_C$, $L_N$, $\alpha_{C1}$, $\alpha_{C2}$, $\alpha_{N1}$, and $\alpha_{N2}$. In equilibrium some college-educated workers are employed in sector 1 and some in sector 2. The marginal college graduate has such preferences that given the wages $w_{C1}$ and $w_{C2}$, she is indifferent between working in either sector.

Let me now define the parameter of interest, i.e. the fraction of college graduates working in "noncollege" occupations as

$$\pi_C \equiv \frac{L_{C2}}{L_C}. \tag{15}$$

In equilibrium (let me denote equilibrium values by an asterix), this is equal to

$$\pi_C^* \equiv 1 - \frac{L_{C1}^*}{L_C} = f\left(L_C, L_N, \alpha_{C1}, \alpha_{N1}, \alpha_{C2}, \alpha_{N2}\right). \tag{16}$$

and depends on the supply conditions, i.e. total amount of each labor type in the economy ($L_i$) and demand conditions, i.e. labor productivities ($\alpha_{ij}$). The sign of the relationship of main interest, i.e. how the equilibrium allocation of college graduates across occupations depends on the relative supply of them to the labor market ($L_C/L_N$) and on the extent of skill bias of technology ($\alpha_{C1}$), is intuitive. Nevertheless, let me perform the comparative statics analysis to derive it.

First, I analyze what changes in the equilibrium allocation when there happens a skill biased technological change in the "college"sector, i.e. when $\alpha_1$ grows and all other parameters are kept unchanged. According to equation (5), this shall increase wages offered by firms in the "college" sector to college graduates (demand for college graduates in sector 1 shifts up). Higher wages attract more college graduates to the "college" sector, as is described by

equation (11). This, in turn, lowers a bit their wages in sector 1 and increases their wages in sector 2 because of the decreasing marginal product property of the production functions. Finally, wages adjust in such a way that no more workers want to change jobs. The new equilibrium is characterized by higher wages for college graduates in both sectors, but wages in sector 1 increase more as compared to the initial level. This makes new $\frac{w^*_{C1}}{w^*_{C2}}$ higher than the initial one and thus new $\pi^*_C$ lower than the initial one. To sum up:

$$\frac{\partial \pi^*_C}{\partial \alpha_{C1}} < 0. \tag{17}$$

Next, let me analyze what happens when the relative supply of college graduates to the labor market ($L_C/L_N$) increases, which usually is a result of a growth in $L_C$. This change can be interpreted as an upward shift in the supply of college graduates to both sectors, as seen in equations (11) and (12). As long as the growth in $L_C$ is not accompanied by a significant fall in $L_N$, it brings wages of all labor types in both sectors down (because of the decreasing marginal product property). It is important to note, however, that wages in sector 2 fall less dramatically because of property (4). Thus, the ratio $\frac{w_{C1}}{w_{C2}}$ falls and some workers reallocate from "college" to "noncollege" sector. This lowers wages in sector 2 and increases them in sector 1 (but not above the initial level) so that finally nobody wants to change job. The new equilibrium is characterized by lower wages for college graduates in both sectors, but wages in sector 1 decrease more as compared to the initial level. This makes new $\frac{w^*_{C1}}{w^*_{C2}}$ lower than the initial one and thus new $\pi^*_C$ higher than the initial one. To sum up:

$$\frac{\partial \pi^*_C}{\partial \left(L_C/L_N\right)} > 0. \tag{18}$$

The above analysis leads me to formulation of the relationship between the relative supply of college graduates to the labor market and the fraction of them working in "noncollege" occupations. It is the following:

$$\pi^*_C = f\left(\underset{+}{L_C/L_N}, \underset{-}{\alpha_{C1}}, \textit{other parameters}\right). \tag{19}$$

Assuming that the relationship is approximately linear[4] and other parameters do not

[4]The model outlined in this Section has no closed form solution. Therefore I have to approximate its functional form.

vary, I can write it in the following form:

$$\pi_C^* = \gamma_0 + \gamma_1 \cdot \frac{L_C}{L_N} + \gamma_2 \cdot \alpha_{C1}, \tag{20}$$

where $\gamma_1 > 0$ and $\gamma_2 < 0$, as derived.

According to the model presented above, the relationship between $\frac{L_C}{L_N}$ and $\pi_C^*$ is positive. However, this model does not take into account the spillover effects from high concentration of skills described at the beginning of this section. Let me now introduce such spillovers to the model to show that they can alternate the relationship of interest. A general representation of productivity spillovers commonly used in the literature is in the form of productivity being an increasing function of total skills (e.g. Acemoglu and Angrist 2002, Moretti 2004). In this paper I use a simple linear relationship:

$$\alpha_{C1} = \alpha_{C0} + \delta_1 \cdot \frac{L_C}{L_N}, \tag{21}$$

where $\delta_1 \geq 0$ ($\delta_1 = 0$ implies no spillovers and $\delta_1 > 0$ implies existence of positive productivity spillovers). Incorporating this into the structural equation (20), I get:

$$\pi_C^* = \gamma_0 + \gamma_1 \cdot \frac{L_C}{L_N} + \gamma_2 \cdot \left(\alpha_{C0} + \delta_1 \cdot \frac{L_C}{L_N}\right) = \tag{22a}$$

$$= \gamma_0 + (\gamma_1 + \gamma_2\delta_1) \cdot \frac{L_C}{L_N} + \gamma_2 \cdot \alpha_{C0}. \tag{22b}$$

When allowing for productivity spillovers from high concentration of skills, the sign of the relationship between the relative supply of college graduates and the fraction of them working in "noncollege" occupations is not clearly predicted by the model. If the direct effect ($\gamma_1$) is stronger than the spillover effect ($\gamma_2\delta_1$), the overall relationship is negative, however if the spillover effect is strong enough to compensate for the direct effect, the overall relationship is positive.

The above analysis holds for a single closed economy where college graduates are produced and employed locally. In this paper, however, I analyze a set of districts across which workers and firms can freely move. This calls for expanding the analysis to a general equilibrium model.

## 3.2 Model for a set of districts within a country

The model describing allocation of workers across occupations and districts bases on Roback (1982, 1988) ideas. For simplicity, let me assume that there are two districts ($A$ and $B$) and both workers and firms are free to move between them. As before, there are two sectors (or two firm types, for simplicity) – a "college" and "noncollege" one. There are also two worker types – with college and with high school diploma. Firms produce a uniform good by hiring both worker types and using land (which is district-specific). Workers earn wages and spend them on the uniform good and land for living purposes. Thus, firms prefer low wages and low rental price of land while workers prefer high wages and high rental price of land. Because workers are free to work in whichever region, in equilibrium they must achieve the same utility level no matter where do they choose to locate. The same logic applies to firms – in equilibrium they bear the same unit costs in each district.

When in this setup the supply of college graduates in one of the districts (say, district B) increases due to some exogenous reasons[5], they are willing to accept lower wages and higher rents in this district to achieve the same utility level as in district A. Moreover, it is plausible to assume that in the district that is attractive for college graduates, the educated workers' preferences towards working in the "college" sector are weaker. They want to live in the given district no matter what kind of occupation they perform. Consequently, rents in city B rise and college-educated workers' wages fall. Even if wages in the "noncollege" sector fall more than those in the "college" sector (because of the substitution effect), due to weaker preferences towards working in the "college" sector, we can observe higher fraction of college graduates working in the "noncollege" sector in city B than in city A. This is a prediction of a model without spillovers.

Let me now introduce spillovers to this model. In the case when the variation in relative supply of college graduates is across districts, they can be interpreted as technologically advanced firms locating in regions relatively abundant in skills. When the variation in relative supply incorporates over-time changes, the spillover effect can be interpreted as

[5]This can be cultural amenities attractive for college graduates or a new college opened in the district with the assumption that graduates prefer living in the district where they have graduated.

increasing supply of skills attracting more firms willing to take advantage of them. If spillover effects exists, the increase of supply of college graduates increases their productivity in the "college" sector and thus allows "college" firms pay higher wages and higher rents to achieve the same unit costs. This shifts rental rates of land in city B even higher, but causes opposite movements in wages of college graduates employed in the two sectors. Wages in the "college" sector increase while wages in the "noncollege" sector fall. Thus, the spillover effect reduces or might even reverse the direct effect and make the final ratio of college wages in the "college" and "noncollege" sector in city B high enough to decrease the fraction of college graduates working in the "noncollege" sector.

The mechanisms described above can be summarized by he following equation:

$$\pi_C^* = \gamma_0 + (\delta_3 + \delta_2 + \delta_1)\frac{L_C}{L_N} + \varepsilon, \tag{23}$$

where $\delta_1$ is the spillover effect, $\delta_2$ is the substitution effect, and $\delta_3$ is the preferences effect. $\varepsilon$ captures all other factors that influence allocation of college graduates across occupations. The expected signs of the above parameters are: $\delta_1 < 0$, $\delta_2 > 0$, and $\delta_1 < 0$. The direction of their joint influence, i.e. the sign of $\theta_1 \equiv \delta_3 + \delta_2 + \delta_1$ can not be theoretically predicted. The goal of this paper is to estimate the parameter $\theta_1$ to find out whether positive or negative effects prevail in the influence of the relative supply of college graduates on their allocation across occupations.

# 4 Estimation strategy

The theoretical model derived in the previous section takes an implicit assumption that the aggregate preference parameters of workers are constant within and across districts. This is, however, a very unrealistic assumption. It could be argued that the composition of characteristics of individuals living in a given district influences their allocation across occupations through their preference parameters. If, for example, in a given district there are many females with college education (who, on average, are less flexible in looking for employment), there might be higher fraction of college graduates in "noncollege" occupations

there. In order to account for such effects, I perform the estimations on individual rather than aggregate level, i.e. estimate a propensity of an individual college graduate to work in a "noncollege" occupation as a function of her characteristics and characteristics of the region where she lives. The source of identification used for this purpose is the variation in fraction of highly educated adults across and within Czech districts' population and the simultaneous variation in proportion of college graduates working in "noncollege" occupations in these districts. In this paper I use the sample of young workers only [6] in the estimations. The reason is that I expect young and old workers of the same education level to be imperfect substitutes (e.g. Ciccone and Peri 2005) and, moreover, the recent higher education policies have influenced only the educational structure of younger generations.

In the estimations, I use a two-stage approach suggested by Donald and Lang (2007) in order to get the inference right. I first estimate a linear probability model with a dummy indicating whether a worker is employed in a "noncollege" occupation as a LHS variable and RHS variables being worker's characteristics and district-time dummies. In the second step, I perform a weighted least squares (WLS) regression of the estimated parameters by district-time dummies on district-time characteristics (especially the share of college graduates in local population), where the variance of the estimated parameters by district-time dummies is used as the weighting factor This approach can be summarized in the following way:

$$1^{\text{st}} \text{ step:} \qquad \text{Prob}(nocollege_{ikt}) = \delta_0 + \mathbf{X}'_{ikt}\boldsymbol{\delta}_1 + \mathbf{TD}'_{kt}\mathbf{d} + \boldsymbol{\epsilon}_{ikt} \tag{24a}$$

$$2^{\text{nd}} \text{ step:} \qquad \widehat{d}_{kt} = \gamma_0 + \theta_1 \cdot CollSh_{kt} + \mathbf{Y}'_{kt}\boldsymbol{\theta}_2 + \varepsilon_{kt} \tag{24b}$$

where $\text{Prob}(nocollege_{ikt})$ is an indicator whether a college graduate $i$ in district $k$ at time $t$ is working in a "noncollege" occupation, $\mathbf{X}'_{ikt}$ is a vector of individual characteristics such as worker's potential labor market experience (in years) and gender, $\mathbf{TD}'_{kt}$ is a vector of year-district dummies, and $\boldsymbol{\epsilon}_{ikt}$ captures unobservable individual characteristics. Further on, $CollSh_{kt}$ is the relative supply of college graduates in district $k$ at time $t$, $\mathbf{Y}'_{kt}$ is a vector of other year-district specific characteristics, and $\varepsilon_{kt}$ represents the time and/or district specific unobservable determinants of college graduates' allocation across occupations. The parame-

[6] Young workers are defined as being younger than 35.

ter of main interest is $\theta_1$; it describes the causal relationship between the relative amount of college graduates in population and their fraction working in "noncollege" occupations.[7]

Unfortunately, there appears an omitted variable problem when estimating equation (24b) by WLS[8]. Some of the unobservables that are captured by the error term might bias the estimate of $\widehat{\theta}_1$ because of being correlated with the relative supply of college graduates. The major source of bias is the unobserved heterogeneity across districts, as well as over time, in the demand for labor. Let me note that the error term contains the unobserved shifters of demand for college graduates in the "college" sector (e.g. their relative productivity, $\alpha_1$). It can be decomposed in the following way

$$\varepsilon_{kt} = u_{kt} + \nu_{kt} + \eta_k, \tag{25}$$

where $\nu_{kt}$ is the time-varying unobservable variation in local demand, $\eta_k$ is time-constant local variation in demand for college graduates, and $u_{it}$ is a transitory component of the allocation of labor which is supposed to be iid across districts and time. The problem is that time-varying and district specific productivity shocks might partially drive the variation in the supply of college graduates. For example, an expansion of hi-tech industry in one district attracts highly educated workers to move there or observation of country-wide SBTC motivates more people to get higher education. This is why I expect $cov(\nu_{kt}, CollSh_{kt}) \neq 0$ and $cov(\eta_k, CollSh_{kt}) \neq 0$. The intuitive sign of these correlations is positive (i.e. positive productivity shocks induce higher fraction of college graduates), thus the WLS estimates of the relationship from equation (24b) would be biased downwards[9].

[7] Ideally, the above should be modeled as a choice between three alternatives: working in a "college" sector, working in "noncollege" sector and being unemployed. Unfortunately, the data set used in this paper does not contain information about hte unemployed. Nevertheless, this is not an important issue in the case of the Czehc Republic, where the unemployment rate of college graduates did not exceed 4.6% in any district over the 2000-2006 period.

[8] There might appear also an omitted variable bias when estimating equation (24a) if workers sort into cities according to their unobservable abilities. In this case $\mathbf{TD}'_{kt}$ and $\boldsymbol{\epsilon}_{ikt}$ are correlated, what influences the estimated of $d_{kt}$. This problem is, however, not adressed in this paper.

[9] A positive demand shock in the "college" sector makes more graduates work there and thus decreases $\pi^*_{Ckt}$. At the same time, it triggers growth in $CollSh_{kt}$. What we observe is just a growth in the relative

Endogeneity of the fraction of population with a college degree can be addressed in several ways. My first proposal is to use an instrument that predicts well the share of college graduates in population but at the same time is uncorrelated with district specific productivity shocks. Another idea is to include among the explanatory variables some proxies for unobservable productivity shocks. In the search for instrumental and proxy variables I am drawing from Moretti (2004) approach towards estimating the social returns to education. He proposes to use historical presence of college as an instrument for the relative supply of college graduates and the Katz&Murphy demand shift index as a proxy for unobservable productivity.

## 4.1 Instrumental variable approach

Moretti's idea of using historical presence of college as an exogenous predictor of the variation in the supply of highly educated labor across districts can be applied also in the case of the Czech Republic (e.g. Jurajda, 2004). The amount of college graduates in district population is to a large extent driven by the presence of a college in this district, what can be illustrated by the correlation parameter between these two[10]. On the other hand, the majority of public colleges in the Czech Republic has been established during communism what makes their presence exogenous to current productivity shocks. Thus, the presence and/or size of a college[11] in a district as of the end of communism might be a good candidate for an instrument predicting the current supply of college graduates across districts. Although some colleges opened in the 1950's and 1960's were tied to local industries, what casts some doubt on the exogeneity of such instrumental variables, the industrial structure of districts has changed during the period of transition and the overall demand for labor has dropped during that time. That is why, while controlling for districts industrial structure at the end

supply of college graduates and decline in the fraction of them employed in "noncollege" occupations what creates an impression of a negative relationship between these two.

[10] The correlation parameter between the presence of a public college and the fraction of population with college degree in Czech districts is 0.7186 for 2002.

[11] Size of district college as of the end of communism is defined as the fraction of district population holding college degree in 1991.

of communism, I can safely use the chosen instruments.

The size and presence of a college in a district as of the end of communism can be used as an instrument only in the case of cross-sectional analysis because this instrument does not vary over time. When applying this instrument, I am left with the variation in relative college supply that is only due to the historical distribution of colleges and thus is uncorrelated with current district-specific productivity shocks, i.e. $cov(\eta_k, CollSh_{kt}) = 0$. This approach should thus allow me identify the unbiased cross-district relationship between the supply of college graduates and the fraction of them working in "noncollege" occupations.

## 4.2 Proxy variable

Another approach towards dealing with the possible correlation between the unobservable shifts in demand for skilled workers and the relative supply of college graduates is to include among explanatory variables a proxy of the latter. Ideal proxies should explain as much as possible the variation in demand for college graduates. For this purpose I use the district specific Katz&Murphy demand shift index ($D_{kt}$). It captures exogenous shifts in the relative demand for labor across districts as predicted by their industrial structure. It is formulated in the following way:

$$D_{kt} = \sum_{s=1}^{S} \eta_{skt-1} \Delta E_{st}, \tag{26}$$

and represents a shift in demand due to changes in national employment across industries. Districts that are rich in industries which experience a significant employment shift face a strong positive demand shock and districts that are rich in industries that experience a significant downturn in employment face a negative demand shock. I use Katz&Murphy demand shift index for college graduates, i.e. $\Delta E_{st}$ is the change in log of total hours worked by college graduates in a 2-digit industry $s$ between periods $t-1$ and $t$, and $\eta_{skt-1}$ is the share of total hours worked in industry $s$ in district $k$ in period $t-1$.

Including the above described proxy among the explanatory variables, I move some of the unobservable variation in the demand for college graduates ($\nu_{kt}$ and $\eta_k$) from the error

term to controllable RHS. In this way I decrease the OLS bias of $\widehat{\theta}_1$. I also include among the explanatory variables the size measures such as the density of district's population, and the logarithm of district's labor force to account for assortative matching effects. It is generally accepted that in larger markets workers and firms find each other easier (e.g. Wheeler 2001), what has a negative effect on my LHS variable. Finally, I control for the share of employment in the public sector, because the individual level data used for estimations cover only employees from the commercial sector, while the public sector usually employs many college graduates what can influence the district's supply of highly educated labor. [12]

### 4.3 Panel data techniques

When working with a panel of Czech districts, I face both the cross-district time-constant ($\eta_k$) and time-varying ($\nu_{kt}$) "bad" shocks to the demand for college graduates. The correlation of the latter with relative supply of highly educated workers can be dealt with by the fixed-effect estimation approach. Using this method I difference-out the time-constant unobservable district-specific demand shiftiers and this way I eliminate part of the endogeneity. This approach combined with inclusion of proxy variables that deal mainly with time-varying demand shocks should further minimize the bias of $\widehat{\theta}_1$.

## 5 Identifying "college" and "noncollege" occupations

In order to perform the estimations described above, I need to measure the fraction of college graduates employed in "noncollege" occupations. For that, there is a need to classify all occupations where college graduates work into "college" and "noncollege" ones. In doing so I follow Gottschalk and Hansen (2003) approach based on the same model as presented in Section 3.1. This approach exploits the property of the model described by inequality (10), i.e. that wages of college graduates relative to high school graduates are higher in sector

[12] I have also experimented with using real GDP per capita as another proxy variable, but it appears to have no power in explaining the variation in the fraction of college graduates working in "noncollege" occupations.

1, the "college" sector. This can be further extended to the situation when there are many different occupations in each sector, but still it holds that in each "college" occupation the relative productivity of college graduates is higher than in each "noncollege" occupation. Consequently, also the relative wages of college graduates are higher in occupations from "college" sector than from "noncollege" sector.

Based on this model, I can distinguish between "college" and "noncollege" occupations once knowing the wage premium paid to college-educated workers over high school-educated workers in each occupation employing both worker types. Gottschalk and Hansen, who perform occupations classification for the U.S., use a 10% college wage premium as a threshold, i.e. they classify an occupation as "college" when it pays at least 10% premium to highly educated workers[13]. This value, as they motivate it, is a bit higher than the lowest estimate of overall college wage premium in the U.S. as estimated by Katz and Murphy (1992). Initially I apply the same threshold. However, taking into account that the overall college wage premium in the Czech Republic is significantly higher than in the U.S., I shall experiment with higher thresholds as well.

Occupations where one type of workers is strongly prevailing are classified automatically. Gottschalk and Hansen propose to call occupations where more than 90% of workers have higher education as "college" ones and occupations where more than 90% of workers have a high school diploma as "noncollege" occupations. In this case I also initially apply the same thresholds as Gottschalk and Hansen, however in my further research I adjust them to the Czech conditions.

The procedure of classifying occupations can be described in the following way. For each 3-digit occupation, listed in the Appendix, where college graduates constitute between 10% and 90% of all employees, I estimate the following wage equation:

$$\log w_{ik} = \beta_{0k} + \beta_{1k} \cdot exp_i + \beta_{2k} \cdot exp_i^2 + \beta_{3k} \cdot female_i + \phi_k \cdot coll_i + \varepsilon_{ik}, \qquad (27)$$

where $\log w_{ik}$ is the logarithm of hourly wage received by an individual worker $i$ in occupation $k$, $exp_i$ and $exp_i^2$ are each worker's potential labor market experience (in years)

[13] The same threshold is used by Cardoso (2007) for the analysis of Portugese situation.

and its square, $female_i$ is a dummy variable indicating workers gender and $coll_i$ is a dummy variable equal to 1 if worker has a college degree and 0 otherwise.[14] This is a standard Mincerian regression used widely in the literature for identification of returns to different workers characteristics. The parameter used for classification of occupations is $\phi_k$, the college wage premium. Occupations for which the hypothesis that $\widehat{\phi_k} > threshold$ (where $threshold$ is initially set at 0.1) can not be rejected are classified as "college" ones. Those for which this hypothesis is rejected are classified as "noncollege". Finally, the occupations where more than 90% of employees are college graduates are classified as "college" occupations and those where less than 10% of employees are college graduates are classified as "non-college" occupations.

# 6 Estimation of the influence of college supply on allocation of college graduates across occupations.

For the purpose of the empirical analysis I use the Czech national employer survey, ISPV. This is a matched employee-employer data gathered and processed according to the requirements of the Czech Ministry of Labor and the European Union. Information is collected from a sample of more than 3500 firms in the commercial sector which report wages and other information about 1.3 million of workers. This dataset is a repeated cross-section; the data is collected on firm-level and individual workers are not explicitly followed.

The main advantage of the dataset used is its size. In order to apply the Gottschalk and Hansen (2003) methodology of classifying occupations there is a need to have no less than 100 observations of workers with high school or higher level of education in each occupation. In ISPV dataset there are about 35,000 young college graduates defined as individuals with at least a bachelor degree below 35 years of age and 65,000 young high school graduates defined as individuals below 35 years of age who have passed a maturity exam for each of

[14] The sample used for classification of occupations contains all college and high school educated workers or workers with a given labor market experience only. The sample choice is discussed in more details in the next section.

the years in 2000 – 2006 period. This is enough to carry out the analysis on the level of 3-digit occupations.

The variables reported in the dataset used include age, gender and education level of each employee. Moreover, one can find there the characteristics of firm in which an individual is employed (location, industry, size, ownership structure, etc.), the occupation that an individual performs and her monthly earnings together with the number of hours worked. The last two variables allow for calculation of hourly wage which is defined as an average pay per hour during the first quarter of a year.

Occupations are coded in the ISPV dataset according to a local system which follows the International Standard Classification of Occupations (ISCO). For the purpose of this paper's analysis I use occupations defined on a 3-digit level. This is the precision used also by Gottschalk and Hansen (2003). Occupations defined by 3-digit codes are detailed enough to capture quite narrowly defined jobs performed there and at the same are wide enough to contain number of workers allowing to perform the estimations. Nevertheless, some occupations had to be merged in order to achieve larger sample size; in each case the aggregation was kept the same for all years of the analysis. The list of occupations used in this paper is presented the Appendix.

## 6.1 Cross-sectional estimation on district level

This section presents the second stage[15] (i.e. district-level) estimates of the relationship between the relative amount of college graduates in population and their fraction working in "noncollege" occupations in cross-district dimension. Columns 1 and 2 of Table 1 present OLS estimates of the relationship under interest with and without the district of Prague, while columns 3 and 4 present the estimates of the same relationship when the share of college graduates in a district has been instrumented by the share of college graduates in district population as of the end of communism, again with and without Prague. The reason

[15] First stage estimation results are presented in the Appendix.

why I exclude the district of Prague is that it is an obvious outlier with a large share of college graduates in local population and high concentration of businesses.

Table 1: Determinants of the share of college graduates in "noncollege" occupations across Czech districts in 2001

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | OLS | OLS | IV | IV |
| CollShare | -1.092* | -1.103* | -0.772# | -0.784# |
| | (0.591) | (0.595) | (0.649) | (0.653) |
| Prague | Yes | No | Yes | No |
| Sample | Young | Young | Young | Young |
| Observations | 72 | 71 | 72 | 71 |
| R-squared | 0.089 | 0.087 | 0.085 | 0.082 |

Notes: *CollShare* is the 2001 share of college graduates in respective district young population; as an IV for this variable I use the share of college graduates in district population as of the end of communism. Young workers are defined as being younger than 35. Standard errors in parenthesis. * p<0.10, # p<0.25

One can see that the estimates of the influence of the share of college graduates in district population on the fraction of them working in"noncollege" occupations are strongly negative when the OLS estimation method is applied. These results are, however, biased downwards due to the simultaneity in the determination of these two variables. Thus, we should expect the true relationship not to be that negative. Indeed, when instrumenting the current share of college graduates in district population with the same measure as of the end of communism, less significant estimates are obtained. The relationship between the share of college graduates in district population and the fraction of them working in"noncollege" occupations is estimated to be negative with 75% confidence. This gives us some evidence to believe that a higher number of college graduates attracts skill-intensive capital and in this way improves the situation of highly educated workers in the district labor market.

## 6.2 Estimation on the panel of districts

Let me now turn to the estimates of the relationship between the relative amount of college graduates in population and their fraction working in "noncollege" occupations in cross- and within-district dimension. Table 2 presents the results of such estimation. Columns (1) and (2) include the OLS estimates of the relationship under consideration while columns (3) and (4) include the FE estimates, where time-constant district effects have been differenced out.

Table 2: Determinants of the share of college graduates in "noncollege" occupations across Czech districts over the 2000-2006 period

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | OLS | OLS | FE | FE |
| CollShare | 0.117* | 0.259*** | 0.210* | 0.449*** |
| | (0.079) | (0.083) | (0.117) | (0.127) |
| Prague | Yes | No | Yes | No |
| Sample | Young | Young | Young | Young |
| Observations | 497 | 490 | 426 | 419 |
| R-squared | 0.029 | 0.028 | 0.406 | 0.420 |

Notes: *CollShare* is the year-specific share of college graduates in respective district population. *Unempl* is the unemployment rate for college graduates across districts. Young workers are defined as being younger than 35. Standard errors in parenthesis, *** p<0.01, ** p<0.05, * p<0.1

It is interesting to see that in the over-time dimension the estimates of the relationship between the share of college graduates in district population and the fraction of them working in "noncollege" occupations are positive even when using OLS. The fixed effect estimates are even higher. This suggests that the substitution effect is stronger than the spillover effect and a higher number of college graduates worsens their situation in the district labor market.

The opposing results of cross-sectional and over-time analysis might be interpreted in the following way. Districts with historically determined higher supply of college graduates have attracted skill-complementing capital and offer more employment possibilities in "college" occupations. Thus, the situation of college graduates is better in such regions. Nevertheless, by increasing the supply of college graduates from year to year, districts are not able to attract enough capital to compensate for the substitution effect and thus over time we observe a positive relationship between the share of college graduates in district population and the fraction of them working in "noncollege" occupations.

Finally, one has to be aware that the data on the share of college graduates in young population are very noisy for other years than the Census year (2001). This could have partially influenced the results.

## 6.3 Robustness check

It could be argued that the results presented above are specific to the definition of "college" occupations. Let me remind that an occupation is defined to be "college" when the wage premium it pays to college graduates exceeds 10% or when the proportion of college graduates working there exceeds 90%. These thresholds have been taken directly from the original paper by Gottschalk and Hansen (2003) and have been chosen for the U.S. economy.

To show that the results are not driven by the chosen thresholds, let me present the results of analogous estimations performed using an alternative definition of a "college" occupation, i.e. with wage premium threshold set at 15% and proportion threshold at 85%. These values are more plausible in the Czech environment where the college wage premium is significantly higher than in the U.S. and the fraction of college graduates in population significantly lower. Use of alternative definition leads to qualitatively the same results.

Table 3: Determinants of the share of college graduates in "noncollege" occupations across Czech districts in 2001

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | OLS | OLS | IV | IV |
| CollShare | -1.079* | -1.103* | -0.688 | -0.715 |
| | (0.680) | (0.680) | (0.747) | (0.747) |
| Prague | Yes | No | Yes | No |
| Sample | Young | Young | Young | Young |
| Observations | 71 | 70 | 71 | 70 |
| R-squared | 0.074 | 0.082 | 0.069 | 0.077 |

Notes: *CollShare* is the 2001 share of college graduates in respective district young population; as an IV for this variable I use the share of college graduates in district population as of the end of communism. Young workers are defined as being younger than 35. Standard errors in parenthesis. * $p<0.10$

# 7 Conclusion

Estimation of the fraction of college graduates working in "noncollege" occupations proposed by Gottschalk and Hansen (2003) and applied further to the U.S., Portugal and the Czech Republic reveals a consistent pattern. In every country this measure has been decreasing over time despite a significant growth in the supply of college educated workers to the labor market. This observation triggers a question about the source of such a state of being. The possible explanations that have been discussed in this paper are that (1) exogenous SBTC shifts demand for college graduates so much that it more than matches growth in the supply of them, or (2) a higher supply of college graduates stimulates SBTC creating, in a way, a demand for itself.

These phenomena are, of course, not mutually exclusive. Most probably they both happen simultaneously. However, it is important from the policy point of view to find out how strong is the self stimulating effect as opposed to exogenous shifts in demand for college

Table 4: Determinants of the share of college graduates in "noncollege" occupations across Czech districts over the 2000-2006 period

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | OLS | OLS | FE | FE |
| CollShare | 0.102 | 0.252** | -0.119 | 0.222# |
| | (0.102) | (0.106) | (0.151) | (0.162) |
| Prague | Yes | No | Yes | No |
| Sample | Young | Young | Young | Young |
| Observations | 490 | 483 | 419 | 413 |
| R-squared | 0.037 | 0.029 | 0.419 | 0.422 |

Notes: *CollShare* is the year-specific share of college graduates in respective district young population. Young workers are defined as being younger than 35. Standard errors in parenthesis, ** p<0.05, # p<0.20

graduates. In this paper, I took a look at Czech district-level variation in the supply of college educated labor to find some evidence for an increased number of highly educated labor attracting skill-intensive industries and endogenously shifting the demand for skills, but only across districts. In the over-time dimension I have not identified a strong enough spillover effect that would compensate for the substitution effect allocating larger fraction of college graduates to "noncollege" occupations when their supply increases. This finding has strong implications for further expansion of the Czech state-funded higher education system. It suggests that in the long run districts are able to positively stimulate their graduate labor markets by providing higher education to higher fraction f their population (explanation 2). Nevertheless, in the short run the supply of college seats should be a response to the observed level of demand for skills (explanation 1).

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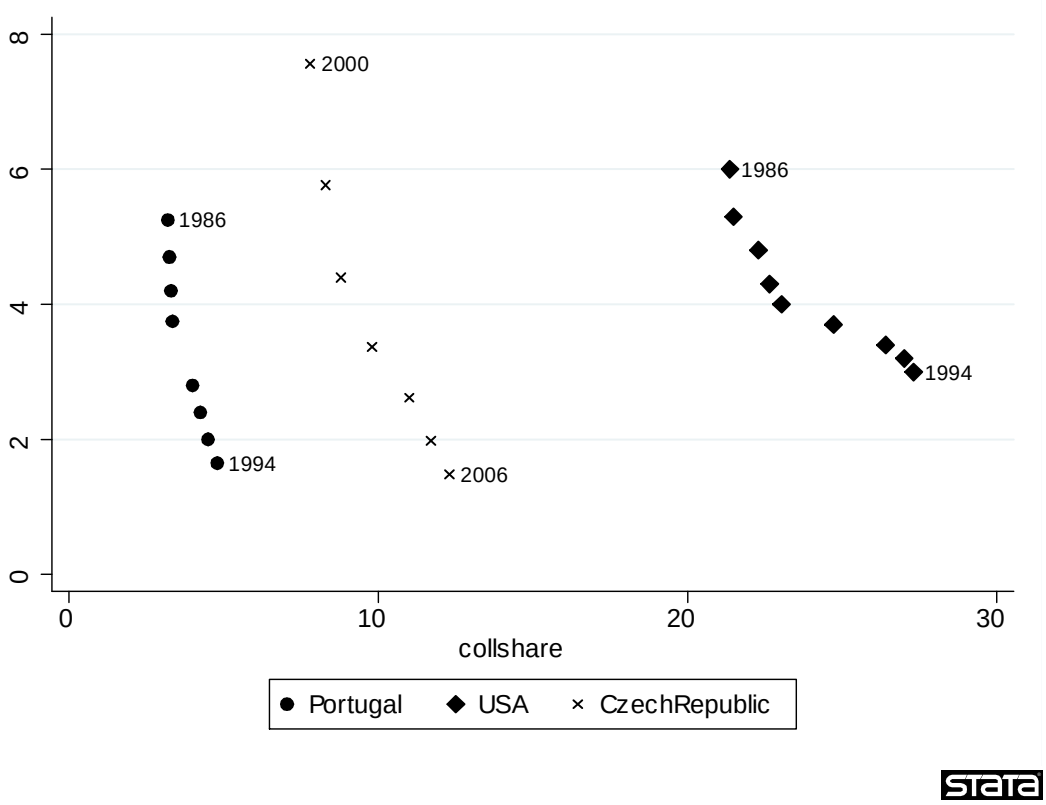
# 8 Appendix

Figure 2: Probability of a college graduate to work in "noncollege" occupations.




Source: Own comparison based on Cardoso (2007), Cardoso (2004), Gottschalk & Hansen (2003), Hecker (1992), US Census data, and own calculations.

Table 5: Summary statistics of the ISPV data

| Year | Total | Education | | Gender | |
|---|---|---|---|---|---|
| | | College | High school | Female | Male |
| 2000 | 77,349 | 28.3% | 71.7% | 43.3% | 56.7% |
| 2001 | 85,169 | 27.8% | 72.2% | 44.6% | 55.4% |
| 2002 | 82,120 | 31.0% | 69.0% | 46.7% | 53.3% |
| 2003 | 83,490 | 34.9% | 65.1% | 45.5% | 54.5% |
| 2004 | 99,241 | 38.5% | 61.5% | 46.9% | 53.1% |
| 2005 | 100,365 | 32.3% | 67.7% | 46.2% | 53.8% |
| 2006 | 108,248 | 34.3% | 65.7% | 45.5% | 54.5% |

Note: The above table presents summary statistics of the sample of young workers, i.e. workers under 35 years of age.

Table 6: List of 3-digit occupations used in the analysis on the sample of young workers

| Code | Description |
|---|---|
| 121 | Directors and chief executives |
| 122 | Production and operations department managers |
| 123 | Other department managers |
| 131 | General managers |
| 211 | Physicists, chemists and related professionals |
| 212 | Mathematicians, statisticians and related professionals |
| 213 | Computing professionals |
| 214 | Architects, engineers and related professionals |
| 221&222 | Life science professionals and health professionals (except nursing) |
| 241 | Business professionals |
| 242 | Legal professionals |
| 243 | Archivists, librarians and related information professionals |
| 244 | Social science and related professionals |
| 245 | Writers and creative or performing artists |
| 247 | Professional administrative workers |
| 311 | Physical and engineering science technicians |
| 312 | Computer associate professionals |
| 313 | Optical and electronic equipment operators |
| 314 | Ship and aircraft controllers and technicians |
| 315 | Safety and quality inspectors |
| 316 | Railway and train technicians |
| 321 | Life science technicians and related associate professionals |
| 322&323 | Modern health, nursing and midwifery associate professionals |
| 331&334&348 | Teaching & religious associate professionals |
| 341 | Finance and sales associate professionals |
| 342 | Business services agents and trade brokers |
| 343 | Administrative associate professionals |
| 344&345 | Police inspectors and detectives, customs, tax and related government associate professionals |
| 346&347 | Social work associate professionals, artistic, entertainment and sports associate professionals |

| | |
|---|---|
| 411 | Secretaries and keyboard-operating clerks |
| 412 | Numerical clerks |
| 413 | Material-recording and transport clerks |
| 414 | Library, mail and related clerks |
| 419 | Other office clerks |
| 421 | Cashiers, tellers and related clerks |
| 422 | Client information clerks |
| 511 | Travel attendants and related workers |
| 512 | Housekeeping and restaurant services workers |
| 516 | Protective services workers |
| 521&522 | Models, salespersons and demonstrators |
| 611&612&613&621 | Market-oriented skilled agricultural workers |
| 614&615 | Market-oriented forestry and fishery workers |
| 711 | Miners, shotfirers, stone cutters and carvers |
| 712 | Building frame and related trades workers |
| 13&714 | Building finishers, painters, building structure cleaners and related trades workers |
| 721 | Metal molders, welders, sheet-metal workers, structural-metal preparers, and related trades workers |
| 722 | Blacksmiths, tool-makers and related trades workers |
| 723 | Machinery mechanics and fitters |
| 724 | Electrical and electronic equipment mechanics and fitters |
| 731 | Precision workers in metal and related materials |
| 732 | Potters, glass-makers and related trades workers |
| 734 | Printing and related trades workers |
| 741 | Food processing and related trades workers |
| 42&733 | Wood treaters, cabinet-makers and related trades workers, handicraft workers in wood, textile, leather and related material |
| 743&744 | Textile, garment, pelt, leather, shoemaking and related trades workers |
| 811 | Mining and mineral-processing-plant operators |
| 812 | Metal-processing-plant operators |
| 813 | Glass, ceramics and related plant-operators |

| | |
|---|---|
| 814 | Wood-processing-and papermaking-plant operators |
| 815 | Chemical-processing-plant operators |
| 816 | Power-production and related plant operators |
| 817&818 | Automated-assembly-line, industrial-robot operators and operators of rail vehicles |
| 821 | Metal-and mineral-products machine operators |
| 822 | Chemical-products machine operators |
| 823 | Rubber- and plastic-products machine operators |
| 824&825 | Wood-products, printing-, binding-and paper-products machine operators |
| 826 | Textile-, fur-and leather-products machine operators |
| 827 | Food and related products machine operators |
| 828 | Assemblers |
| 829 | Other machine operators and assemblers |
| 831&834 | Locomotive engine drivers, ships' deck crews and related workers |
| 832 | Motor vehicle drivers |
| 833 | Agricultural and other mobile plant operators |
| 911&912&913&914 | Street vendors, Shoe cleaning and other street services elementary occupations, domestic and related helpers, cleaners and launderers, uilding caretakers, window and related cleaners |
| 915 | Messengers, porters, doorkeepers and related workers |
| 916 | Garbage collectors and related laborers |
| 931 | Mining and construction laborers |
| 932 | Manufacturing laborers |
| 933 | Transport laborers and freight handlers |