The Aggregate Labor Market Effects of The Swedish Knowledge Lift Program

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Abstract

The Swedish adult education program known as the Knowledge Lift (1997–2002) was unprecedented in its size and scope, aiming to raise the skill level of large numbers of low-skill workers. This paper evaluates the potential effects of this program on aggregate labor market outcomes. This is done by calibrating an equilibrium search model with heterogeneous worker skills using pre-program data and then forecasting the program impacts. We compare the forecasts to observed aggregate labor market outcomes after termination of the program.

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1 Introduction

Life-long learning, adult education, and employability have become focal points in the labor market policies of many advanced economies (see e.g. the recent OECD Employment Outlook 2004). It is expected that these economies will face more turbulent conditions than in the past and that the development of novel production technologies will proceed at a sustained high speed. This will require a flexible and suitably skilled workforce. Indeed, the role of low-educated workers has diminished in modern knowledge-based economies. The fact that there is now a heavier representation of older workers in the labor force means that the human capital adjustment needs to be made by the existing stock of workers rather than solely by the inflow of new workers.

Sweden is relatively well prepared for such a policy intervention, given its long tradition of training of adult unemployed workers (see e.g. Ministry of Education, 1998, Friberg, 2000, and Ministry of Industry, 2001). In 1997, Sweden implemented a new major adult education program called the “Adult Education Initiative” or “Knowledge Lift” (henceforth denoted as KL). Without exaggeration, this constitutes the largest and most ambitious skill-raising program ever. It aimed to raise the skill level of all low-skill workers to the medium-skill level. It focused on workers with a low level of education. The size of the program was unprecedented: in the period 1997-2000 alone, more than 10% of the labor force participated in it.

Obviously, the program reflected a great deal of optimism about the extent to which an adult’s human capital can be improved. The empirical literature on training programs for unemployed workers does not warrant this optimism. The general conclusion from this literature is that training does not have large effects on individual labor market outcomes (see e.g. Fay, 1996, Heckman, LaLonde and Smith, 1999, and Martin and Grubb, 2001). A potential exception concerns training for women who return to the labor market after a spell of child-raising activity, who clearly form an important target group for adult education. However, perhaps more importantly, training participants with a low initial level of education benefit even less than other educational groups.

While this evidence questions the presence of effects on individual outcomes, it is still possible with a large training program such as KL that there are macroeconomic labor market effects. In this paper, we analyze these macroeconomic effects of KL. Specifically, we examine the equilibrium effects of KL by calibrating an equilibrium matching model with labor market frictions and skill heterogeneity. Given the size of the program, equilibrium effects may be substantial. In addition to any effect on the individuals in the program, other workers in the economy are likely to be impacted through changes in wages and/or through changes in unemployment and employment probabilities.[1] Obviously, the model

[1]See e.g. Lise, Seitz and Smith (2005) for a general discussion of equilibrium evaluation of policy

we use should incorporate skill heterogeneity and equilibrium unemployment. Also, firms should be able to choose their production technologies in the face of the prevailing skill distribution. We use a model based on Albrecht and Vroman (2002), which is a concise and amenable model satisfying the above requirements. It assumes two worker types, low skill and medium skill, with the number of workers of each type taken as exogenous in a given market.[2] There are frictions in the process by which unemployed workers and vacancies contact one another, and the surplus generated by a worker/job match is divided using the Nash bargaining solution. The flow output of a match depends on the skill level of the worker as well as on the job type as decided by the firm when it created the vacancy.[3]

We use data from 1996 to calibrate the pre-KL economy.[4] This allows us to set values for the unobserved parameters that drive the theoretical model. We then address the question: "Suppose KL were to change the skill distribution in the economy in a particular way. What would the effects be?" Specifically, we impute potential post-KL skill distributions and solve the model for the new steady-state equilibria. We derive wages for low-skill and medium-skill workers as well as their unemployment rates and employment in low-skill and medium-skill jobs. We also derive the overall unemployment rate, labor market tightness (vacancies over unemployment), the proportions of low-skill and medium-skill vacancies, and the equilibrium effects on the treated. Since the model we use is a steady-state model, the aggregate effects it predicts should be long-run effects. Nonetheless, we look at early post-KL data to see what aggregate labor market effects occurred.

We use our predicted aggregate labor market effects to carry out the following policy experiment. A "partial" treatment effect is calculated as the difference between average wages and employment probabilities for a low-skill worker and a medium-skill worker calibrated to the distribution of skills in the pre-KL economy. This approximates the effect of upgrading the skill of a single worker, leaving the skill distribution unchanged. Next, the equilibrium of the model economy in which the distribution of low- and medium-skill workers has been exogenously changed to the one induced by the KL is calculated. An equilibrium treatment effect is calculated by computing the difference in outcomes (average wages and employment probabilities) between the two economies for workers who

programs.

[2]We abstract from the interaction between high-skill workers and the rest of the labor market. We do this because the primary impact of the knowledge lift is on low- and medium-skill workers and because adding a third worker type to the model would considerably complicate our calibrations.

[3]Plesca (2007) also uses the Albrecht and Vroman (2002) model as the basis for a general equilibrium evaluation analysis. Specifically, she evaluates the US Public Labor Exchange (PLX), a program that helps arrange meetings between job seekers and firms with vacancies. She finds that the general equilibrium effects of the PLX are substantially greater than the corresponding partial equilibrium effects; that is, the PLX has substantial effects even for workers who do not participate in the program. Her results are thus quite consistent with ours.

[4]A calibration for 1994 was also done. The results were very similar.

changed form low to medium skill, relative to a worker who remained low skilled in both economies. Spillover effects are also calculated as the effect on workers who remained either low or medium skilled in both economies. We find that the equilibrium treatment effect is between 1.5 and 2 times the partial treatment effect and that the spillover effect is negative for those who remain low skilled but positive for those who stay at the medium skill level. This highlights the importance of accounting for the equilibrium effects of large-scale "treatments."

In addition to the aggregate labor market effects that we analyze, KL may have had other effects on the economy. For example, Björklund et al. (2005) show that KL generated a large flow of teachers from regular secondary education to adult education, and they argue that KL therefore may have generated substantial negative external effects on the quality of regular education. However, addressing these effects is beyond the scope of our paper. We also do not aim to address the use of adult education by young individuals who left the regular school system with low educational levels, as a short-cut towards regular university education (see e.g. Björklund et al., 2005, and Ekström, 2003, for discussions). For this reason we exclude individuals aged below 25 in our calibration.

The paper is organized as follows. Section 2 describes the KL program. In Section 3, we describe the equilibrium model that is the basis for the calibration. Section 4 describes the data used to calibrate the model and gives the results of the calibration. Section 5 contains the results of the equilibrium analysis. A discussion of aggregate labor market changes between 1996 and 2003 and how they compare to our simulation results is given in Section 6, while Section 7 concludes.

2 The Knowledge Lift

As explained below, KL was run through the existing municipal adult education system (KOMVUX) and can be seen as a major qualitative and quantitative upscaling of KOMVUX. By now, many studies provide detailed descriptions of KL and/or KOMVUX and their participants. See, for example, The National Agency for Education (1999), Axelsson and Westerlund (1999), Skolverket (2001), and Stenberg (2003) for information on KL, and Skolverket (2001) and Ekström (2003) for information on KOMVUX. We therefore restrict ourselves here to a brief summary.

KL was by far the largest adult education program ever in Sweden. It ran from July 1, 1997 to December 31, 2002. The objective was to increase the skill level of adult low-skill workers to the medium skill level, thereby helping these individuals strengthen their position in the labor market. Here, low skill means having an educational attainment below the level of a 3-year "gymnasium" degree, while medium skill means having attained this level but not any levels beyond that. The 3-year gymnasium degree roughly corresponds to the upper secondary education level or senior high school. Since 1995 this is the lowest possible upper secondary school diploma, whereas before that many individuals left high school with a 2-year degree. The program particularly targeted unemployed adult low-skill workers. However, low-skill employed workers and medium-skill unemployed workers were also often eligible for KL, and the enrollees included many low-skill employed workers, working part time or full time.

Due to KL, the number of individuals in adult education became dramatically larger than in earlier years (the increase in the stock of participants was about 80%). The old KOMVUX system included courses that were not aimed at the attainment of a medium skill level but rather an improvement within the class of low skill sublevels. Compared to the old KOMVUX system, KL also involved the improvement and modernization of teaching methodologies and pedagogy. For all practical purposes, KL and KOMVUX were indistinguishable in the period in which KL ran. Therefore, in the remainder of the paper, we simply refer to KL as the program we evaluate.

KL focused on the enhancement of general skills (for example, English, Swedish, and Mathematics), as opposed to specific skills needed for particular professions. However, part of KL could be used for vocational courses and work placement. In principle, it was possible to combine upper secondary courses with studies at an elementary level or with a program organized by the National Labor Market Board for the unemployed. The curricula and grade criteria for the attainment of the medium skill level were roughly the same as in the regular upper secondary education system.

KL was organized at the municipal level and run through the KOMVUX system. It was possible for the organization to be joint among several municipalities. A municipality could purchase the services of education providers and/or cooperate with them. However, the municipalities were responsible for admission into KL. A single course typically started twice a year and covered a half-year term.

At the level of the individual, admission into KL was in principle unrestricted. The underlying view was that KL participation should be led by the demand for education. A participant should have ample scope for personal choice regarding the type of study and its timing and location. Whether one could participate in a desired course only depended on the availability of courses and on the entry skill level requirement. Recruitment of participants was sometimes carried out in cooperation with trade union organizations or local employment offices.

KL participants were eligible for a range of income grants and financial study support measures. Some enrollees received “special education support” (UBS). The amount of financial support was equivalent to unemployment insurance (UI). UBS was only given to KL participants who were entitled to UI payments at date of entry into the program. Moreover, the worker had to be between 25–55 years old at date of entry into the program and had to study at the elementary or upper secondary level. The grant was typically given for a maximum of one year. Sometimes, special adult study assistance and funding were available as a combination of a grant and a loan. Many participants relied on other financial resources. An individual who was full-time in KL was considered to be out of the labor force unless he/she earned income on the side.

The state channelled funds to the municipalities to finance KL. The amount of funding depended on the municipality's unemployment rate and skill level distribution, and on the scope of the municipality's program. A conservative estimate is that, in the first years of its existence, the state spent at least SEK 3.5 billion per year on KL. This equaled almost SEK 1000 per labor force participant in Sweden. The spending covered the creation of some 100,000 annual study slots. In practice, the funding was more than sufficient to meet the demand for KL (see Statskontoret, 1999). This fact is important for our analysis because it implies that there was no quantity rationing.

The following gives an indication of the size of the program in terms of numbers of enrollees. In the fall of 1997, 538,004 individuals (out of a population of 8.8M) were (i) aged between 25 and 55, and (ii) participated in the municipal adult education, or were unemployed (in the sense of actively searching), or participated in one or more training programs. About 220,000 of these participated in KL, and of these about 56,000 received UBS. About 35,000 KL participants were registered as unemployed, and another 5,000 participated both in KL and in employment training. The number of registered unemployed, including those participating in KL and/or training programs was about 330,000. For comparison, the number of pupils in regular upper secondary school was about 300,000, while the number of individuals participating in employment training programs was about 40,000. The figures do not sum to the total of 538,004 because some individuals fall into more than one category. Typically, the number of individuals enrolled in KL is about 50% larger than the full-time equivalent of the number of occupied slots. This indicates that many enrollees were part-time participants. Skolverket (2001) provides a wealth of additional information on the composition of participants and courses.

3 The Model

As indicated in the introduction, we use the equilibrium labor market model from Albrecht and Vroman (2002). We first present a generalization of that model. Then we calibrate it using pre-program data.

The model is a stylized one in which risk-neutral workers live forever. The measure of workers is normalized to 1. The skill distribution is taken as exogenous and we denote the fraction of the labor force with skill level s_i as p_i with $\sum_{i=1}^{S} p_i = 1$. Jobs are described by their minimum skill requirement, y. The technology is such that the output produced by a job of type y with a worker of skill s is $x(s,y) = \begin{cases} y & \text{if} \quad s \geqslant y \\ 0 & \text{if} \quad s < y \end{cases}$.

A job is either vacant or filled. When a job of type y is filled by a worker of skill s, a wage of $w(s,y)$ is paid and a cost of c_y is incurred. That is, the flow value to the firm of filling a job of type y with a worker of skill s is $y - w(s,y) - c_y$, conditional, of course, on $s \geqslant y$. The corresponding flow value to the worker holding the job is the wage. When a job is vacant, the fixed cost must still be paid so the flow value of a vacancy of type y is $-c_y$. The corresponding flow value to an unemployed worker is b, which can be interpreted as unemployment compensation and/or the value of not working.

Matches break up (filled jobs become vacant) at the rate δ_y, i.e., we assume that job stability varies by job type (this, as well as the dependence of c on y, generalizes Albrecht and Vroman, 2002). The flow in the opposite direction is governed by a matching function. Specifically, unemployed workers and vacancies match randomly according to a constant returns to scale matching function

$$m(u,v) = m(1, \frac{v}{u})u = m(\theta)u, \text{where } \theta = \frac{v}{u}$$

with $m'(\theta) > 0$ and $d(\frac{m(\theta)}{\theta})/d\theta < 0$.[5]

We use the following notation:

$U(s)$ is the value of unemployment for a worker of skill s

$N(s,y)$ is the value of employment for a worker of skill s on a job of type y

$V(y)$ is the value of a vacancy of type y,

$J(s,y)$ is the value to an employer of filling a job of type y with a worker of skill s.

A match will be formed if and only if

$$N(s,y) + J(s,y) \geqslant U(s) + V(y)$$

and when a match is formed, the wage, $w(s,y)$, is given by the Nash bargaining condition,

$$N(s,y) - U(s) = \beta[N(s,y) + J(s,y) - U(s) - V(y)],$$

[5]As in Albrecht and Vroman (2002), we assume that search is undirected, to capture the idea that medium-skill workers can search in the low-skill market and "crowd out" the low-skill workers. This is a disadvantage (in addition to lower productivity) that low-skill workers face. Additional arguments in favor of undirected search are given in Albrecht and Vroman (2002). Gautier, Van den Berg, Van Ours and Ridder (2002) analyze matching in the labor market empirically. They find that at each level of job complexity there are workers with different skill levels and that workers with a higher education are not more productive than lower educated workers. They use data from The Netherlands. However, our Swedish data also display a very high amount of wage dispersion among medium-skill workers, and the support of the wage distribution among them covers the support of the wage distribution of low-skill workers.

where β is the exogenously given worker's share of the surplus.

We assume free entry and exit of vacancies, so in equilibrium, there will be at most S skill requirements: $y_j = s_j$, $j = 1, ..., S$, where S is the number of worker skill levels. We define ϕ_j to be the fraction of vacancies requiring skill s_j and γ_i to be the fraction of the unemployed who have skill s_i. The unemployment rate, u, labor market tightness, θ, and the fractions $\{\phi_j\}_{j=1}^S$ and $\{\gamma_i\}_{i=1}^S$ are the fundamental endogenous variables of the model.

The value functions for filled jobs are

$$\begin{aligned} rN(s_i, s_j) &= w(s_i, s_j) + \delta_j[U(s_i) - N(s_i, s_j)] \\ rJ(s_i, s_j) &= s_j - w(s_i, s_j) - c_j + \delta_j[V(s_j) - J(s_i, s_j)] \end{aligned}$$

Both of these are conditional on $s_i \geq s_j$. The value of unemployment for a worker of skill s_i is

$$rU(s_i) = b + m(\theta) \sum_{j \leq i} \phi_j \max[N(s_i, s_j) - U(s_i), 0]$$

and the value of a vacancy of type s_j is

$$rV(s_j) = -c_j + \frac{m(\theta)}{\theta} \sum_{j \leq i} \gamma_i \max[J(s_i, s_j) - V(s_j), 0]$$

Free entry and exit of vacancies implies $V(s_j) \leq 0$, with equality if $\phi_j > 0$, $j = 1, ..., S$.

Substituting the above expressions into the match formation condition implies that a match will be formed if and only if

$$s_j - c_j \geqslant rU(s_i)$$

and the wage of a worker of skill s_i on a job requiring skill s_j is

$$w(s_i, s_j) = \beta(s_j - c_j) + (1 - \beta) rU(s_i).$$

Both of these are conditional on $s_i \geq s_j$. Note that this allows for wage dispersion both within and across worker types.

We look for steady-state equilibria. A steady-state equilibrium is a collection of variables u, θ, $\{\phi_j\}_{j=1}^S$, and $\{\gamma_i\}_{i=1}^S$ such that (i) the appropriate steady-state conditions hold, (ii) there is free entry and exit of vacancies, i.e., $V(s_j) \leq 0$ ($= 0$ if $\phi_j > 0$), and (iii) matches form iff $s_j - c_j \geq rU(s_i)$. Several equilibrium types are possible. For example, one might consider an equilibrium in which workers at each skill level match only with vacancies requiring precisely that skill, i.e., an equilibrium with perfect assortative matching. We refer to this case as equilibrium with *ex post* segmentation. At the other extreme, an equilibrium might entail all possible matches; i.e., a worker of skill s_i could match with any job of type

$s_j \leq s_i$. We refer to this case as equilibrium with full cross-skill matching. Intermediate cases, in which some but not all possible matches are formed, are also possible.

The nature of equilibrium depends on the exogenous parameters of the model. If an equilibrium of a particular type exists, e.g., an equilibrium with *ex post* segmentation, then that equilibrium is unique within that class. There may, however, be multiple equilibria in the sense that equilibria of more than one type can exist simultaneously.

In our analysis of KL, we consider only two skill levels, low and medium, and model KL as moving low-skill workers to the medium skill level, i.e., as a change in the proportions of the labor force in the various skill categories.[6] We assume that before KL, the labor force has a particular skill distribution, and the market is in the corresponding steady-state equilibrium. We use pre-KL data to calibrate this equilibrium. After KL, the labor force has another skill distribution, with more medium-skill workers and fewer low-skill workers. In the next section, we simulate the new labor market equilibrium on the basis of possible new skill distributions using the structural parameters obtained in the calibration. Comparison of the equilibrium outcomes is informative about the equilibrium effects of KL for various worker types. We are particularly interested in the changes in outcomes for individuals who were previously low skill and currently medium skill.

A comparative statics exercise that compares two equilibria cannot be translated into a sequence of actions and reactions by individual agents. However, from the above model we can get some idea about the underlying mechanisms.[7] With more medium-skill workers, the rate at which employers contact them increases. Similarly, the rate at which low-skill workers are contacted decreases. This provides an incentive for employers to create medium-skill jobs rather than low-skill jobs. Labor demand thus adjusts to labor supply. The extent to which this occurs depends on the parameters of the model and on the assumed production technology.[8] Simultaneously, labor market tightness, the transition rates from unemployment to employment by worker-skill level, the unemployment rate,

[6]As discussed in footnote 2, we ignore any interaction between high-skill workers and the rest of the labor market.

[7]We do not solve for the transition path between equilibria. The KL changed the low- and medium-skill labor forces gradually over time, and tracing out the corresponding dynamics for low- and medium-skill vacancies and unemployment would require us to make arbitrary assumptions about the time path of changes in the labor force stocks.

[8]For example, if β is close to one, so almost all of the rent from the match goes to the worker, the vacancy mix is relatively insensitive to changes in labor force composition, and the opposite is true if β is close to zero. In terms of the production technology, one could assume, as has been done in variations on Albrecht and Vroman (2002), that medium-skill workers are more productive than low-skill workers at low-skill jobs but less productive than they would be in medium-skill jobs. See, e.g., Davidson, Matusz, and Shevchenko (2007). Changes like these would affect the quantitative, but not the qualitative, properties of the model, at least so long as the equilibrium does not switch from cross-skill matching to *ex post* segmentation.

and the wage rates by worker/job-skill combination change. Again the results depend on the model parameters and functions.

It is important to point out that we do not assume that KL has a direct effect on the individual contact rate for a given skill level in a given equilibrium. So in this sense there is no causal "job search assistance" effect on the transition rates to work. However, individuals who are treated in KL qualify for a different set of jobs in the new equilibrium. In addition, since KL affects the proportions of low-skill workers and low-skill jobs, there is an indirect effect on the transition rates to work even for individuals who do not change skill level.

4 Calibration to Pre-Program Data

4.1 Data for the calibration

The data we use for our baseline calibration are for 1996,[9] the year before the start of KL. In particular, we use data from the Swedish labor force survey (AKU) to derive unemployment, employment, and labor market flows. We use wage data from LINDA, the longitudinal individual data set with a 3 per cent sample of the Swedish population. (See Edin and Fredriksson, 2000.)

For our calibration, we use two skill levels, namely, low-skill (s_1) and medium-skill (s_2). We assume exogenous skill fractions, identifying skill with educational attainment. We take those with less education than a 3-year gymnasium degree, i.e., SUN Codes 1, 2 and 3, to be low-skill and those with a 3-year gymnasium degree (SUN Code 4) and those with less than 3 years of post-gymnasium education (SUN Code 5) to be medium-skill. AKU Tables 43 and 48 provides observations for labor force participants and unemployed aged 25-64 by SUN Codes.[10]

Unemployment

SUN Codes	1	2	3	4	5	Total
LF in 100's	4320	4544	12346	5870	5649	32729
U in 100's	398	431	996	448	249	2522
U rates	.092	.095	.081	.076	.044	.077

[9] We also calibrate the model for 1994. The results for both 1994 and 1996 are given in Appendix Table 1.

[10] SUN stands for Swedish Education Level. There are 7 SUN codes. Category 6 is 3 or more years of post-gymnasium education and category 7 is doctoral education. We assume there is no interaction between the labor markets for workers in these higher skill levels and those that we are calling medium skill. We attempted to calibrate a three-skill level model extension, but the data appeared to be inconsistent with such a model.

These imply that $p_1 = 0.648$ and $p_2 = 0.352$. In addition, the fraction of unemployment accounted for by low-skill workers γ_1 equals $\frac{398+431+996}{2522} = 0.724$ (implying that $\gamma_2 = 0.276$), and the skill-specific unemployment rates are $u_1 = 0.086$ and $u_2 = 0.060$.

We also quantify the exit rates out of unemployment for the two skill groups. For this we use AKU Table 49, giving the elapsed unemployment duration distribution by skill. Our model assumes exponential duration distributions. The exponentiality assumption helps us in two ways. We have data on elapsed, as opposed to completed, durations. The exponential assumption implies that these two distributions, i.e., of elapsed and completed durations, are the same. Second, if ξ is the median of an $\exp\{\lambda\}$ distribution, then $\lambda = \frac{\ln 2}{\xi}$, i.e., we can use the median of the elapsed duration distribution to estimate the exponential parameter. As a result, the exit rates out of unemployment for low and medium skills equal 1.867 and 2.163, respectively, in per-year terms.

Using the wage data from LINDA, we set $w_{11} = 180,000$, the median of real wages for low-skill workers, $w_{21} = 192,276$, the 40^{th} percentile real wages for workers with more than 3 years of gymnasium, and $w_{22} = 224,274$, the average of the 60^{th} and 70^{th} percentile real wages for these workers.[11] We use w_{ij} as a shorthand for $w(s_i, s_j)$.

4.2 The calibration of the pre-KL equilibrium

Since we are considering a model with 2 skill levels, there are 2 possible equilibrium configurations, namely

1. Cross-skill matching: In this equilibrium, medium-skill workers match with both medium-skill and low-skill vacancies. Low-skill workers match only with low-skill vacancies.

2. Ex-post segmentation: In this equilibrium, medium-skill workers match only with medium-skill vacancies, and low-skill workers match only with low-skill vacancies.

The large amount of variation in the wage data for medium-skill workers fits better with the first configuration. Indeed, in Appendix 2 we demonstrate that calibration of the second configuration for 1996 provides nonsensical results. We therefore base our analysis on the cross-skill matching equilibrium.

The first step in the calibration is to use the exit rates from unemployment and the steady-state conditions to identify the flow parameters, namely, $\delta_1, \delta_2, \phi_1, \phi_2$, and the contact rate, $m(\theta)$.[12] The first steady-state condition is that the flow of low-skill workers into

[11] These are annual earnings expressed in 1996 SEK.

[12] We do not have reliable data on employment duration by worker skill level. If we did, we could, of course, simply estimate δ_1 and δ_2 directly.

low-skill employment equals the flow of low-skill workers back into unemployment. This can be expressed as

$$\phi_1 m(\theta)\gamma_1 u = \delta_1 e_{11},$$

where e_{11} is the fraction of the labor force accounted for by employment of low-skill workers in low-skill jobs. Given our estimated exit rates and data on unemployment by skill level, we know the value of the left-hand side of this equation. Further, since $e_{11} = p_1 - \gamma_1 u$, we can compute the remaining unknown in this first steady-state equation, namely, δ_1. The second steady-state condition is that the flow of medium-skill workers into low-skill employment equals the corresponding flow from low-skill employment back into unemployment,

$$\phi_1 m(\theta)\gamma_2 u = \delta_1 e_{21}.$$

This condition gives us e_{21}, the fraction of the labor force accounted for by medium-skill workers employed in low-skill jobs. Next, the flow of medium-skill workers into medium-skill employment equals the corresponding flow from medium-skill employment back into unemployment. That is,

$$\phi_2 m(\theta)\gamma_2 u = \delta_2 e_{22}.$$

We know $e_{21} + e_{22}$, i.e., total employment of medium-skill workers. We know e_{21} from the second steady-state condition, so we know e_{22}. The third steady-state condition thus gives us δ_2.

Finally, we know that $\phi_1 + \phi_2 = 1$. Since we know the exit rates from unemployment for each skill group, we can recover $m(\theta)$, ϕ_1, and ϕ_2. It may be possible at this point to use the requirement that each $\phi_i \in [0, 1]$ to rule out some equilibrium possibilities.

In the second step, we set values for b and r. For our specific application, we assume that $r = 0.05$ and that $b = 83,226$, which equals 0.5 times the 30^{th} percentile real wage for the workers with less than a 3-year gymnasium degree.[13] Given the three wage equations

$$w(s_i, s_j) = \beta(s_j - c_j) + (1-\beta)rU(s_i) \text{ for } s_i \geq s_j$$

and the expression for $rU(s_1)$, we can solve for $s_1 - c_1$, $s_2 - c_2$, $rU(s_1)$, $rU(s_2)$, and β.

At this point, we need to check that the relevant conditions on these values for a cross-skill matching equilibrium type hold, namely,

$$\begin{aligned} s_1 - c_1 &\geq rU(s_2) \\ s_1 - c_1 &\geq rU(s_1) \\ s_2 - c_2 &\geq rU(s_2). \end{aligned}$$

[13]This value is a compromise between the level of unemployment benefits for low- and medium-skilled workers, the zero level of personal income for potential program participants who are not entitled to UI or welfare (e.g. because they are labor market non-participants with a working partner), and the non-pecuniary disutility of being unemployed.

If these are not satisfied then the parameters of the model are inconsistent with this type of equilibrium.

The third step of our calibration strategy is to use the zero-value conditions to recover the cost parameters and the parameters of the matching function. At this point, we need to fix two more parameters. We assume a Cobb-Douglas matching function, so $m(\theta) = A\theta^{\alpha}$, and we choose plausible values for A and α. We choose $\alpha = 0.5$, with reference to estimates from the empirical literature on matching functions (e.g., Petrongolo and Pissarides 2001). The choice of A is more arbitrary, but since we have already recovered $m(\theta)$ from the first step of our procedure, a choice of A is equivalent to choosing θ. Since the numerator of θ (i.e., the measure of vacancies) is difficult to quantify, this can be viewed as a normalization. We take $A = 5$. Finally, the zero-value conditions for the relevant equilibrium type give us c_1 and c_2. We would naturally like $c_1 < c_2$ and $s_1 < s_2$.

We now give the results, which are also given in Appendix Table 1. The exit rates from unemployment are $m(\theta)\phi_1 = 1.867$ for low-skill workers and $m(\theta)(\phi_1 + \phi_2) = m(\theta) = 2.163$ for medium-skill workers. These imply that $\phi_1 = 0.863$ and $\phi_2 = 0.137$. Putting these values into the steady-state conditions allows us to recover the job-specific exit rates, $\delta_1 = 0.176$ and $\delta_2 = 0.059$, and the skill composition of employment, $e_{11} = 0.592$, $e_{21} = 0.225$, and $e_{22} = 0.106$. Subsequently, from step 2, we have net outputs of $s_1 - c_1 = 194,920$ and $s_2 - c_2 = 272,590$. The two flow unemployment values are $rU(s_1) = 169,560$ and $rU(s_2) = 190,430$, while labor's share of the match values is $\beta = 0.412$. Note that the inequality required for cross-skill matching ($s_1 - c_1 > rU(s_2)$) is satisfied.

Finally, we solve for θ, c_1, c_2, s_1, and s_2. Given $m(\theta) = 2.163$, our choice of α and A implies $\theta = 0.187$ and $\dfrac{m(\theta)}{\theta} = 11.56$. We recover the costs and gross outputs from the zero-value conditions. These are $c_1 = 589,760$, $c_2 = 1,414,000$, $s_1 = 784,680$, and $s_2 = 1,686,590$. This solution ranks the cost and productivity parameters in the desired order.

Before turning to the simulations of KL, note that our calibration results can be used to assess the effects of upgrading the skill level of a single low-skill individual to the medium skill level. In a market with a continuum of workers the upgrading has no measurable effects on the other agents, and we restrict attention to the effects on outcomes for the individual under consideration. We may call these the "partial" effects of a skill-raising program. They do not have an empirical counterpart, but as we shall see they are helpful to understand the equilibrium effects.

For such an individual, the average wage changes from w_{11} to the mean wage among medium-skill workers ($\sum_j e_{2j} w_{2j} / \sum_j e_{2j}$), which is a real wage increase of 22,530. The average unemployment rate changes from u_1 to u_2, i.e. it decreases by 2.6 percentage points. This difference is partly due to the fact that medium-skill jobs have a much lower job separation rate than low-skill jobs, and partly due to the higher exit rate out of unemployment for medium-skill workers. Subsequently, it can be deduced that the average annual income (which is a weighted average of b and the average wage) increases by $23,688$. This exceeds the effect on the average wage, despite the fact that income in unemployment is independent of skill level. This is of course due to the dominating reduction of the average amount of time spent unemployed.

5 Simulation of KL

In our simulations, we suppose that KL reduces the proportion of low-skill workers from $p_1 = 0.648$ to 0.60 and then to 0.55. The Swedish Labor Force Survey (AKU) data for 2003 indicate $p_1 = 0.584$. The values of p_1 that we use for our simulations (0.55 and 0.60) bracket this figure. From Sections 1 and 2 and the references therein we know that well over 10% of the labor force participated in KL at some point during its existence, but this also includes some participation by high-skilled individuals and participation in courses that are conceivably not skill-enhancing. Of course, it is not clear how precisely the official figures capture the concepts of low- and medium-skill that we use in our model - this is why we simulate the KL using the two values of p_1. We keep the other structural parameters fixed at the values obtained in the last section, i.e., $r = 0.05$, $b = 83,226$, $m(\theta) = 5\theta^{.5}$, $\delta_1 = 0.176$, $\delta_2 = 0.059$, $c_1 = 589,760$, $c_2 = 1,424,000$, $s_1 = 784,680$, $s_2 = 1,686,590$. In Appendix 3, we derive the equations that must be solved for the simulation. We do this assuming that the economy stays in a cross-skill matching equilibrium. We did, however, check for the possibility of multiple equilibria by recalibrating the model for 2003, i.e., using the observed data for that year. As was the case for 1996, these data are consistent with cross-skill matching but not with ex post segmentation. The results of our simulations are given below. We first discuss the equilibrium effects on aggregate outcomes and then the equilibrium effects at the individual level.

The results suggest that a program such as KL that moves workers from low to medium skill can have important equilibrium effects. The first-order equilibrium effect comes via the equilibrium change in job composition. As the fraction of medium-skill workers in the labor force increases, the fraction of vacancies tailored towards those workers increases commensurately. In our simulations, increases in p_2 translate to a little more than one-for-one increases in ϕ_2. The measure of low-skill workers employed in low-skill jobs (e_{11}) falls by about the same amount as p_2 rises. There is a slight decrease in the measure of medium-skill workers employed in low-skill jobs (e_{21}). On the one hand, there are more medium-skill workers; on the other hand, there are fewer low-skill jobs. In our simulations, the second effect dominates slightly. Finally, the increase in the measure of medium-skill workers employed in medium-skill jobs increases by a bit more than the fraction p_2 does.

The effect of a change in skill composition on *aggregate* unemployment is small. This

Table 1: Simulation Results			
	Baseline	Simulation1	Simulation2
p_1	0.648	0.600	0.550
p_2	0.352	0.400	0.450
θ	0.187	0.176	0.167
$m(\theta)$	2.163	2.100	2.045
u	0.077	0.079	0.081
u_1	0.086	0.094	0.103
u_2	0.060	0.057	0.054
γ_1	0.724	0.712	0.698
γ_2	0.276	0.288	0.302
ϕ_1	0.863	0.807	0.750
ϕ_2	0.137	0.193	0.250
e_{11}	0.592	0.544	0.493
e_{21}	0.225	0.220	0.213
e_{22}	0.106	0.157	0.212
w_{11}	180,000	178,860	177,620
w_{21}	192,276	195,680	198,860
w_{22}	224,274	227,680	230,860
rU_1	169,560	167,610	165,500
rU_2	190,430	196,220	201,620

is partly because the change in labor market tightness is small. The fact that θ falls means that workers in general take a bit longer to locate a vacancy. However, there are important distributional effects on unemployment across the two skill categories. There are more medium-skill workers, and these workers on average find jobs more quickly and on average retain them longer than low-skill workers do. Unemployment even decreases among the fraction of medium-skill workers who have always been medium-skill, because, even though $m(\theta)$ falls slightly, there are relatively more medium-skill jobs which are on average kept longer. At the same time, the remaining low-skill workers have more difficulty finding a job than they did before the policy change. The reason is again the shift in job composition – relatively fewer low-skill vacancies are being opened (ϕ_1 falls). The fraction of unemployment accounted for by medium-skill workers, γ_2, increases simply because there are now more medium-skill workers.

There is also a clear effect on the distribution of real wages. The real wages of low-skill workers fall whereas those of medium-skill workers increase on both low- and medium-skill jobs. This reflects the change in unemployment values for the two worker types. The value of unemployment among low-skill workers falls because these workers now take longer on average to find a job; i.e., $\phi_1 m(\theta)$ decreases.[14] The value of unemployment among medium-skill workers falls with the decrease in $m(\theta)$, but this effect is more than offset by the increase in ϕ_2, i.e., the improvement in the mix of job opportunities.

One could, in principle, use our simulation results to calculate the overall costs and benefits of the KL. Net output per worker per year can be calculated as

$$(e_{11} + e_{21})(s_1 - c_1) + e_{22}(s_2 - c_2) - \phi_1 \theta u c_1 - \phi_2 \theta u c_2.$$

The first term in the above expression is output per filled low-skill job, the second is output per filled medium-skill job, the third gives vacancy creation costs for low-skill jobs, and the fourth gives vacancy creation costs for medium-skill jobs. Plugging in baseline values gives a figure of 176,947 SEK per worker; using the corresponding values from the first simulation gives a figure of 179,707 SEK per worker. That is, our more conservative simulation suggests an increase in annual net output of 2,760 SEK per worker. The increase in net output comes from the changed composition of employment – the fraction the labor force that is employed in low-skill work falls and the fraction employed in medium-skill work rises. This is offset to some extent by an increase in vacancy creation costs (mostly because ϕ_2 rises). Multiplying 2,760 SEK per worker by the total size of the low- and medium-skill labor force (3,173,200 in 2003) gives an overall gain of 8.76 billion SEK per year. This is, of course, a phenomenally large number. On the other hand, the costs of the KL were also phenomenally high. The expected cost figures in Statskontoret (1999) mentioned in Section 2 produce a total cost estimate of 21 billion SEK, while estimates

[14]The wages in Table 1 are expressed in 1996 SEK.

Table 2: Equilibrium average treatment effects if KL changes the relative measure of low skilled from 0.65 to 0.55 and that of medium skilled from 0.35 to 0.45			
outcome measure:	average wage	employment probability	average income
(a) pre-KL, low skill	180	0.914	172
(b) pre-KL, medium skill	203	0.940	195
(c) post-KL, low skill	178	0.897	168
(d) post-KL, medium skill	215	0.946	208
"partial" treatment effect on treated: b minus a	23	0.026	23
equil. change for remaining low skilled: $c-a$	–2	-0.017	-4
equil. change for remaining medium skilled: $d-b$	12	0.006	13
equil. change for treated: $d-a$	35	0.032	37
equil. treatment effect: $(d-a)-(c-a)$	37	0.049	40
Note: Monetary variables are annual averages in 1000's of 1996 SEK			

in Stenberg and Westerlund (2008) lead to total cost estimate of 27 billion SEK. But if one could quantify and include the indirect costs discussed by Björklund, et al. (2005) then total costs would be substantially higher. In short, while the above calculation is suggestive, we prefer to remain agnostic regarding an overall cost-benefit calculation.

We next consider equilibrium effects at the individual level. The top panel of Table 2 summarizes the average wage, employment, and income outcomes, before and after KL, and by skill level. These are subsequently used to quantify the changes in outcomes for those who stay low skill, those who stay medium skill, and those whose skills are upgraded, in the bottom panel of the table. For completeness we also list "partial" effects, which are analogous to results of microeconometric analyses of the effect of treatment on the treated. The last row of Table 2 gives the effects on the outcomes for the low-skill individuals whose skills are actually upgraded, by comparing them to the change in post-program outcomes of the individuals whose skills are not upgraded. These are the counterparts of the difference-in-differences and the conditional probit analysis found in the microeconometric evaluation literature.[15] They may be called the average equilibrium treatment effects on the treated.

The rows in the top panel of the table display the same ranking for each outcome measure: $c < a < b < d$. This confirms for each outcome measure that the treated gain most from the program. Those who have always been medium skill also benefit, whereas the remaining low skill suffer. Moreover, the equilibrium effects are always a factor 1.5 to 2 times larger than the "partial" effects. Again, this is because the program generates an equilibrium response of the skill distribution of vacancies towards the higher skill. In this sense, the program has a multiplier effect at the aggregate level.

To what extent do the above treatment effects agree with earlier microeconometric studies? To date, a few studies have examined the effects of adult education in Sweden on individual labor market outcomes. Several studies compare individual labor market outcomes between unemployed individuals who enroll in KL and unemployed individuals who enroll in labor market training, using propensity score matching or IV methods (see, e.g., Axelsson and Westerlund 1999 and Stenberg 2003). The results depend strongly on the outcome measure, the evaluation method, and the type of labor market training and subpopulation considered.[16] Albrecht, Van den Berg, and Vroman (2005) performs difference-in-differences and conditional probit analyses. The simulated effect on employment in the current paper is in agreement with their econometric results for young men. Our current finding that the average "partial" effect on wages is positive and bounded from above by the average equilibrium effect on wages is harder to reconcile with the corresponding econometric results that suggest that there is no significant treatment effect on the treated. However, the "post-program" year used in our earlier microeconometric analysis was 2000 and fell in the middle of the era during which KL ran. In 2000, not enough time had passed to allow the full effects of the program to come to fruition. Indeed, in 2000, individuals whose skills were upgraded may not even have had enough time to leave their post-program dip.[17] Employment effects may reveal themselves earlier than wage effects if the wage setting institutions do not allow for swift wage adjustments.[18] In a

[15]An example of this type of analysis can be found in Albrecht, Van den Berg, and Vroman (2005).

[16]For the US, Jacobson, LaLonde and Sullivan (2003) estimate the effects of adult education using a sample of displaced prime-aged workers. They find sizeable returns. However, as Björklund, et al. (2005) argue, generalizing from evidence on US adult education programs is difficult because there are so many low-skilled individuals in the US, many of whom may have had insufficient human capital investment opportunities earlier in life. Indeed the skill distribution in Sweden is more compressed than in the US (see Björklund, et al. 2005 for an exposition).

[17]Also, the sample sizes in the econometric analysis in Albrecht, Van den Berg and Vroman (2005) may have been too small to detect significant effects.

[18]Of course, the simulated equilibrium wage effects may be affected by misspecification of the equilibrium model. An equilibrium model with skill heterogeneity along the lines of Heckman, Lochner and Taber (1998), for instance, would give different results. In their model, there are no matching frictions and thus

more recent study, Stenberg and Westerlund (2008) use data for the period 1993 through 2003 and find that the annual earnings effect for participants is significantly positive if the length of stay in KL exceeds one semester.

6 The Aggregate Changes in the Swedish Labor Market from the pre-KL to post-KL (1996 to 2003)

To provide further insight into the aggregate effects of the KL program, we look at changes in the Swedish labor market from 1996 to 2003 in this section. In addition, we compare the results of our simulations with the changes that actually occurred in Sweden. We begin with two figures that summarize aggregate labor market developments for low- and medium-skill workers over this period. Figure 1 shows the time paths of w_{11}, w_{21}, and w_{22} (all expressed in 1996 SEK) over 1993-2003; Figure 2 shows the corresponding time series for u_1 and u_2. These figures indicate that cyclical considerations were not important over the 1996-2003 period. There were, however, important developments in trend. The early to mid-1990's was a particularly difficult period for the Swedish economy. Wage growth was sluggish at best, and unemployment rates were extraordinarily high relative to the rates experienced in the 1970's and 1980's. The situation began to improve in the mid-1990's. Wages began to grow again starting in 1995, and unemployment rates fell sharply starting in 1997. In short, in 1996, just before the KL began, labor market conditions had been quite bad for several years. By 2002, when the KL concluded, conditions had improved dramatically. However, unemployment rates responded slowly over this period to the improving conditions in the labor market because by the end of the recession in the early 1990's a large stock of long-term unemployed individuals had accumulated.

no unemployment. Wages are determined by equating supply and demand, so a rise in tuition subsidies for college students increases the supply of college graduates, which in turn reduces their wages. In a model like ours, an increase in the medium-skill labor force leads employers to open more medium-skill vacancies; i.e., supply can in effect create its own demand.

Table 3: Simulated vs Actual Labor Market Data				
	1996	Simulation1	Simulation2	2003
p_1	0.648	0.600	0.550	0.584
p_2	0.352	0.400	0.450	0.416
u	0.077	0.079	0.081	0.045
u_1	0.086	0.094	0.103	0.046
u_2	0.060	0.057	0.054	0.043
$\frac{1}{\phi m(\theta)}$	0.536	0.590	0.652	0.363
$\frac{1}{m(\theta)}$	0.463	0.476	0.489	0.336
γ_1	0.724	0.712	0.698	0.601
γ_2	0.276	0.288	0.302	0.399
w_{11}	180,000	178,860	177,620	211,970
w_{21}	192,276	195,680	198,860	219,939
w_{22}	224,274	227,680	230,860	261,011

The next step is to compare developments in observables with the predictions generated by our simulations. This is done in Table 3, which presents a comparison of the labor market data for 1996 and 2003 from the Swedish Labor Force Survey as well as the relevant wage figures from the LINDA Survey. In addition, we insert the model simulations reported in the previous section. These data indicate that the proportion of workers in the low-skill group fell from 0.648 in 1996 to 0.584 in 2003, which is between our simulated changes to 0.60 and 0.55. While the model predicted that labor market tightness would decline, we see that the opposite occurred in the Swedish economy. The unemployment rate fell dramatically from 0.077 to 0.045 , reflecting large decreases in expected unemployment duration for both low- and medium-skill workers. (Expected unemployment durations are $1/\phi m(\theta)$ and $1/m(\theta)$ for the two skill groups, respectively.). Of course, any comparison of simulation outcomes and post-program outcomes is hampered by external long-run trends and short-run cycles in the outcomes, as those are not incorporated into the equilibrium model. It therefore makes sense to focus on the relative ordering of effects across groups of workers. For a program that resulted in $p_1 = 0.6$, the simulations predicted that $\gamma_1 = 0.712$, $\gamma_2 = 0.288$, $u_1 = 0.094$ and $u_2 = 0.057$. In the 2003 data, we see that γ_1 fell and γ_2 rose as predicted, but the effects were much larger than in the simulations. We also see that because overall unemployment fell, the unemployment rates among both the low skilled and medium skilled fell. In contrast to the model predictions, the fall was greater among the low skilled than among the medium skilled. In any case, from the overall unemployment rate, it is clear that 2003 had a much more favorable labor market than 1996, and this complicates our assessments. With respect to wages, the simulations predicted that real wages for low-skill workers would fall. They rose, but this is likely due to an increasing trend in overall productivity.

Since ours is a steady-state model, one could argue that evaluating its forecasts over a 7-year period is not a fair test. After all, the economy was subjected to a major skill-enhancing program and may take longer to adjust. Insofar as the economy was able to adjust, our model predicts that the upgrading of the skills of a large fraction of the low-skill work force eventually (in steady-state equilibrium) would lead to an economy with more medium-skill jobs and fewer low-skill jobs. It further predicts wage increases for those who make the skill upgrade. We note in the table that the proportion of low-skill workers declined, but more detailed data indicates that this decline occurred in the lower education categories (SUN codes 1 and 2), while the highest education category in the low-skill group (SUN code 3) had an increase in labor force. This means that the low-skill workers may have had skills upgraded, but failed to leave the low-skill group making it more productive on average.

One obvious factor that is particularly important in explaining the discrepancies between our simulations and the actual changes in the Swedish labor market is the productivity growth in the Swedish economy over the period 1996 to 2003. Between 1996 and 2003, productivity for the economy as a whole grew by 19.3 percent.[19] The simulations given in Section 4 assumed that the productivity of workers remained at the 1996 level. In an effort to better explain the 2003 data, we reran the simulations incorporating the productivity change. To do this, we scaled up s_1, s_2, c_1, and c_2, all by 19.3 per cent.[20] The new simulation results are shown in Table 4.

[19] This figure is based on the data underlying the analysis presented in Fredriksson and Topel (2006). We thank Peter Fredriksson for sharing these data with us.

[20] If technical change was biased towards more highly skilled workers over this period, that would argue for more growth in s_2 than in s_1.However, as we argued above, we believe the composition of the low-skill group changed for the better. This is an argument for more growth in s_1 than in s_2.

Table 4: Simulated vs Actual Labor Market Data			
(Productivity Increase of 19.3%)			
	Simulation1	Simulation2	2003
p_1	0.600	0.550	0.584
p_2	0.400	0.450	0.416
θ	0.204	0.193	0.353
u_1	0.086	0.094	0.046
u_2	0.055	0.052	0.043
$\frac{1}{\phi m(\theta)}$	0.535	0.592	0.363
$\frac{1}{m(\theta)}$	0.442	0.456	0.336
γ_1	0.702	0.688	0.601
γ_2	0.298	0.312	0.399
w_{11}	212,700	211,110	211,970
w_{21}	231,400	235,330	219,939
w_{22}	269,590	273,520	261,011

These simulations do much better in matching the wage data, particularly for the low-skill workers. They overestimate wages for the other group, but the average of the two simulations is only 6 percent over for the medium-skill workers at low-skill jobs and only 4 percent over for medium-skill workers at medium-skill jobs. These simulations also do a bit better in the unemployment figures. They are still however far off for the unemployment rates. In retrospect, perhaps this is not so surprising. First, as the extensive literature based on Shimer (2005) suggests, models with matching frictions in which wages are determined by Nash bargaining typically do not do a good job of capturing the effects of productivity changes on vacancies and unemployment. Second, the dramatic recession in Sweden in the early 1990s led to major policy interventions that directly influenced the skill-specific unemployment rates. Before the early 1990s, the main active labor market policy program in Sweden was Labor Market Training (LMT). This is an expensive program of vocational training for unemployed workers with relatively good prospects. Usually, participation in an active labor market program was sufficient to ensure an extension of the unemployment benefits entitlement period. When unemployment rates for low-skilled workers sky-rocketed during the recession, the use of LMT exploded beyond what was thought to be effective, and as a result, a range of new programs was introduced in order to accommodate low-skilled workers and their need to be able to extend their benefits entitlement by way of program participation (see Richardson and Van den Berg, 2006, for details). When at least some of these programs work, and some of these participants are not counted as unemployed, then the unemployment rate among low-skilled workers decreases for reasons outside of our model. Finally, as we noted above, in the actual Swedish economy, the proportion of low-skill workers declined to a figure between the two simulations.[21] This decline was in part due to retirements of older, less-educated workers and entry of younger and better-educated workers rather than to the KL program. Both within and between skill groups, the composition of cohorts exiting into retirement is most likely different from the composition of new entrants. To some extent, this is captured by our correction for productivity changes during the observation window. However, a more detailed analysis is infeasible because the precise compositional changes may have been triggered by the policy that we are evaluating in the first place. In short, post-KL, the low-skill labor force was arguably "less low skilled" than it was earlier, and, perhaps, the medium-skill labor force was "more low skilled" than it was earlier. These compositional changes may go some ways towards explaining our inability to match the skill-specific unemployment rates.

7 Conclusions

Our theoretical analysis of an equilibrium search model with heterogeneity, together with the calibration of the model and the simulation of the policy change, provide some interesting insights into the equilibrium effects of the knowledge lift program. Most notably, according to the model, the program should generate an equilibrium change in the skill distribution of vacancies towards higher skills. In our simulations, as the fraction of medium-skill workers in the labor force increases at the expense of the fraction of low-skill workers, the fraction of vacancies tailored towards the medium-skill workers increases commensurately, almost one-for-one. This change in vacancy composition leads to corresponding changes in the skill-specific unemployment rates and in the wages paid to low- and medium-skill workers, for the latter on both low- and medium-skill jobs.

Our simulations suggest substantial equilibrium effects. Will the knowledge lift program have such large effects in the long run? This is of course difficult to assess. In the short run, i.e., by 2003, we see substantial changes in unemployment for the low- versus middle-skill workers in Sweden. Should these be attributed to KL? Rather than make large claims for our model, we would rather argue that such macroeconomic analysis focuses attention on effects beyond the impacts on those directly enrolled in the training program.

Indeed, we view this point as a major contribution of our paper. Our approach establishes a link between, on the one hand, the microeconometric literature on the evaluation of treatments for unemployed workers, and, on the other, the macroeconomic literature on

[21] In fact, the total size of the labor force in the low- and medium-skill categories declined between 1996 and 2003 from 3,272,900.to 3,173,200 (by more than 3 percent).

the implications of productivity change and changes in the skill distribution. Our analysis incorporates equilibrium effects of large-scale programs on typical microeconometric outcomes such as wages, employment status and income. We show how the effect on an individual's outcome relates to a partial treatment effect and to equilibrium effects on the untreated and on the treated. For each outcome measure, the treated gain most from the program. Those who have always been medium skill also benefit, whereas those who remain low skill suffer. Our simulations suggest that the equilibrium effects are always a factor 1.5 to 2 times larger than the "partial" effects. For large programs such as KL, this perspective is an important one to keep in mind, and we believe that models such as ours are useful in pointing this out.

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Appendix

Appendix 1. Calibration Results

Table A1: Calibration Results		
	1996	1994
p_1	0.648	0.653
p_2	0.352	0.347
θ	0.187	0.203
$m(\theta)$	2.163	2.252
u	0.077	0.074
u_1	0.086	0.083
u_2	0.060	0.056
γ_1	0.724	0.738
γ_2	0.276	0.262
ϕ_1	0.863	0.822
ϕ_2	0.137	0.178
δ_1	0.176	0.169
δ_2	0.059	0.067
e_{11}	0.592	0.598
e_{21}	0.225	0.212
e_{22}	0.106	0.116
$real\ w_{11}$	180,000	169,739
$real\ w_{21}$	192,276	184,437
$real\ w_{22}$	224,274	214,655
β	0.412	0.391
$s_1 - c_1$	194,920	184,730
$s_2 - c_2$	272,590	262,010
$rU(s_1)$	169,560	160,110
$rU(s_2)$	190,430	184,250
c_1	589,760	564,690
c_2	1,414,000	1,177,2000
s_1	784,680	749,420
s_2	1,686,590	1,439,210

Appendix 2. Calibration of the ex post segmentation equilibrium

In an ex post segmentation equilibrium, there is no steady-state condition for the flows of medium-skill workers in and out of low-skill jobs. We therefore must specify a value for one more parameter and so we assume that $\beta = 0.5$. In this case, the inequalities on $U(s_i)$ are

$$\begin{aligned} s_1 - c_1 &< rU(s_2) \\ s_1 - c_1 &\geq rU(s_1) \\ s_2 - c_2 &\geq rU(s_2). \end{aligned}$$

We assume that $w_{11} = 180,000$, the median real wage for the low-skill workers and $w_{22} = 202,920$, the median wage for the medium-skill workers. The first two steps of the calibration yield

$m(\theta)\phi_1$	1.867
$m(\theta)\phi_2$	2.163
$m(\theta)$	4.030
ϕ_1	0.463
ϕ_2	0.537
δ_1	0.176
δ_2	0.139
e_{11}	0.592
e_{22}	0.331
$s_1 - c_1$	190,450
$s_2 - c_2$	212,580
$rU(s_1)$	169,550
$rU(s_2)$	193,340

Note that $s_1 - c_1 < rU(s_2)$, which is consistent with ex post segmentation.

Finally, in this case, $\theta = .65$ and $\dfrac{m(\theta)}{\theta} = 6.20$, and the zero-value conditions imply

c_1	207,670
c_2	87,509
s_1	398,120
s_2	300,089

Clearly, the cost and productivity parameters are in the wrong order.

Appendix 3. Simulation equations

The two steady-state equations equate the flows into and out of unemployment for each of the skill levels. These two equations can be written as

$$\phi_1 m(\theta)\gamma_1 u = \delta_1(p_1 - \gamma_1 u)$$

$$m(\theta)\gamma_2 u(\frac{\phi_1}{\delta_1} + \frac{\phi_2}{\delta_2}) = p_2 - \gamma_2 u.$$

In the cross-skill matching equilibrium, the two unemployment values are

$$rU(s_1) = \frac{bR_1 + m(\theta)\phi_1\beta S_1}{R_1 + m(\theta)\phi_1\beta}$$

$$rU(s_2) = \frac{bR_1R_2 + \beta m(\theta)[\phi_1 R_2 S_1 + \phi_2 R_1 S_2]}{R_1R_2 + \beta m(\theta)(\phi_1 R_2 + \phi_2 R_1)},$$

where $S_1 = s_1 - c_1$, and $S_2 = s_2 - c_2$, $R_1 = r + \delta_1$, and $R_2 = r + \delta_2$.

The zero vacancy value equations for this equilibrium type are

$$rV(s_1) = -c_1 + \frac{m(\theta)}{\theta}\{\gamma_1[\frac{(1-\beta)[S_1 - rU(s_1)]}{R_1} - V(s_1)] + \gamma_2[\frac{(1-\beta)[S_1 - rU(s_2)]}{R_1} - V(s_1)]\}$$

$$rV(s_2) = -c_2 + \frac{m(\theta)\gamma_2}{\theta}[\frac{[(1-\beta)S_2 - rU(s_2)]}{R_2} - V(s_2)].$$

Setting $V(s_1) = V(s_2) = 0$ and substituting for the unemployment values gives

$$\frac{c_1 R_1 \theta}{(1-\beta)m(\theta)} = \frac{\gamma_1(S_1 - b)R_1}{R_1 + m(\theta)\phi_1\beta} + \gamma_2(\frac{(S_1 - b)R_1R_2 + \beta m(\theta)\phi_2 R_1(S_1 - S_2)}{R_1R_2 + \beta m(\theta)(\phi_1 R_2 + \phi_2 R_1)})$$

$$\frac{c_2 R_2 \theta}{(1-\beta)m(\theta)} = \gamma_2[\frac{(S_2 - b)R_1R_2 + \beta m(\theta)\phi_1 R_2(S_2 - S_1)}{R_1R_2 + \beta m(\theta)(\phi_1 R_2 + \phi_2 R_1)}].$$

These two equations, along with the two steady-state equations, are the equations that must be solved for the equilibrium. After solving for the equilibrium, the wages can be found by using the wage equations

$$\begin{aligned} w(s_1, s_1) &= \beta S_1 + (1-\beta)rU(s_1) \\ w(s_2, s_1) &= \beta S_1 + (1-\beta)rU(s_2) \\ w(s_2, s_2) &= \beta S_2 + (1-\beta)rU(s_2). \end{aligned}$$

Figure 1: Real Wages

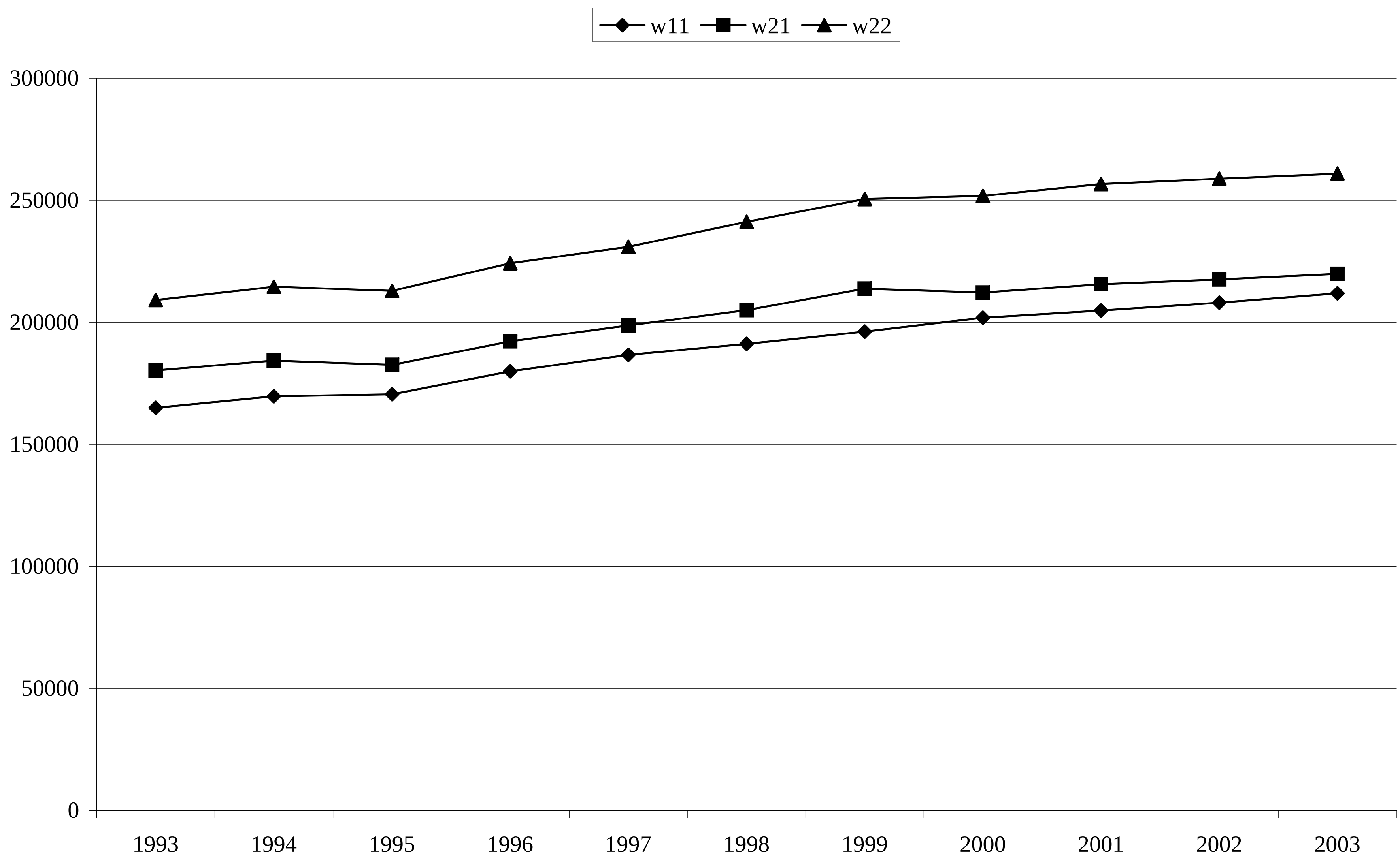

Figure 2: Unemployment Rates