# Offshoring and Occupational Specificity of Human Capital

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## Abstract

This paper develops a dynamic general equilibrium model in which workers acquire human capital specific to the task they complete. The dynamic nature of the model allows for differentiation between short and long run effects of offshoring on productivity and labour market outcomes. The welfare effects of increased offshoring are unambiguously positive; their magnitude depends on the difference between autarky and world relative prices, but not on the skill-content of offshored and inshored tasks. For reasonable terms of trade, the steady state welfare gains are found to be between 1.8% and 4% in the calibrated model. The distribution of the gains from trade critically depends on the time horizon: in the short term, workers with human capital specific to the inshored occupations gain, while workers with human capital specific to the offshored occupations lose. In the long run, the gains from trade are equally distributed among ex-ante identical agents.

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# 1.   Introduction

Technological progress has led to considerable changes in the organization of the production process – tasks traditionally completed in close physical proximity can now be spatially separated and carried out independently, thus spurring offshoring of intermediate processes or tasks. Differently from past trade experiences, "trade in tasks"[1] affects not only manufacturing but also high-skill service occupations.[2] This has spurred a debate between two opposing viewpoints, one of which focuses on the long term gains and maintains that offshoring is productivity-enhancing. The other outlook stresses potential short term losses and warns about the disruptive effects of offshoring of high skill tasks.

Previous work evaluating claims of either side of the debate has relied mainly on static models to address the impact of offshoring on productivity and wages and consequently could not jointly evaluate both short term as well as the long term impacts and the transition between the two. This paper ascertains that using a dynamic model in which workers accumulate specific human capital is imperative for assessing the potential devaluation of human capital due to offshoring of high skill tasks and for quantifying the magnitude of its short and long term effects on aggregate productivity and wages.

Differentiating between specific and general human capital is particularly relevant in the context of worker reallocation due to high-skill offshoring.[3] Were reallocated workers' human capital mostly general, their loss in productivity would likely be small as they would be able to apply most of their knowledge to the new task. However, if workers who are exposed to increased offshoring have relatively more occupation specific human capital, switching occupations may cause a significant loss in workers' productivity and wages. Motivated by this observation, I develop a dynamic general equilibrium model in which workers acquire human capital specific to the task they are completing.

Different occupations are modeled as islands as in Lucas and Prescott (1974); workers choose

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[1]Grossman and Rossi-Hansberg (2008) coined this term for the fragmented global production process.

[2]In the context of trade in tasks, an occupation is the relevant labour market counterpart; a task is the output of an occupation.

[3]See section 3.1. for evidence on the skill-content of tradeable service occupations.

an occupation to which to apply and enter the occupation with some probability or else remain unemployed. The model developed in this paper features four sources of heterogeneity in workers: educational attainment, level of occupation specific human capital,[4] a match-specific productivity draw, and labour market status. This structure allows the model not only to evaluate aggregate welfare effects, but also distributional effects. First, the fraction of educated workers is fixed, which allows for an assessment of the possible distributional effects arising from a skill bias in trade.[5] Second, the distribution of specific human capital is endogenous, which generates short run distributional effects which differ from the long run effects. Third, since the distribution of specific human capital is endogenous and its accumulation is explicitly modelled, the transition from short to long run can be evaluated using the calibrated model. Lastly, labour market frictions generate unemployment in equilibrium.

Expanding the set of tasks that can be traded triggers a reallocation of workers out of offshored and into inshored occupations, causing a loss of specific human capital. Both the increase in unemployment during the reallocation process and the loss of human capital have a negative impact on aggregate productivity. At the same time, increased trade allows the economy to exploit its comparative advantage and so generates a positive productivity effect. In the short run, the total effect depends on the relative magnitude of the negative reallocation and the positive comparative advantage effects. In the long run, workers reacquire human capital and unemployment falls to its pre-trade level, so the positive productivity effect prevails.

The magnitude of the aggregate productivity effect depends on differences between autarky and world relative prices (i.e. the comparative advantage), but not on the skill-content of offshored and inshored tasks. For reasonable terms of trade, the steady state gains of increased offshoring are found to be between 1.8% and 4%, with 2% in the most likely scenario. Yet, workers differ in their specific human capital and match-specific productivity, so increased trade does have short-run distributional effects. Moving from a state of no trade in services to a new

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[4]For brevity, "specific human capital" in the present environment always denotes occupation specific human capital.

[5]The fraction of educated workers need not to be fixed; as long as workers differ in their cost of acquiring an education, distributional effects may arise.

trade equilibrium in which high skill service tasks are also tradable, workers employed in import-competing occupations see their incomes reduced, while workers employed in exported tasks see their incomes increase. In the same simulation as above, the life-time expected utility of a worker with human capital specific to the offshored occupation falls by 3.1%, while the life-time expected utility of a worker with human capital specific to the inshored occupation increases by 3%. This change in the relative values between occupations causes workers to switch to the exporting sector. Because of labour market frictions, unemployment increases temporarily and switching of skilled workers also leads to a loss in specific human capital. Over time, reallocated agents attain specific human capital anew, which eliminates most of the distributional effects of reallocation. In the long run, the gains from trade will be shared by all agents through the competitive nature of the labour market.

The environment most similar to that in this paper is Kambourov (2009), who assesses the impact of labour market rigidities on the success of trade reforms and calibrates the model to the Chilean and Mexican trade liberalizations.[6] As the goal of the present paper is to examine the impact of task offshoring on the U.S. economy, the model used here adds substantial worker heterogeneity to capture important features of the U.S. labour market. On the other hand, labour market frictions are modelled much more parsimoniously. An alternative approach to study the dynamic nature of the reallocation of workers is presented in Cameron et al. (2007), who develop a model with moving costs for workers; their model is estimated and the distributional effects of a trade reform are studied in Artuc et al. (2007). Also, earlier work on the dynamics of adjustment after a trade shock includes Mussa (1978) and Matsuyama (1992).

This paper also touches on a variety of other literatures: Grossman and Rossi-Hansberg (2008) provide a setting in which to consider fragmentation ("trade in tasks") and show that offshoring can generate shared gains for all factors of production. They, however, make the assumption of full employment. This assumption is relaxed in Mitra and Ranjan (2007), who demonstrate that in an environment with search frictions offshoring can both increase wages

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[6]A similar environment with occupation specific human capital is also used in Kambourov and Manovskii (2008a), who investigate the impact of an increase in occupational mobility on wage inequality.

and lower unemployment if labour is mobile between sectors. On the empirical side, Amiti and Wei (2006) and Liu and Trefler (2008) have studied employment consequences for offshore outsourcing in services and found the employment effect is (still) small. Using Swedish data, Ekholm and Hakkala (2006) find a small negative effect for workers with intermediate levels of education.

Also closely related to this paper is the recent literature that incorporates search models of the labour market into trade models.[7] These frictions give rise to equilibrium unemployment, which allows a consideration of the impact of trade on employment and of the distributional consequences of trade beyond a skill premium. Davidson et al. (2008a, 2008b) suggest a model in which heterogeneous firms and workers match in a frictional labour market as in Albrecht and Vroman (2002). In particular, Davidson et al. (2008b) study the impact of offshoring of high skill employment on labour market outcomes and show that low skilled workers may benefit from high skill offshoring. Helpman and Itskhoki (2009) and Helpman et al. (2009) study models in which ex-ante identical workers are matched with heterogonous firms and investigate the relationship between labour market frictions and comparative advantage, unemployment, and inequality.

This paper differs from the aforementioned literature in two important ways. While previous work on trade and the labour market was mostly static in nature and typically either studied the short or the long run, this paper explicitly focuses on the dynamic nature of factor accumulation and the redistribution of workers across occupations and skill levels. Furthermore, the goal of this paper is to provide a model whose labour market structure captures key features in the data – a model which can be calibrated to quantify the impact of trade in tasks on key labour market outcomes. As such, it does not aim to explain the actual pattern of trade, but rather takes it as given.

The remainder of the paper is structured as follows: Section 2. presents a model in which the distribution of workers across occupations and skill levels is endogenous. Section 3.1. presents evidence on the skill-content of newly tradable service occupations and the model is calibrated

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[7]This literature goes back to Davidson et al. (1999).

and several quantitative exercises are undertaken in section 3.2.; section 4. concludes.

## 2. A Model of Trade in Tasks with Specific Human Capital

In this section, I present a model of trade in tasks (intermediate goods) which incorporates workers' specific human capital. As a key feature of the model, the distribution of specific human is not exogenously fixed, but rather arises endogenously as agents choose which task to produce and for which to acquire specific human capital. Every period, workers may switch occupations and forego their current specific human capital, while over time acquiring it again for the new task. Consequently, the distribution of workers across occupations and levels of specific human capital responds to shocks the economy experiences, such as technological progress and trade.

### 2.1. The Environment

The economy is populated by a measure 1 of risk-free, infinitely lived agents (workers). Thus, the agent maximizes

$$\sum_{t=0}^{\infty} \beta^t c_t \,,$$

where $c_t$ is the consumption of the final good in period $t$ and $\beta < 1$ is the time discount factor.

The final consumption good $Y$ is a CES-aggregate of $N$ distinct tasks:

$$Y = \left[ \sum_{i=1}^{N} \kappa_i y_i^{\rho} \right]^{\frac{1}{\rho}} \,,$$

where $\kappa_i$ is a share parameter for each task.

For each task, there is a large number of producers, so both input and output market are competitive. Labour is the only variable input in the production; there is a also fixed factor for each task to which each agent holds an equal share. The fixed factor is implied by the decreasing returns technology, which is needed to asure that occupation task will have a positive mass of

workers. The representative task producer's technology is given by:

$$y_i(z, l) = z_i(l_i)^\alpha \quad, \alpha < 1,$$

where $z_i$ is a time-invariant task-specific productivity parameter and $l_i$ is the total effective labour employed in the occupation.

**Human Capital**

Ex ante, agents differ only by their general human capital, the level of education; a fraction $E$ has high education and a fraction $(1 - E)$ low education. Highly educated workers can be employed in any occupation, while low educated workers can only be employed in some. After entering an occupation, there are two additional sources of heterogeneity between agents. First, upon entering, agents draw their worker-occupation specific productivity $\theta$ from some distribution $F_i(\theta)$; a worker provides $\theta$ units of productive time each period. Second, agents differ by their level of specific human capital. In each occupation, there are two skill-types of workers, those with acquired specific human capital (skilled workers) and those still unskilled. At the end of each period (except the first one) the worker may acquire the specific human capital necessary to become a high skill worker; the arrival rate of the skill shock for an unskilled worker is $\gamma$.[8]

After becoming skilled, a worker remains skilled until she leaves the sector. This captures the human capital that is specific to the occupation. The increase in productivity upon becoming skilled varies between occupations, but within an occupation all agents experience the same relative increase in their productivity. While an unskilled worker has $\theta$ units of productive time each period, a skilled worker has $a_i\theta$, $a_i > 1$. A worker can either choose to leave the occupation or she can get separated exogenously at rate $\pi$; however, it is assumed that at the end of her the first period in the occupation the worker will not get separated.

At the beginning of each period, an employed worker decides whether to stay in the current

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[8]For the purposes of this paper, an unskilled worker is a worker without *specific* human capital, whereas a non-educated worker is one with low education. The occupations that employ (high) educated workers are referred to as "high education" occupations. Incidentally, in the data, these are also the occupations in which workers acquire the most specific human capital.

occupation and keep the current productivity draw $\theta$ or become unemployed and search for a new offer (i.e. try to sample a new productivity draw). There is no time gap between quitting and searching; a worker who elects to leave her occupation begins searching in the same period. An unemployed worker chooses the sector to which to apply and with probability $(1 - \epsilon)$ receives an offer $\theta$.[9] A worker who receives a productivity draw remains in the occupation for the current period before deciding whether or not to search again. For an educated worker, the application process consists of 2 stages. First, an educated worker applies to a high education occupation; if she receives an offer, the search has ended. However, if she does not receive an offer, she applies to a low education occupation. This structure captures the empirical observation that many college graduates start their career in a non-college occupation but stay there only for a short period of time (see Figure 2.1). The non-educated and unskilled worker's problem is summarized in Figure 2.2, the educated and unskilled worker's problem is summarized in Figure 2.3.

This structure generates a rich pattern of heterogeneity and allows the model to capture key features of the data, beyond the already discussed specific human capital. This is to address three key concerns regarding the distribution of the gains from trade. The partition between educated and non-educated generates an education premium which is potentially affected by structural changes. Because of the match-specific productivity draw it takes time for workers to find a "good match". It also introduces residual income inequality, which has been argued to be affected by increased trade, a claim that can be investigated using this model.

The labour market friction generates unemployment, both along the transition path and in equilibrium.

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[9]While there is evidence that workers do not always start working in the occupation they are seeking in their search process, the longer the time frame, the more likely it is they arrive in an occupation they are targeting. Furthermore, I am interested in the worker relocation resulting from a large, permanent shock and it is more likely agents will specifically target occupations with a positive shock and avoid those with a negative one; in the steady state, agents are indifferent between all occupations, so they would be willing to apply for positions in any occupation; only along the transition path is the assumption of directed search critical.

### 2.1.1. The Agent's Problem

**a. Non-Educated Workers**

The value of being an unskilled worker in occupation $i$ with productivity shock $\theta$ at the beginning of a period is given by:

$$V_i^u(\theta, \Sigma) \quad = \quad \max\{J_i^u(\theta, \Sigma); U(\Sigma)\}, \tag{1}$$

where

$$J_i^u(\theta, \Sigma) \quad = \quad \theta w_i(\Sigma) + \beta(1-\pi)\left((1-\gamma_i)V_i^u(\theta, \Sigma') + \gamma_i V_i^s(\theta, \Sigma')\right) + \beta\pi U(\Sigma') \tag{2}$$

is the value of staying in occupation $i$ for an unskilled worker,

$$U(\Sigma) \quad = \quad \max_i \left\{(1-\epsilon_i)E_\theta\left(J_i^1(\theta, \Sigma)\right) + \epsilon_i\beta U(\Sigma')\right\} \tag{3}$$

is the value of being unemployed, and

$$J_i^1(\theta, \Sigma) \quad = \quad \theta w_i(\Sigma) + \beta V_i^u(\theta, \Sigma') \tag{4}$$

is the value of entering the occupation $i$ with draw $\theta$. $w_i$ denotes the real wage per effective unit of labour in occupation $i$, so the worker's income is $\theta w_i$. Wages are determined competitively and agents therefore take them as given. $\Sigma(\theta) = (\sigma_1^u(\theta), \sigma_2^u(\theta)..., \sigma_1^s(\theta), \sigma_2^s(\theta)...)$ denotes the distribution of workers across sectors and productivities at the beginning of the period. $E_\theta$ denotes the expectation operator over the possible draws of the productivity shock $\theta$.

Similarly, the value of being a skilled worker in occupation $i$ with productivity $\theta$ at the beginning of a period is given by:

$$V_i^s(\theta, \Sigma) \quad = \quad \max\{J_i^s(\theta, \Sigma); U(\Sigma)\}, \tag{5}$$

$$\text{with} \quad J_i^s(\theta, \Sigma) \quad = \quad \theta a_i w_i(\Sigma) + \beta(1-\pi)V_i^s(\theta, \Sigma') + \beta\pi U(\Sigma'). \tag{6}$$

Search is directed, so any occupation that wishes to attract applicants must offer them the same expected value, so

$$\overline{U}(\Sigma) \geq (1 - \epsilon_i) E_\theta \left( J_i^1(\theta, \Sigma) \right) + \epsilon_i \beta \overline{U}(\Sigma'). \tag{7}$$

If the value of applying to occupation $i$ is less than for other occupations, i.e. (7) is not satisfied as equality for occupation $i$, no worker will apply and employment will shrink due to the exogenous separation and possible quitting. However, due to a decreasing returns technology, every sector will have a positive mass of workers and (7) will eventually be satisfied with equality for all occupations.

Workers are identical, so it is natural to assume that all follow the same application strategy. However, this implies that if one worker applies to an occupation with probability 1, all workers would apply to this one occupation and employment in that occupation would increase drastically while it decreases in all the others. Since wages are determined competitively, (7) would be violated. Therefore, in equilibrium, workers must use a mixed strategy and apply to each occupation with some probability. Let $g^A(\Sigma)$ denote the policy function describing this optimal application strategy and $A(\Sigma)$ the total number of applicants; then $A_i(\Sigma) = g_i^A(\Sigma)A(\Sigma)$ is the number of applicants for occupation $i$.

Since each worker takes the value of search, $\overline{U}(\Sigma)$, and the future values $V^u$ and $V^s$ as given, the workers optimal quitting decison can be described by a simple reservation productivity strategy: if the productivity draw exceeds the reservation level, the worker remains in the occupation, otherwise the worker leaves and searches for a better match. These reservation productivity levels $(\hat{\theta}^u, \hat{\theta}^s)$ satisfy

$$J_i^u(\hat{\theta}_i^u, \Sigma) = \overline{U}(\Sigma), \text{ and} \tag{8}$$

$$J_i^s(\hat{\theta}_i^s, \Sigma) = \overline{U}(\Sigma). \tag{9}$$

Let $g^u(\theta, \Sigma)$ denote the policy function for unskilled workers describing the optimal quitting de-

cisions, with the convention $g_i^u(\theta, \Sigma) = 1$ if $\theta \geq \hat{\theta}_i^u$. Similarly, $g^s(\theta, \Sigma)$ denotes the policy function for skilled workers. In a stationary equilibrium (see below), two types of workers will be employed in each occupation – temporary and permanent. Temporary workers are those who entered at the beginning of the current period, received a low draw and will search again in the next period, while permanent workers will remain and only leave after an exogenous separation. As a result, in a stationary environment, skilled workers are always permanent workers.

### b. Educated Workers

A fraction $E$ of all workers are educated. Only educated workers can apply to high education occupations. Furthermore, if an educated worker is employed in a low education occupation she is more productive than a non-educated worker conditional on the occupation-specific productivity draw. An educated worker employed in a low education occupation provides $a_c\theta$ efficiency units of labour if she is unskilled and $a_c a_i \theta$ if she is skilled, where $a_c > 1$ is the relative productivity of an educated to a non-educated worker who is otherwise identical. Alternatively, one can view the educated worker as drawing from a distribution whose mean is shifted by $a_c$ relative to non-educated workers. For notational convenience, I will adopt this convention – $E_\theta^E = a_c E_\theta$ in low education occupations.[10]

The value of being unemployed for an educated worker is given by

$$U^E(\Sigma) = \max_{h \in H} \left\{ (1 - \epsilon_h) E_\theta \left( J_h^1(\theta, \Sigma) \right) + \epsilon_h \max_{l \in L} \left\{ (1 - \epsilon_l) E_\theta^E \left( J_l^{E,1}(\theta, \Sigma) \right) + \epsilon_l \beta U(\Sigma') \right\} \right\} \quad (10)$$

where $H$ is the set of high education occupations to which the worker applies first and $L$ is the set of low education occupations to which the worker applies if she fails to secure an offer in a high education occupation. Using the same notation as for non-educated workers, $J_h^{E,1}$ and $J_l^{E,1}$ denote the value of entering high and low education occupations, respectively.

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[10]A superscript $E$ denotes educated, while no superscript denotes non-educated.

Then,

$$J_i^{E,1}(\theta, \Sigma) = \theta w_i(\Sigma) + \beta V_i^{E,u}(\theta, \Sigma'), \tag{11}$$

$$\text{with} \quad V_i^{E,u}(\theta, \Sigma') = \max\left\{J_i^{E,u}(\theta, \Sigma); U^E(\Sigma)\right\}, \tag{12}$$

$$\text{and} \quad J_i^{E,u}(\theta, \Sigma) = \theta w_i(\Sigma) + \beta(1-\pi)\left((1-\gamma_l)V_i^{E,u}(\theta, \Sigma') + \gamma_i V_i^{E,s}(\theta, \Sigma')\right) + \beta\pi U^E(\Sigma') \tag{13}$$

After entering a sector and drawing the specific productivity shock, the only difference be-
tween an educated and non-educated worker is the continuation value in case of separation.
As a result, the reservation productivity level for educated and non-educated workers differ; the
reservation productivity levels $(\hat{\theta}^{E,u}, \hat{\theta}^{E,s})$ for the educated satisfy:

$$J_i^{E,u}(\hat{\theta}_i^{E,u}, \Sigma) = \overline{U}^E(\Sigma), \tag{14}$$

$$J_i^{E,s}(\hat{\theta}_i^{E,s}, \Sigma) = \overline{U}^E(\Sigma). \tag{15}$$

Let $g^{E,u}(\theta, \Sigma), g^{E,s}(\theta, \Sigma)$ denote the resulting policy functions.

Again, due to the directed nature of the search process, any high education occupation which
attracts a positive number of applicants must offer at least $\overline{U}^E(\Sigma)$. This condition applies to high
education occupations only; low education occupations which attract non-educated applicants
satisfy (7). Since the productivity premium for educated workers, $a_c$ is the same across occupa-
tions and educated and non-educated workers only differ by this constant, (7) also assures that
the educated are indifferent between all low-education occupations in the second stage. Since
educated agents are indifferent between occupations, I assume they follow the same application
strategy as the non-educated in low education occupations in the second stage.

**c. Labour Supply**

Let $g^{E,A}(\Sigma)$ denote the policy function describing the optimal application strategy for educated
workers and $A_H^E(\Sigma)$ the total number of educated applicants to high skill occupations. Then the

total number of educated agents applying to low skill occupations is $A_L^E(\Sigma) = \epsilon_h A_H^E(\Sigma)$.

Total labour supply in each occupation is total productive time available in the occupation,

$$
\begin{aligned}
l_i^s = \quad & a_i \int_\theta \theta \, g^s(\theta, \Sigma) \, d\sigma_i^s(\theta) + \int_\theta \theta \, g^u(\theta, \Sigma) \, d\sigma_i^u(\theta) + (1 - \epsilon_i) A_i \int_\theta \theta \, dF_i(\theta) \\
& + a_i \int_\theta \theta \, g^{E,u}(\theta, \Sigma) \, d\sigma_i^{E,s}(\theta) + \int_\theta \theta \, g^{E,u}(\theta, \Sigma) \, d\sigma_i^{E,u}(\theta) + (1 - \epsilon_i) A_i^E \int_\theta \theta \, dF_i^E(\theta).
\end{aligned}
\tag{16}
$$

Recall that $\Sigma(\theta) = (\sigma_1^u(\theta), \sigma_2^u(\theta)..., \sigma_1^s(\theta), \sigma_2^s(\theta)...)$ denotes the distribution of workers across sectors and productivities at the beginning of the period and $g_i^j(\theta, \Sigma)$, $j = u, s$ denotes the policy function indicating whether the worker with draw $\theta$ stayed or quit the occupation in the current period.

Finally, the resulting law of motion for the distribution of workers are given by

$$
\sigma_i^{s'} = (1 - \pi) \left( g^s(\theta, \Sigma) \, \sigma_i^s + \gamma_i \, g^u(\theta, \Sigma) \, \sigma_i^u \right),
\tag{17}
$$

$$
\sigma_i^{u'} = (1 - \pi)(1 - \gamma_i) \, g^u(\theta, \Sigma) \, \sigma_i^u + (1 - \epsilon_i) A_i(\Sigma),
\tag{18}
$$

$$
\sigma_i^{E,s'} = (1 - \pi) \left( g^{E,s}(\theta, \Sigma) \, \sigma_i^{E,s} + \gamma_i \, g^{E,u}(\theta, \Sigma) \, \sigma_i^{E,u} \right), \text{ and}
\tag{19}
$$

$$
\sigma_i^{E,u'} = (1 - \pi)(1 - \gamma_i) \, g^{E,u}(\theta, \Sigma) \, \sigma_i^u + (1 - \epsilon_i) A_i^E(\Sigma),
\tag{20}
$$

where the prime denotes the beginning of next period's element.

### 2.1.2. The Producer's Problem

The Producer's problem in this environment is a simple static problem. Let $p_i$ denote the price of each task in terms of the numeraire good; then the demand for each task is given by

$$
y_i^d = \left( \frac{\kappa_i P}{p_i} \right)^{\frac{1}{1-\rho}} Y,
\tag{21}
$$

$$
\text{where } P = \left( \sum_{i=1}^N p_i^{\frac{-\rho}{1-\rho}} \kappa_i^{\frac{1}{1-\rho}} \right)^{\frac{\rho-1}{\rho}}.
\tag{22}
$$

where $P$, the price index for the final good, follows from the zero-profit condition for the final

good's producer.

Labour markets in each occupation are competitive, so the real wage per effective unit of labour is the value of the marginal product in terms of the numeraire good:

$$w_i = p_i \, \alpha z_i \, (l_i)^{\alpha-1} \,, \tag{23}$$

where $p_i$ is the price of each task in terms of the numeraire good. As normalization, let $w_1 = 1$.

## 2.2. Stationary Equilibrium

Before studying the impact of increased trade in this environment, it is instructive to study the stationary equilibrium first. A stationary equilibrium is characterized by a time-invariant distribution of workers across skill levels and occupations, i.e. $\Sigma' = \Sigma$. First, notice that in a stationary environment the critical level of the match specific productivity is constant. As a result, a worker either quits after the first period, or stays with the occupation until the match is exogenously separated. Further, recall that an unskilled worker's income is $\theta w$, and that the wage paid per effective unit of labour is a constant, determined in a competitive market. Consequently, one can regard the productivity draw as an income draw as well: in a stationary environment the model reduces to a variant of the stochastic job matching model with a constant matching rate.

### a. Non-Educated Workers

Using the fact that a skilled worker never quits in a stationary equilibrium, the steady state value of being a skilled worker in occupation $i$ with shock $\theta$ is given by

$$J_i^s(\theta, \Sigma) = \frac{a_i \theta w_i}{1 - \beta(1-\pi)} + \frac{\beta\pi}{1 - \beta(1-\pi)} \overline{U}(\Sigma); \tag{24}$$

similarly, for an inexperienced worker in occupation $i$, it is as follows:

$$J_i^u(\theta, \Sigma) = w_i \frac{1 - \beta(1-\pi)(1 - \gamma_i a_i)}{(1 - \beta(1-\pi))(1 - \beta(1-\pi)(1 - \gamma_i))} + \frac{\beta\pi}{(1 - \beta(1-\pi))} \overline{U}(\Sigma). \tag{25}$$

Here, $\overline{U}(\Sigma)$ denotes the value of searching.

Substituting (4) into (3) and using the optimal reservation productivity strategy, the value of applying at any occupation $i$ can be written as

$$U_i(\Sigma) = \overline{U}(\Sigma) = \frac{(1-\epsilon)}{1-\beta\epsilon}\left[E_{\theta,i}w_i + \beta\left(F_i(\hat{\theta}_i) + \int_{\hat{\theta}_i}^{\bar{\theta}} J_i^u(\theta,\Sigma)dF_i(\theta)\right)\right]. \tag{26}$$

Using (25), the condition for the reservation productivity level (8) can be rearranged to yield

$$\hat{\theta}_i w_i = (1-\beta)\overline{U}(\Sigma)\frac{1-\beta(1-\pi)(1-\gamma_i)}{1-\beta(1-\pi)(1-\gamma_i a_i)}. \tag{27}$$

Lastly, after substituting (25) into (26), the fundamental reservation productivity equation can be obtained:

$$\hat{\theta}_i = (1-\epsilon_i)\left[E_{\theta,i}(\theta)\frac{1-\beta(1-\pi)(1-\gamma_i)}{1-\beta(1-\pi)(1-\gamma_i a_i)} + \frac{\beta(1-\pi)}{1-\beta(1-\pi)}\int_{\hat{\theta}_i}^{\bar{\theta}}(\theta-\hat{\theta}_i)dF_i(\theta)\right]. \tag{28}$$

First, note that the reservation productivity level is independent of the wage rate. In a stationary equilibrium, each occupation offers a time-invariant wage per effective unit of labour. Since all sectors offer the same value to applicants, a worker who quits after the first period is willing to resample with the same occupation again – and receive the same wage rate per efficiency unit (her income $\theta w$ will only change because $\theta$ changes). Therefore, the wage rate reduces to a scaling parameter and does not have an impact on the reservation productivity level.

The interpretation of (28) is easiest after multiplying both sides with the wage rate $w_i$. Then, the left-hand side is the utility per period from maintaining the job at the reservation productivity, while the right-hand side is the expected utility from quitting: the expected draw in the current period plus the discounted expected improvement. The optimal reservation level equates these two values.

Finally, using that $U_i = U_j$, (27) allows solving for the relative wage between two occupations

as

$$\frac{w_i}{w_j} = \frac{\hat{\theta}_j}{\hat{\theta}_i} \frac{1 - \beta(1-\pi)(1-\gamma_i)}{1 - \beta(1-\pi)(1-\gamma_i a_i)} \frac{1 - \beta(1-\pi)(1-\gamma_j a_j)}{1 - \beta(1-\pi)(1-\gamma_j)}. \tag{29}$$

Recall from (28) that the reservation levels are independent of the wage paid in the occupation. Thus (29) states that the steady state relative wage between sectors depends on parameters alone; output prices only affect the overall level of wages. This is a result of the directed search in the labour market – agents will apply to the occupation with the highest expected value, driving down the wage paid and the value in that occupation until all occupations offer the same value of applying. Consequently, in the steady state, all gains from trade or technological progress are equally distributed among occupations – in the long run, trade will make *all* ex ante identical workers equally better off. Distributional effects arise only along the transition path and between the different educational groups, as discussed below.

**b. Educated Workers**

Just as with non-educated workers, the directed search assures that all high skill occupations offer the same expected value in steady state and, as a result, all occupations benefit equally from trade or technological progress. Yet, the sequential nature of the application process implies that the reservation productivity level depends on the relative wage between high and low education occupations. Following the same steps as above, the reservation productivity level for

an educated worker in a high education occupation is given by

$$\hat{\theta}_h^E \;=\; \frac{(1-\beta)}{1 - \beta\left((1-\epsilon_h) + \epsilon_h(1-\epsilon_l)\Omega_l + \epsilon_h\epsilon_h\right)} \left[ \frac{1 - \beta(1-\pi)(1-\gamma_h)}{1 - \beta(1-\pi)(1-\gamma_h a_h)} \right. \tag{30}$$

$$\left. \left( (1-\epsilon_h)E_{\theta,h}(\theta) + \epsilon_h(1-\epsilon_l)\frac{w_l}{w_h}B_l \right) + \frac{\beta(1-\pi)(1-\epsilon_h)}{1 - \beta(1-\pi)} \int_{\hat{\theta}_h}^{\bar{\theta}} (\theta - \hat{\theta}_h)dF_h(\theta) \right],$$

$$\text{with }\; \Omega_l \;=\; F_l(\hat{\theta}_h) + (1 - F_l(\hat{\theta}_h))\frac{\beta\pi}{1 - \beta(1-\pi)}, \;\text{ and}$$

$$B_l \;=\; E_{\hat{\theta}}^E(\theta) + \beta \int_{\hat{\theta}_l}^{\bar{\theta}} \theta \, \frac{1 - \beta(1-\pi)(1-\gamma_l a_l)}{(1 - \beta(1-\pi))(1 - \beta(1-\pi)(1-\gamma_l))} dF_l^E(\theta),$$

where $\hat{\theta}_l^E$ denotes the reservation level in low skill occupation $l$, and $w_h$ and $w_l$ denote the respective wage rate per effective unit of labour. Note that agents are indifferent between all sectors, so any low education sector can be used when computing (30). The reservation level for low education occupations, $\hat{\theta}_l^E$, can be obtained similarly.

A non-educated worker effectively resamples from the same occupation until she receives a large enough productivity draw; an educated worker, on the other hand, might not resample from the same occupation if she quits. If an educated worker leaves a high education occupation and reapplies, she may not receive an offer and will subsequently apply to and receive an offer from a low education occupation. As a result, the relative wage between the high and low education occupation will affect her quitting decision. This, of course, has implications for the distribution of the gains from trade. While the welfare gains will be equally distributed within one group, this may not hold across groups. Depending on the terms of trade, the education premium, the relative value of being an unemployed educated to an unemployed non-educated $\frac{\overline{U}^E(\Sigma)}{\overline{U}(\Sigma)}$, may rise or fall; this is discussed in more detail below.

## c. The Stationary Distribution

In a stationary equilibrium the productivity cut-offs are constant, consequently the distribution across productivity levels is the underlying distribution truncated at $\hat{\theta}$. The total number of

workers of each skill type follow from the skill acquisition process. Let $\Theta = E\left(\theta | \theta \geq \hat{\theta}\right)$, then the steady state labour supply can be written as

$$
\begin{aligned}
l_i^s \quad = \quad & \Theta_i(a_i \bar{s}_i + \bar{u}_i) + E_i(\theta)(1 - \epsilon_i) A_i \\
& + \Theta_i^E(a_i \bar{s}_i^E + \bar{u}_i^E) + E_i^E(\theta)(1 - \epsilon_i) A_i^E.
\end{aligned}
\tag{31}
$$

$\bar{u}_i$ and $\bar{s}_i$ are the steady state numbers of skilled and unskilled workers in each occupation:

$$
\begin{aligned}
\bar{u}_i \quad &= \quad \frac{(1 - \epsilon_i)(1 - F_i(\hat{\theta}))}{\pi + \gamma_i - \pi\gamma_i} \, A_i \\
\bar{s}_i \quad &= \quad \frac{\gamma_i(1 - \delta)}{\pi} \, \bar{u}_i \\
\bar{u}_i^E \quad &= \quad \frac{(1 - \epsilon_i)(1 - F_i^E(\hat{\theta}_i^E))}{\pi + \gamma_i - \pi\gamma_i} \, A_i^E \\
\bar{s}_i^E \quad &= \quad \frac{\gamma_i(1 - \delta)}{\pi} \, \bar{u}_i^E
\end{aligned}
$$

$$
\begin{aligned}
\text{and } (1 - E) \quad &= \quad \sum_i \left( \bar{s}_i + \bar{u}_i + A_i \right), \\
E \quad &= \quad \sum_i \left( \bar{s}_i^E + \bar{u}_i^E + A_i^E \right), \\
\sum_{l \in L} A_l^E \quad &= \quad \sum_{h \in H} \epsilon_h A_h^E.
\end{aligned}
$$

In order to close the model, the goods market must be cleared – the conditions for goods market clearing, however, depend on the trade regime.

### 2.2.1. Autarky Equilibrium

The total demand for the final consumption good is equal to the total value of the output of each occupation

$$Y^D = \sum_i \frac{p_i y_i}{P}. \tag{32}$$

In autarky, all goods consumed must be produced domestically:

$$z_i \left(l_i^s\right)^\alpha \;=\; \left(\frac{\kappa_i P}{p_i}\right)^{\frac{1}{1-\rho}} Y^D. \tag{33}$$

Together, the market clearing condition (33), the firms' profit maximizing condition (23) and the conditions on relative wages from the agent's problem solve equilibrium prices, wages and the numbers of applicants for each occupation.

**Definition**

A *stationary competitive equilibrium* for the *closed* economy consists of value functions $V_i^s(\theta, \Sigma)$, $V_i^u(\theta, \Sigma)$ $J_i^s(\theta, \Sigma)$, $J_i^u(\theta, \Sigma)$, $J_i^1(\theta, \Sigma)$ for non-educuated and the corresponding value functions $V_i^{E,s}(\theta, \Sigma)$, $V_i^{E,u}(\theta, \Sigma)$, $J_i^{E,s}(\theta, \Sigma)$, $J_i^{E,u}(\theta, \Sigma)$, $J_i^{E,1}(\theta, \Sigma)$ for educated workers; values of search for non-educated and educated, $U(\Sigma)$ and $U^E(\Sigma)$; the associated policy functions $g_i^s(\theta, \Sigma)$, $g_i^u(\theta, \Sigma)$, $g_i^A(\Sigma)$; $g_i^{E,s}(\theta, \Sigma)$, $g_i^{E,u}(\theta, \Sigma)$ and $g_i^{E,A}(\Sigma)$; a time invariant distribution of workers across occupations and skill levels $\Sigma$; prices for each task, $p_i$; wages in each occupation, $w_i$, and sectorial and aggregate output, $y_i$ and $Y$ such that:

1. Given prices and wages, the functions $V_i^s(\theta, \Sigma)$, $V_i^u(\theta, \Sigma)$ $J_i^s(\theta, \Sigma)$, $J_i^u(\theta, \Sigma)$, $J_i^1(\theta, \Sigma)$ solve the non-educated agent's problem and $g_i^s(\theta, \Sigma)$, $g_i^u(\theta, \Sigma)$, $g_i^A(\Sigma)$ are the optimal policy functions.

2. Given prices and wages, the functions $V_i^{E,s}(\theta, \Sigma)$, $V_i^{E,u}(\theta, \Sigma)$, $J_i^{E,s}(\theta, \Sigma)$, $J_i^{E,u}(\theta, \Sigma)$, $J_i^{E,1}(\theta, \Sigma)$ solve the educated agent's problem and $g_i^{E,s}(\theta, \Sigma)$, $g_i^{E,u}(\theta, \Sigma)$, $g_i^{E,A}(\Sigma)$ are the optimal policy functions.

3. Individual decision rules $g_i^s(\theta, \Sigma)$, $g_i^u(\theta, \Sigma)$, $g_i^A(\Sigma)$ are consistent with the invariant aggregate distribution of types.

4. The distribution of workers across sectors and skill levels is time invariant: $\Sigma' = \Sigma$.

5. Wages are determined competitively.

6. The labour market in each occupation clears; aggregate feasibility is satisfied.

7. The task markets and the final good market clear.

### 2.2.2. Trade Equilibrium

In the trade equilibrium in which a subset $\mathcal{T}$ of tasks are tradable, prices for tradable tasks $(p_{t1}, p_{t2}, ..)$ are taken as given and supply and demand are perfectly elastic at these prices.[11] For simplicity, assume there are no trade costs or tariffs. Thus, the labour market clearing conditions and the relative wage conditions, together with market clearing conditions for the non tradable tasks, determine the trade stationary equilibrium. The *stationary competitive equilibrium* for the *open* economy differs from that of the closed economy by condition 7 and an additional condition 8:

7. The task markets for non-tradeable tasks clear; aggregate feasibility is satisfied.

8. Trade is balanced: $0 = \sum_{i \in \mathcal{T}} p_i \left( y_i^s - y_i^d \right)$.

## 3. Quantitative Analysis

In this section, I conduct the main quantitative experiment – predicting the time-path of key labour market outcomes resulting from increased trade in high skill service tasks. I calibrate the model to match the U.S. economy in the early 2000s, around the time when trade in (high skill) services became more common. I then introduce trade in tasks by allowing the economy

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[11] Since trade is balanced, the country really is faced with a set of international relative prices.

to import or export any quantity of some tasks (those identified below in section 3.1.) at given world prices and compute the resulting stationary equilibrium and the transition path.

Since trade in services remains a nascent phenomenon, it is difficult to predict the actual terms of trade. Currently, we do not know which occupations will experience import-competition and which will export, as well as the magnitude of the difference between autarky and world relative prices. When determining the ensuing trade equilibrium, I compute three hypothetical scenarios for the trade in tasks. The first scenario is intended as the likely candidate for actual developments in trade to arise in the future, while scenarios 2 and 3 investigate the importance of the exact pattern and the terms of trade.

The key insight from these experiments is that the gains from trade almost exclusively depend on the magnitude of the comparative advantage. While the skill content of occupations has an impact on the transition path, it only marginally affects the aggregate gains from trade. The skill content of imports and exports impacts the distribution of gains between educated and non-educated workers – while all ex-ante identical agents gain equally from trade, the relative standing of non-identical agents depends on the exact pattern of trade. If trade is biased against high-skill occupations, educated workers may benefit little from trade and the college premium may fall.

## 3.1.   Trade in Tasks and Specific Human Capital - Evidence

In order to analyze and discuss the labour market implications of offshoring, it is crucial to know which occupations are actually tradable. This, however, is not an easy task as trade in tasks is only at its beginning. One attempt has been made by Blinder (2009), who uses the Occupational Information Network (O*NET) database to characterize occupations by their degree of offshorability.[12] He finds that between 22.2% and 29.0% of all jobs are potentially offshorable.

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[12]Two other approaches to identify tradable occupations have been proposed by Liu and Trefler (2008), who link service import and export data (as reported by the Bureau of Economic Analysis, BEA) to the associated occupation, and Jensen and Kletzer (2005), who construct a geographic concentration index for occupations to classify tradable and non-tradable occupations. While both approaches give valuable insights into occupations potentially affected by trade in services, they both suffer from some important shortcomings. High geographic concentration of occupations can be an indication of tradability, but is not a necessary condition. Using BEA data on currently traded services does not identify every potentially tradable occupation since this type of trade is only in its early stages.

Table 3.1 breaks down the employment in tradable occupations into the major occupation groups. The first column lists the total employment for each group and the second column the total employment within that group that is employed in tradable occupations, using Blinder's most conservative estimate. The third column gives the fraction of employment that is potentially tradable in each group. Tradable occupations fall into four groups: managerial, professional (including technical and engineering occupations), administrative, and production occupations. The first two groups are commonly referred to as "high skill" occupations. Together, they make up 28.3% of total employment and 36.1% of all employment in tradable occupations. Disregarding production occupations (which have been traded in the past) these "high skill" occupations account for 52.2% of tradable employment, while making up 30.7% of the total non-production employment. This provides a preliminary indication that workers in newly tradable occupations possess more human capital than workers previously exposed to offshoring.[13] However, the analysis does not distinguish between specific and general human capital.

In order to discern whether occupations increasingly exposed to offshoring require high specific or general human capital, I estimate returns to occupational tenure using the Survey of Income and Program Participation (SIPP). In the estimation I follow Kambourov and Manovskii (2009b), who stress the importance of occupation specific human capital, noting that after controlling for occupational tenure, employer and job tenure do not contribute significantly to wage growth. This finding led them to conclude that workers accumulate significant occupation-specific human capital during their careers.[14]

Table 3.2 presents the calculated returns for occupational tenure.[15] For comparison, Table 3.3 lists the returns to overall labour market experience. I find that 2 years in an occupation increases wages by about 2.0%, and 5 and 10 years yield returns of 4.6% and 7.8%, respectively.[16]

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[13]It is important to keep in mind that the tasks these occupations perform can *potentially* be traded and that, as a consequence, the U.S. will not necessarily become a net importer of higher skill tasks.

[14]However, as in most of the previous work, the paper does not investigate how specific human capital varies across groups. Only recently, using the National Longitudinal Survey of Youth 1979, Sullivan (2009) showed that there is substantial heterogeneity across occupations in the relative importance and magnitude of occupation and industry specific human capital.

[15]See Appendix A for the details on model and data.

[16]These returns are lower than those reported by Kambourov and Manovskii (2009b), where 5 years in an occupation increase wages by 12.0% and Sullivan (2009), who reports 5-year returns of 13.3% if occupational tenure is

Columns [c]-[f] report the returns to occupational tenure only for higher skill occupation groups. I find that the returns to tenure in these occupations are indeed significantly higher than in the full sample of occupations, indicating that individuals working in higher skill occupations not only accumulate more general human capital, but also more occupation-specific human capital. The highest returns are detected for technical occupations, with 30.3% for 10 years in a technical occupation.

For comparison, I also estimate returns to occupational tenure in manufacturing occupations and find that they are about the same as the returns in the full sample: 3.0%, 6.0%, and 7.4% for 2, 5, and 10 years, respectively. This is in line with the intuition that occupations previously exposed to offshoring boast with less specific human capital. Furthermore, the returns to tenure in manufacturing occupations estimated here for the second half of the 1990s and early 2000s may actually be higher than the returns in already offshored manufacturing occupations – i.e. the manufacturing jobs that we still observe today are more human capital intensive then the average manufacturing job in the 1970s and 80s, which have been offshored in the past. Conventional wisdom is that US imports have (slightly) less skill content than exports (e.g. Wolff, 2003), which aligns with this suspicion.

## 3.2. Calibration

For the calibration, I rely on data from several sources. The information on occupational tenure is drawn from the SIPP.[17] Data on occupation and industry affiliation and educational attainment comes from the 2000 Census 5% sample and data from the national accounts (NIPA tables) is used to compute the labour share.

The model period is chosen to be one year, as the focus of the analysis is the long-run transition from one steady state to another rather than movements at the business cycle frequency. This is also consistent with the modelling choice of directed search, as discussed in the previous

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computed comparably. Several factors are potentially responsible, not least of which the fact that the returns to occupational tenure may have diminished since the 1980s, which represent a sizeable portion of the PSID. If the wage increase is largest for workers switching employers and not occupations, and if these switches are correlated with exiting the sample, the high attrition rate in the SIPP will cause a downward bias in the returns to tenure as well.

[17] See Appendix A for a detailed discussion of the SIPP.

section. The time discount factor, $\beta$, is taken to be 0.96, which is standard.

To be able to compute the transition path, the number of occupations must not be to large. Therefore, I group service occupations into 6 major categories: occupations are first divided into high and low skill (or college and non-college) occupations. Each of these groups is then separated into inshored, offshored and non-traded, for a total of 6 groups. Production occupations are only assigned to inshored and offshored occupations groups.

The parameters of the specific human capital process, $a_i$ and $\gamma_i$, are chosen to match the occupational tenure profile identified in the data. The relative productivity of workers with specific human capital, $a_i$, varies by occupation group and ranges from 1.07 (production occupations) to 1.31 (technical occupations). The probability of becoming skilled, $\gamma$, is assumed constant across occupations. Observing that the wage-occupation tenure curve flattens after 8-10 years in an occupation, I set $\gamma$ at 0.125, which implies an average tenure of 9 years at the time of separation.

The distribution of match-specific productivity shocks is uniform; its mean is set to 1. As proposed by Menzio and Shi (2009), the variance, $\sigma_\theta$, can be selected to match the fraction of workers in the first year of their occupational tenure. The probability of leaving an occupation after accumulating more than one year of tenure, $\pi$, is 0.079. This aligns with the average occupational tenure of 12.7 years at the time of an occupation switch, conditional on the switch occurring after year 1. Figure 3.2.1 depicts how the combination of $\sigma$ and $\pi$ can be used to match the aggregate occupational tenure distribution found in the data.

The probability of not receiving an offer, $\epsilon$, is 0.2. This implies an expected unemployment spell of 13 weeks for a non-educated worker. While the actual average unemployment duration measured in the data is higher than this (18.1 weeks in 2007, according to data from the Bureau of Labor Statistics), this figure is upward biased in the context of estimates for the expected unemployment duration because longer spells are more likely to be found in the data. In light of this fact, I use the lower estimate of 13 weeks, which is in line with estimated expected unemployment durations (e.g. Valletta, 2002). Again, as a result of the sequential search by highly educated workers, the expected length of unemployment predicted by the model for high educated workers is shorter than in the data.

Calibrating the parameters of the production process is less straightforward due to the lack of data available at the occupation level. For example, the labour share of output within an industry can easily be calculated from national accounts data, but there is no comparable information available for occupations as the output of an occupation on its own is not as easily measured.

To calibrate the labour share, $\alpha$, I construct an occupation-industry matrix using the 2000 Census data; each cell in this matrix represents the fraction of the occupation's total employment working in a given industry. For example 0.14% of all accountants are employed in cosmetic manufacturing. From the national accounts (NIPA tables), I compute the labour shares for 15 major industry groups.[18] For each occupation, the labour share is computed as the weighted average of the labour shares in the industries in which the occupation is employed. The underlying assumption is that the labour share within an industry is the same across all occupations in that industry and differences in the labour share across occupations stem from differences across industries in which the workers in that occupation are employed in.

The productivity parameter for each task, $z_i$, and its share in the final good production function, $\kappa$, cannot be separately identified. I therefore set $\kappa$ to 1 and choose the relative magnitudes of the respective $z_i$ to match the employment share of each occupation from the 2000 Census; the level of each parameter is selected such that the autarky aggregate output $Y^A = 1$. Finally, since there is no clear target for the elasticity of substitution between tasks, I set $\rho = -2.34$, which implies an elasticity of substitution of 0.3 (i.e. tasks are complements in the production of the final good). I conduct a sensitivity analysis: as long as tasks are strong complements, the results are materially unaffected by the exact choice of $\rho$.

The fraction of "high-educated" workers, $E$, is calibrated as follows. Calculating the fraction of the labour force with at least "some college" education is straightforward from the Census data. However, an educated worker may switch back and forth between college and non-college occupations in the model. Hence, that fraction does not appear to be the empirical counterpart to $E$. For consistency with the model, I therefore count all workers in high skill occupations as

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[18]The breakdown into industries is limited by the availability of "Non-farm Proprietors' Income" by industry, which must be considered when computing the labour share for service occupations, where self-employment is more important then for manufacturing occupations.

"high educated" irrespective of their educational background. Furthermore, all workers with college education who work in low skill occupations under the age of 30 are also counted as "high educated" since the model allows individuals with high education to be employed in high skill occupations regardless of their current employment. In the data, mostly younger workers sample low-skill occupations despite their high education; such workers search heavily for the best match, as evident by the fraction of the high-educated employed in "high degree" occupations increasing until about age 30 and remaining constant almost until the end of the work-life. This is depicted in Figure 2.1. Assuming that older workers with a college education employed in a lower skill job do no longer possess the qualifications for employment in a college occupation, I only include young highly educated workers employed in lower skill occupations; this results in $E = 36.7$.

## 3.3.   The Experiment

In evaluating the trade equilibrium, I compute three hypothetical scenarios of trade in tasks. Since this trade is still in its early stages, it is difficult to predict the exact pattern of trade i.e. the importing occupations' and the exporting occupations' terms of trade. Between scenarios 1 and 3, I vary the relative size of the four tradable services occupations; between scenarios 1 and 2, I vary the terms of trade. The scenarios are:

1. The U.S. imports and exports both high and low skill service tasks equally. For both skill groups, the autarky employment in tradable occupations is equally split between imported and exported tasks. The world market price is (on average) 20% lower for imported tasks than the domestic autarky price and 20% higher for exported tasks.

2. As scenario 1, except the world market price is 30% lower than the domestic autarky price for imported tasks and 30% higher for exported tasks.

3. The U.S. comparative advantage is biased against high skill tasks: the autarky employment in inshored high skill occupations makes up only 30% of the total employment in tradable

high skill occupations, while 70% of the workers are employed in offshored high-skill occupations. The shares are reversed for low skill occupations. As in scenario 1, the world market price is 20% lower than the domestic autarky price for imported tasks and 20% higher for exported tasks.

For all three scenarios, I assume that trade is introduced to its full extent at once and not gradually. While this assumption is not necessarily particularly realistic, it maximizes the short run adjustment cost and thus presents a useful worst case scenario. Were trade introduced very gradually, none or only few permanent workers would switch occupations and so no destruction of human capital would occur, which implies that there would be no short term distributional effects.

## 3.4. Results

### 3.4.1. Steady State Comparison

Compared to the autarky steady state, the new stationary equilibrium sees welfare (output of the final consumption good) increase in all three scenarios, as shown in Table 3.2.1. Not surprisingly, the increase is most pronounced (4.03%) in scenario 2, when the differences between autarky and trade relative prices are largest. In scenario 1, the welfare gain is 2.02%, while in scenario 3 the gain is 1.82%. The difference in outcomes between scenarios 1 and 3 can be explained by the fact that employment in occupations with high specific human capital is higher in scenario 1. As a result, the effective labour supply is higher, which causes a higher output of the comparative advantage task. Nevertheless, it can be said that the terms of trade are of first order importance from an aggregate standpoint; whether or not the offshored tasks are high or low skill is secondary.

While the terms of trade are more crucial than the economy's particular comparative advantage occupation for aggregate welfare, the opposite is true for the distribution of the gains from trade. The directed search mechanism assures that all ex-ante identical agents benefit equally from trade in steady state. However, the gains from trade are not equally distributed

across education groups, as evident from the third and fourth rows of Table 3.2.1. If the economy has a comparative advantage in low-skill occupations (scenario 3), almost all gains from trade are reaped by the non-educated; in the more balanced case (scenario 1), the educated gain slightly more. The value of entering the labour force (the value of searching, in the context of this model) as an educated worker relative to entering the workforce while non-educated (the education premium) falls from 1.41 in autarky to 1.37 in scenario 3. In scenarios 1 and 2, where the comparative advantage is more balanced between high and low skill occupations, the education premium increases slightly to 1.419 and 1.425.

The distributional effect of trade is a result of the occupational mobility restriction for non-educated workers in the model – the non-educated cannot be employed in high education occupations, but educated workers may work in any occupation. In other words, educated workers have a comparative advantage in working in high skill occupations, or alternatively, non-educated workers are like a specific factor. As a result, college-educated workers are able to attain an education premium in autarky. However, in scenario 3, they are exposed to strong import-competition, while the non-educated see the value of their specific factor increase. It is important to point out that the number of educated workers remains constant – if agents had the choice of becoming educated at some cost, the number of educated workers would fall in scenario 3 and increase in scenarios 1 and 2, attenuating the education premium towards its autarky value.

### 3.4.2. The Transition Path

Figures 3.2.2 - 3.2.4 display the time path of aggregate output. In scenarios 1 and 2, output initially remains almost constant and then increases quickly – within 3 years, output is close to the equilibrium value. However, output then overshoots the new steady state level, staying noticeably above this level for a period of over ten years. Interestingly, the rapid increase in output and the prolonged overshooting together cause the welfare gain including transition path to be the same as the steady state gain – 2.02% steady state gain and 2.08% including the transition path for scenario 1. In scenario 3, there is no overshooting; output jumps by about 1% in the first year

and after a period of rapid growth converges to the new equilibrium value.

To better understand the time dynamics of aggregate output, it is instructive to investigate the reallocation of workers first. Inspecting the time path of wages (Figure 3.2.6) for scenario 1,[19] one can see that the initial response mirrors that of a specific factors model: the wage rate per unit of labour (the value of the marginal product) in the inshored occupation increases by about 4.5%, while the wage rate in the offshored occupation falls by about 21% – at the autarky reservation productivity levels, the indifference conditions on relative wages (29) is violated.[20] This triggers a reallocations process: the value of applying to the inshored occupations exceeds the value of applying to offshored occupations and the offshored occupations do not attract any applicants. Furthermore, because of the shift in relative wages, the value of remaining permanently in the offshored occupation is now lower than the value of searching for a worker with a low specific productivity draw. The reservation productivity in offshored occupations increases and most unskilled and even some skilled workers leave the offshored occupations and for the inshored ones. This causes an increase in unemployment, an increase in average worker productivity in the offshored occupations, and a decrease in average worker productivity in the inshored occupations. Note that this implies that the average income in these occupations changes less than the wage per effective unit of labour.

After the first period, some of the former applicants to inshored occupations become permanent workers and increase the effective labour supply in those occupations, which lowers the wage rate per unit of labour. The labour supply in the offshored occupations is further reduced through exogenous separation, which somewhat increases the wage rate. Thus the value of searching relative to the value of staying permanently in offshored occupations decreases; permanent workers (skilled and unskilled) only leave their occupation in the first period after the negative shock. However, the value of applying to the inshored occupations still exceeds that for the offshored; just as in the first period, only the inshored occupations receive applicants in the second period. Over time, the effective labour force in the offshored occupations

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[19]The path for the other scenarios is similar, so only scenario 1 is discussed in detail.

[20]The wage in the offshored occupation need not fall; if the comparative advantage is strong, the wage could potentially increase. However, it will always be lower than the trade steady state real wage.

is further reduced through exogenous separation, while it keeps growing in the inshored – both through entry and acquisition of specific human capital. Eventually, the value of applying to all occupations is equalized again and both receive a positive number of applicants. The gains from trade are now equally distributed across occupations.

The behaviour of the permanent workers' values in either occupation, presented in Figure 3.2.7, is similar to that of wages; the value overshoots the steady state value for the exported task and undershoots for the imported task. However, since the value function captures all discounted future wages, the deviation from the steady state value is much smaller than for wages.[21] With trade, workers already employed in the inshored occupations are better off unambiguously. On the other hand, skilled workers in the offshored occupations may see their value rise or fall, depending on the loss in wages and the length of the transition path. For unskilled workers in the offshored occupation, the value similarly depends on the loss in wages and the length of the transition path, but also on their position in the productivity distribution. In the autarky equilibrium, a worker with a productivity shock equal to the autarky reservation level is indifferent between quitting and staying in the occupation by definition. In the first period after the economy opens to trade, the value of searching increases and the worker is better off. On the other hand, the worker with the highest possible productivity level sees her value decrease, just like a skilled worker.

Figure 3.2.7 shows the path of the value of being a skilled worker with a productivity draw at the 67th percentile for scenario 1; the time paths for the other productivity levels follow the same pattern. In the first year, the value of having human capital specific to the offshored occupation falls about 3% relative to its autarky value, while the value of having human capital specific to the inshored occupation increases by the same amount. The latter quickly converges to its steady state value, while the former has recovered to its autarky level in 8 years and converges to the trade steady state in about 15 years – Figure 3.2.7 best exemplifies the conflict between long term gains and short term losses, while also stressing the importance of the specificity of human

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[21]This also stresses the need for a dynamic model – judging the impact of increased trade based on wage levels as in a static model overstates its impact drastically.

capital. If all human capital were general, the transition to the new equilibrium is instantaneous and there are no short term losses.

Now returning to the dynamics of output, the initial increase in output is a result of the economy taking advantage of its comparative advantage paired with the reallocation of workers from the offshored to the inshored occupation. All but the most productive unskilled and also some of the less productive high skill workers are leaving the offshored occupation and apply to the inshored occupation, as discussed above. However, since some of these workers do not receive an offer in the first year and others receive a low productivity draw, aggregate output in the first period is only slightly increased – the effective labour force employed in the economy in the first year is smaller than in autarky. Yet, at world relative prices, the value of output is higher and aggregate output does not fall. By the end of the third year, most workers who switched receive a productivity draw above the reservation level, i.e. they find a good occupation match in one of the inshored occupations, and output increases significantly.

At the same time, the average productivity of the workers remaining in the offshored occupation is very high, as only skilled and unskilled workers with a high productivity shock remain. This causes aggregate output to overshoot in scenarios 1 and 2: after three periods, the effective labour force in the inshored occupation is markedly increased, while it still remains relatively high in the offshored occupation because of the high average productivity. In scenario 3, just as in scenarios 1 and 2, two opposing forces affect aggregate output in the first period: the positive comparative advantage effect and the negative reallocation effect. Since the former is stronger in scenario 3 than in scenarios 1 and 2, output already increases significantly (by 1%) in the first period. Furthermore, because of the strong comparative advantage effect, output does not overshoot: the high productivity workers who separate from the offshored occupation over time do not see the value of their product decrease because the price of their output increases more than their productivity falls.

### 3.5.    The Impact on the Wage Distribution

The distribution of wages is affected through three channels as wage dispersion in the model comes from three sources: agents vary by their education, their acquired specific skill and their match-specific productivity draw. In the short run, the inequality within offshored occupation will be reduced and within the inshored occupation increased. Only permanent workers remain in the offshored occupations, eliminating the left tail of the productivity distribution. Furthermore, the increase in the productivity cut-off further truncates the distribution and also eliminates more unskilled than skilled workers. In other words, only good matches and mostly workers with high specific human capital remain in the offshored occupation.

The inshored occupation will attract more applicants, i.e. more workers in their first year of tenure. Since workers in their first year of occupational tenure can have productivity shocks below the reservation level as well as above, both sources of within-inequality are amplified in the short term.

In the long term, however, the reservation productivity level is unchanged, and so is the relative number of first year, permanent unskilled to skilled workers within an occupation. Consequently, offshoring does not affect the residual inequality within occupation. In the long term changes to the wage distribution can only stem from changes of the occupational composition of the economy. However, changes to the occupational composition can cause changes to the education premium. If trade is biased against high skill occupations, as in scenario 3, demand for college graduates falls which lowers the college premium. While the competitive forces of the labour market assure that ex-ante identical workers gain equally from trade, different agents may gain differently. College educated workers have a comparative advantage in high skill occupations. If the tasks that are being offshored are produced in these occupations, college educated workers gain relatively less from trade. However, even under scenario 3, in which trade is strongly biased against high skill occupations, college graduates still gain from increased offshoring.

### 3.6. Labour Market Frictions

Finally, I conduct an experiment to investigate the potential role of flexible labour market institutions in the transition from an autarky to a trade equilibrium. In the model, labour market frictions are captured by $\epsilon$, the probability of receiving an offer if searching in the current period. Also, one can think of $\pi$, the arrival rate for exogenous separation, as capturing labour market institutions such as the imposition of firing costs. For this experiment, I increase $\epsilon$ from 0.2 to 0.3, thus increasing the expected length of unemployment to 22.3 weeks. Also, I reduce $\pi$ to 0.050 (from 0.079) which implies an average tenure of 21 years at separation. I also recalibrate the task productivity parameters $z$; all other parameters are kept unchanged to focus on the impact of labour market institutions.[22] Together, these changes leave the steady state gains from trade almost unchanged – in steady state, the gains under scenario 1 represent a 2.07% increase in aggregate output.

The importance of strong labour market institutions for the transition can best be demonstrated by comparing the path of aggregate output to that generated in the initial experiment (Figure 3.2.8). First, output falls upon impact in the first period dues to the lower job finding rate; i.e. a larger number of workers who choose to leave their occupations in response to the trade shock do not receive another job offer, thus becoming unemployed. This also causes output growth to slow down: in the economy with frictions, output takes 7 years to reach the steady state level (as opposed to 3 in the calibrated economy). The output growth is further slowed by the lower exogenous separation – a worker who decided not to quit in the first period will remain in the offshored occupation until her occupation-match is destroyed. As a consequence, these workers to remain in the offshored occupation for a longer period of time.

Together, the lower job-finding rate and the lower separation rate have a noticeable impact on the transition and hence on welfare. In this simple experiment, the steady state increase in aggregate output is 2.07%, but the total welfare gain decreases to 1.79% after taking the transition path into account. This stands in contrast with the calibrated model with fewer labour market

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[22]One could argue that such an environment is likely to produce higher levels of specific human capital (e.g. Wasmer, 2006); an exercise such as calibrating the model to continental Europe is left for future research.

frictions in which the welfare improvement including the transition path actually exceeded the steady state gains. Although the difference is not staggering, it is larger than the difference between the steady state welfare gains for scenarios 1 and 3.

## 4.   Conclusion

This paper develops a model of trade in tasks in which occupation-specific human capital plays a pivotal role in determining the transition path after the country opens up to offshoring. Using this model, I demonstrate that the characteristics of the traded tasks are of secondary importance for the magnitude of the gains from trade – the key determinant of the gains from trade is the difference between autarky and trade relative prices and not the skill content of the traded tasks. As in other models of trade, the more different trading partners are, the larger the gains from trade. The distribution of the gains from trade critically depends on the time horizon: in the short term, workers with human capital specific to the inshored occupation gain, while workers with human capital specific to the offshored occupation loose. In the long run, when the distribution of specific human capital is endogenous, the gains from trade are equally distributed among identical agents. Agents with different characteristics, e.g. ability to go to college, may gain differently if trade is biased against high or low skills.

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Table 3.1: Employment in Tradable Occupations in 2004, by Major Occupation Groups

| Major Occupation Group (SOC Code) | Total Employment | Employment in Tradable Occupations | Fraction Tradable in Occupation Group | Fraction of Total Tradable |
|---|---|---|---|---|
| | [a] | [b] | [b]/[a] | [b]/total([b]) |
| Management, business, and financial occupations (11-1300) | 11,370,970 | 4,561,728 | 40.1% | 15.8% |
| Professional and related occupations (15-2900) | 25,509,800 | 5,878,192 | 23.0% | 20.3% |
| Service occupations (31-3900) | 24,749,560 | 93,500 | 0.4% | 0.3% |
| Sales and related occupations (41-0000) | 13,930,320 | 652,570 | 4.7% | 2.3% |
| Office and administrative support occupations (43-0000) | 22,784,330 | 8,836,777 | 38.8% | 30.5% |
| Farming, fishing, and forestry occupations (45-0000) | 443,070 | 0 | 0% | 0% |
| Construction and extraction occupations and Installation, maintenance, and repair occupations (47-4900) | 11,675,660 | 0 | 0% | 0% |
| Production occupations (51-0000) | 10,249,220 | 8,906,130 | 86.9% | 30.8% |
| Transportation and material moving occupations (53-0000) | 9,594,920 | 0 | 0% | 0% |

Source: BLS and Blinder (2009)

Table 3.2: Return to Occupational Tenure, by Occupation Groups

| Years in Occupation | All Occupations | College Graduates all occupations | Executive | Professional | Technical | All "High Skill" | Production |
|---|---|---|---|---|---|---|---|
| | [a] | [b] | [c] | [d] | [e] | [f] | [g] |
| 2 years | 0.0242*** | 0.0514*** | 0.0200 | 0.0448* | 0.0867*** | 0.0338*** | 0.0304** |
| | (0.0056) | (0.0113) | (0.0184) | (0.0231) | (0.0330) | (0.0118) | (0.0120) |
| 5 years | 0.0506*** | 0.1074*** | 0.0664* | 0.0879** | 0.1884*** | 0.0784*** | 0.0597** |
| | (0.0108) | (0.0208) | (0.0358) | (0.0433) | (0.0643) | (0.0224) | (0.0237) |
| 10 years | 0.0723*** | 0.1548*** | 0.1663*** | 0.1029* | 0.3031*** | 0.1325*** | .0743** |
| | (0.0135) | (0.0243) | (0.0467) | (0.0540) | (0.0941) | (0.0281) | (0.0316) |

Note: Standard errors in parentheses.

* denotes statistical significance at 10%, ** at 5%, and *** at 1%.

Table 3.3: Return to (Potential) Experience, by Occupation Groups

| Years of Experience | All Occupations | College Graduates all occupations | Executive | Professional | Technical | All "High Skill" | Production |
|---|---|---|---|---|---|---|---|
| | [a] | [b] | [c] | [d] | [e] | [f] | [g] |
| 2 years | 0.0896 | 0.1091 | 0.1103 | 0.1199 | 0.0751 | 0.1177 | 0.0745 |
| | (0.0030) | (0.0065) | (0.0123) | (0.0124) | (0.01870 | (0.0091) | (0.0062) |
| 5 years | 0.2036 | 0.2451 | 0.2488 | 0.2684 | 0.1673 | 0.2662 | 0.1720 |
| | (0.0064) | (0.0135) | (0.0262) | (0.0259) | (0.0397) | (0.0194) | (0.0132) |
| 10 years | 0.3461 | 0.4079 | 0.4177 | 0.4470 | 0.2732 | 0.4489 | 0.3002 |
| | (0.0095) | (0.0196) | (0.0399) | (0.0385) | (0.0609) | (0.0293) | (0.0200) |

Note: Standard errors in parentheses.

All statistically significant at 1%

Table 3.2.1: Steady State Comparison

|  | Autarky | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Output | 1 | 1.0202 | 1.0403 | 1.0182 |
| Unemployment | 2.97% | 2.97% | 2.97% | 2.95% |
| $\overline{U}^{E,Trade}/\overline{U}^{E,Autarky}$ |  | 1.0236 | 1.0462 | 1.0032 |
| $\overline{U}^{Trade}/\overline{U}^{Autarky}$ |  | 1.0172 | 1.0355 | 1.0319 |
| $\overline{U}^{E}/\overline{U}$ ("College Premium") | 1.4100 | 1.4189 | 1.4247 | 1.3708 |
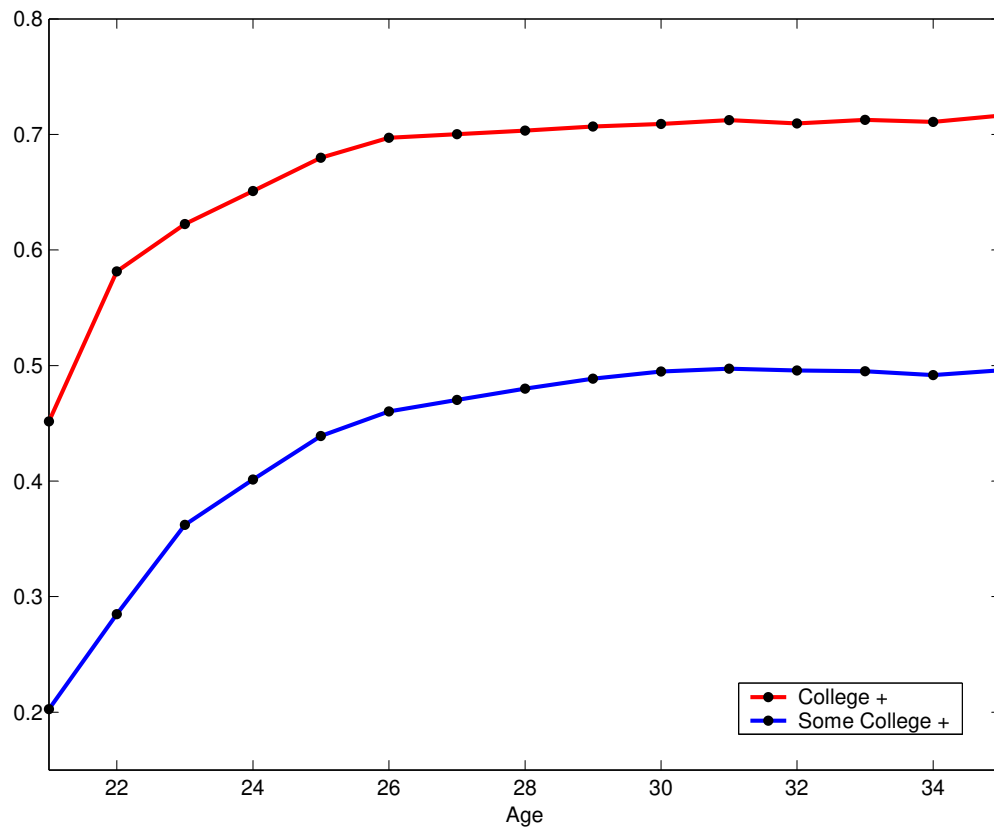
Figure 2.1: Fraction of Educated Working in College Occupation
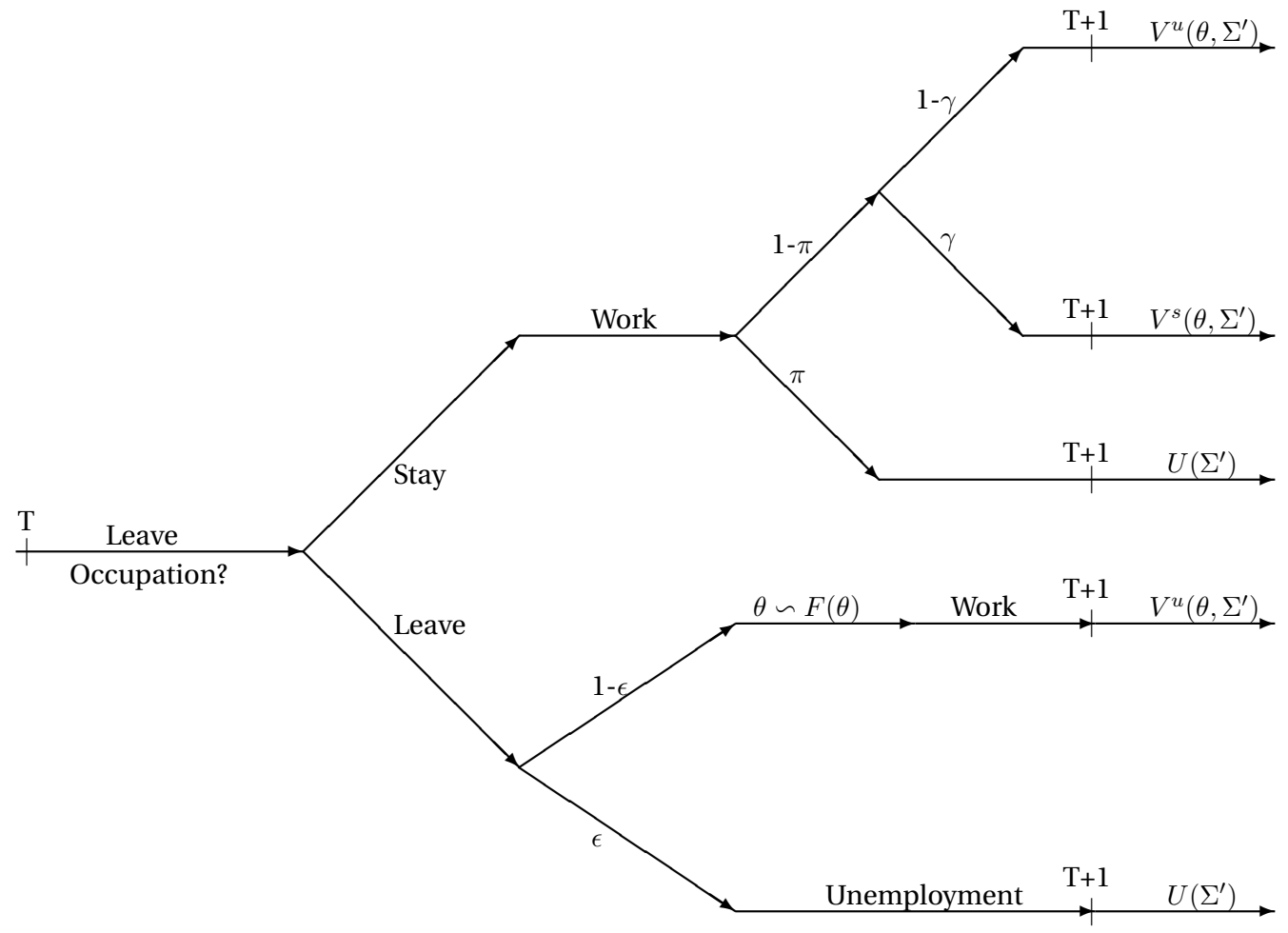
Figure 2.2: The Problem of an Non-Educated, Unskilled Worker
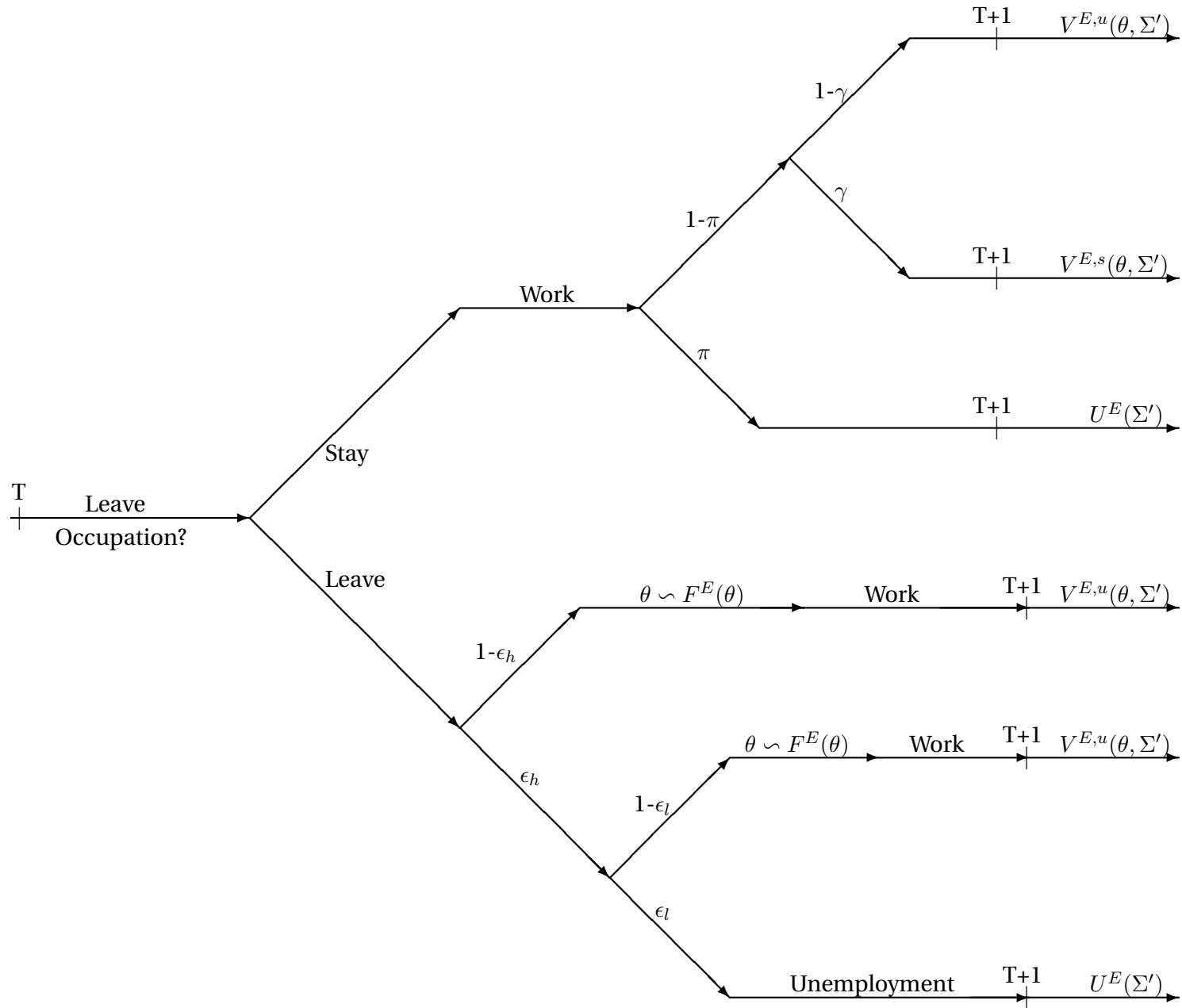
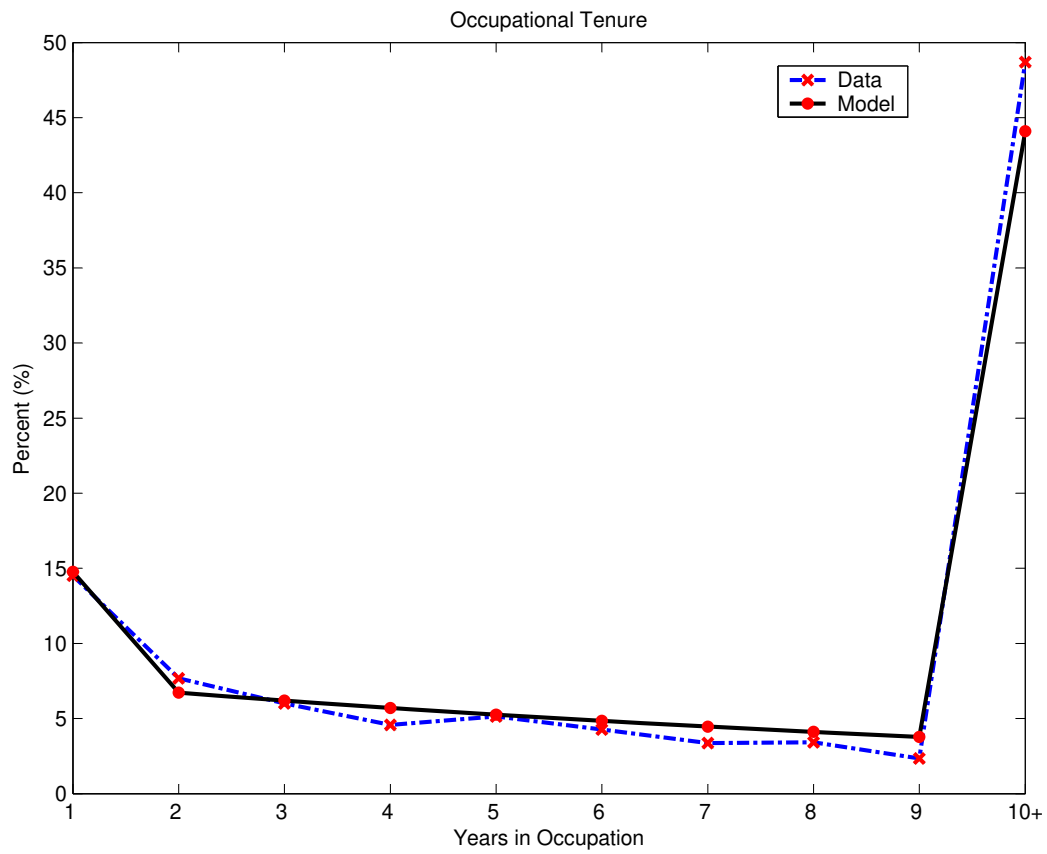Figure 2.3: The Problem of an Educated, Unskilled Worker

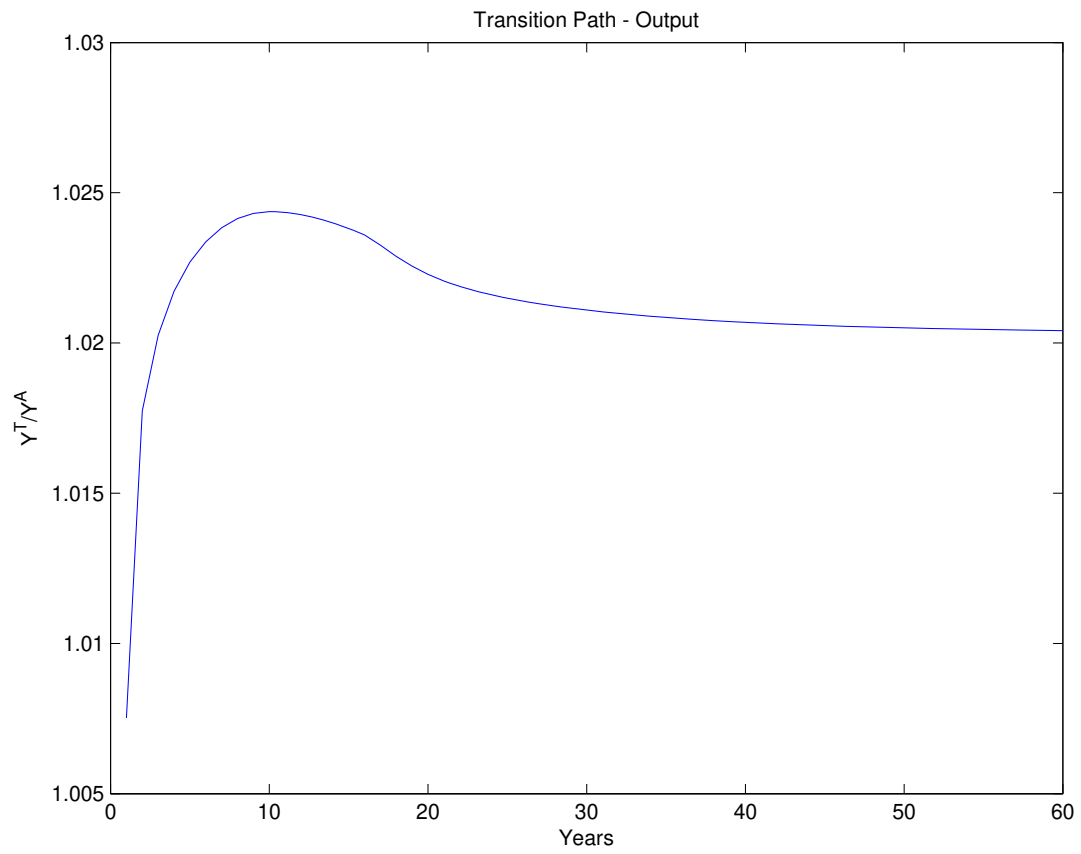Figure 3.2.1: Distribution of Tenure in Occupation
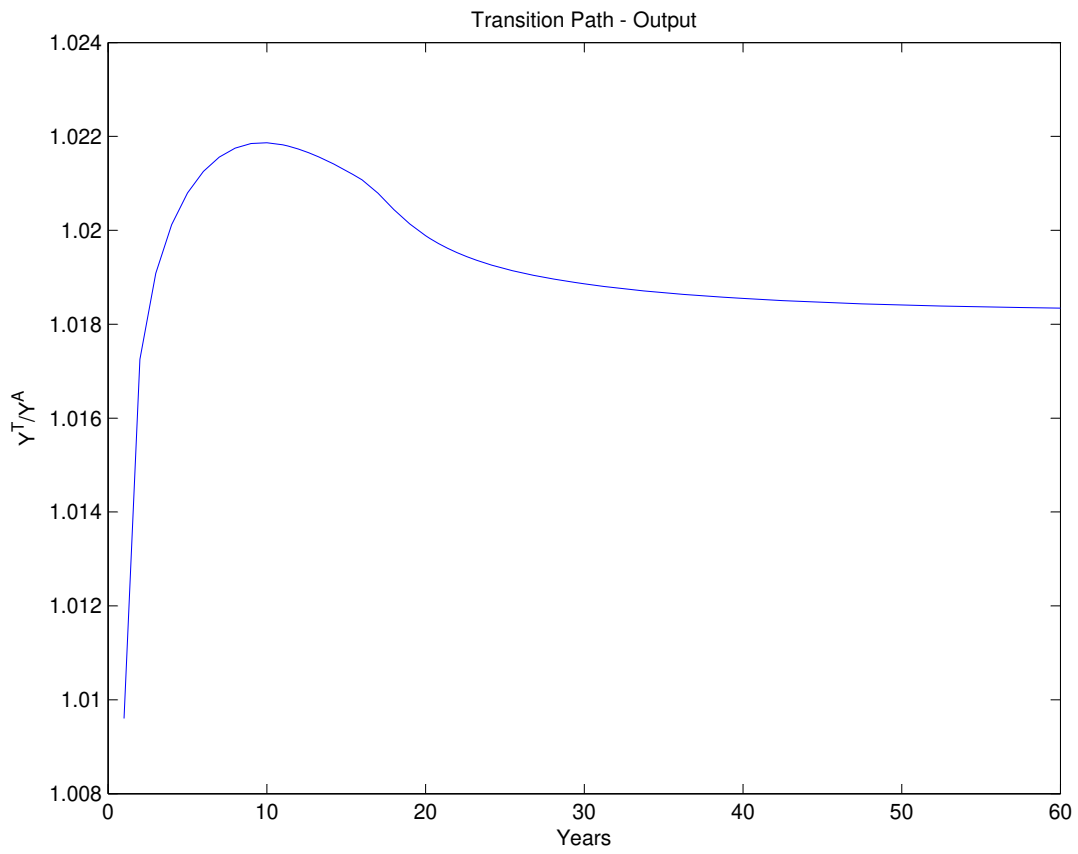
Figure 3.2.2: Transition Path $Y$, Scenario 1
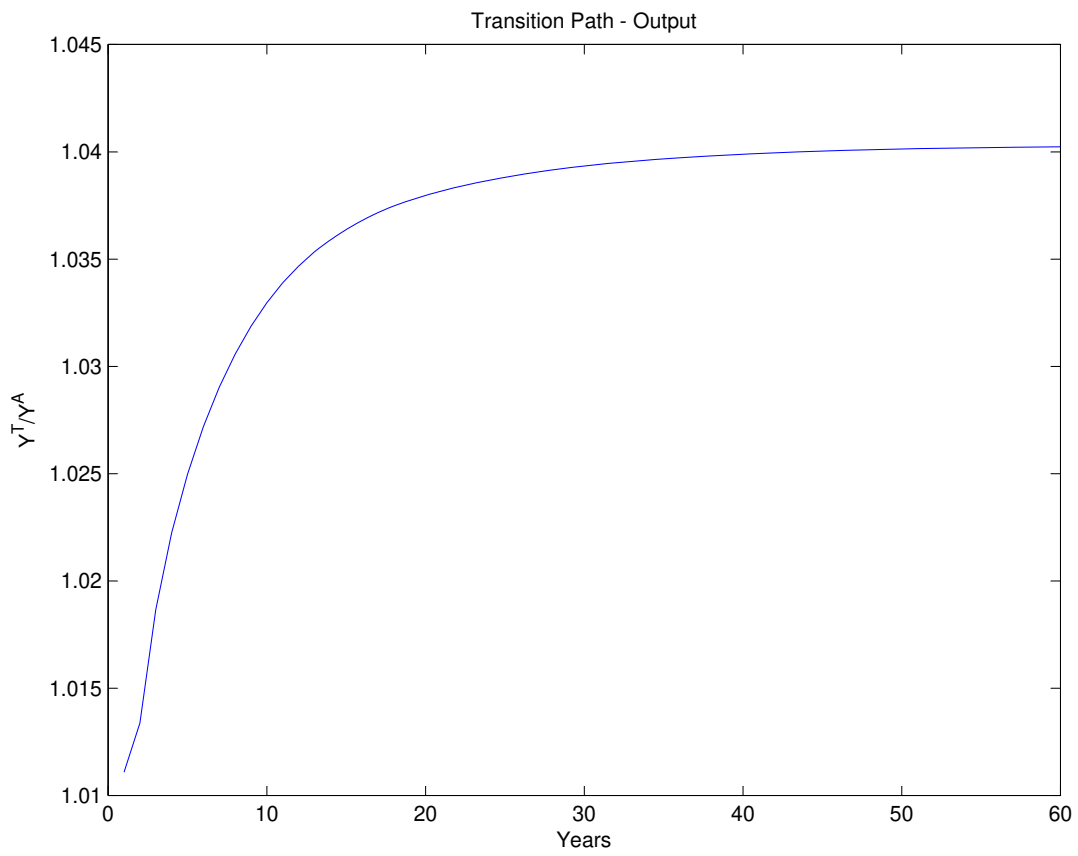
Figure 3.2.3: Transition Path $Y$, Scenario 2
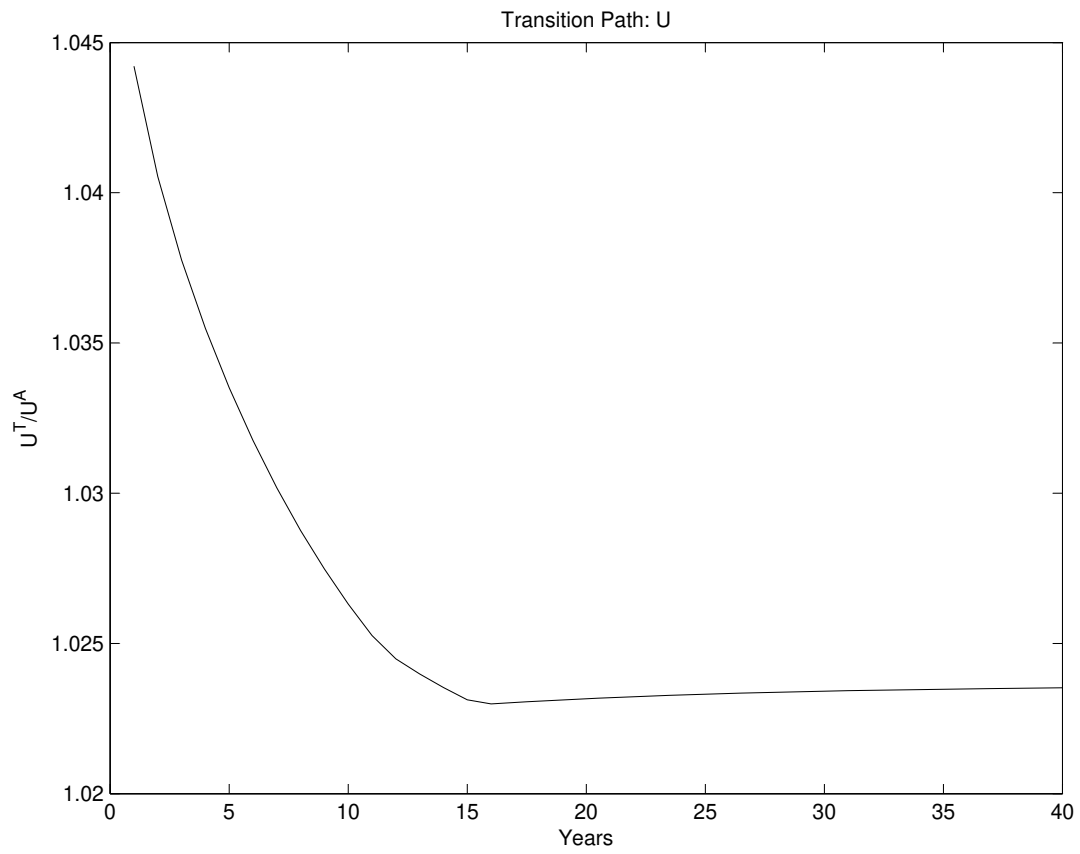
Figure 3.2.4: Transition Path $Y$, Scenario 3

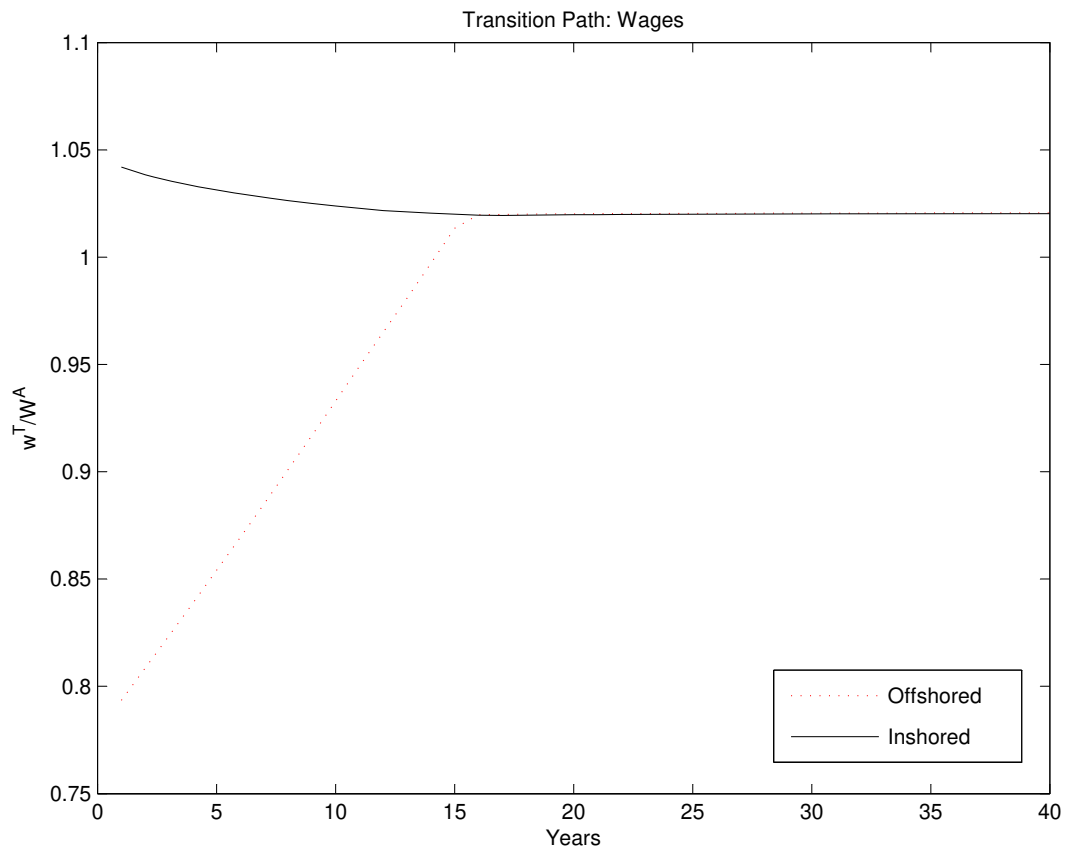Figure 3.2.5: Transition Path $\overline{U}^E$, Scenario 1

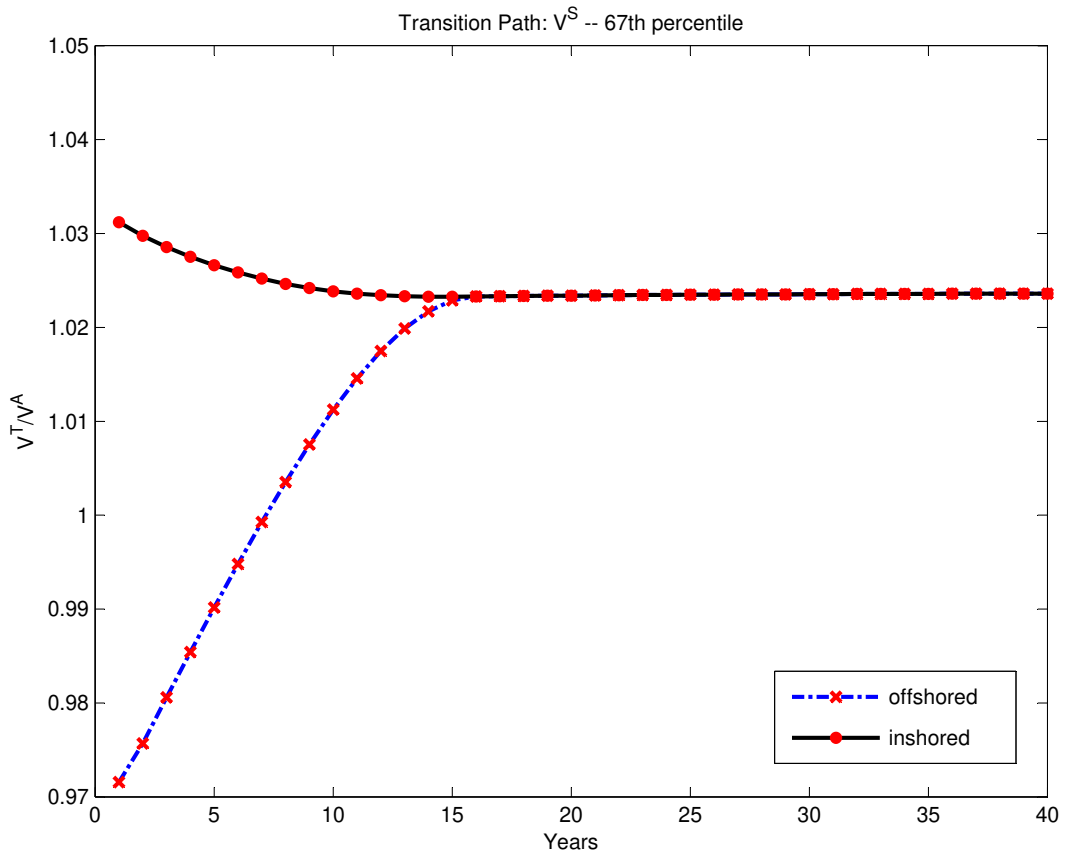Figure 3.2.6: Transition Path Wages, Scenario 1

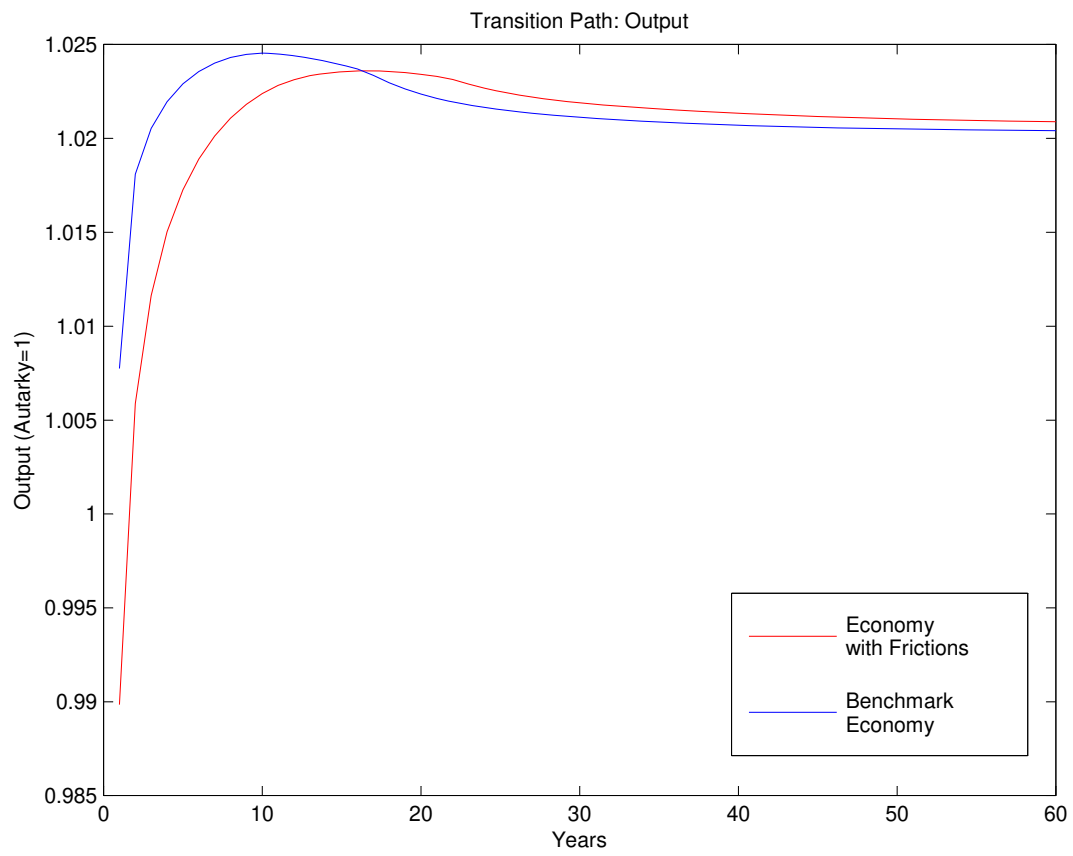Figure 3.2.7: Transition Path $V^S$, $67^{th}$ percentile, Scenario 1

Figure 3.2.8: Transition Path $Y$, Economy with Labour Market Frictions

# APPENDIX A: Estimation of Specific Human Capital

Following the empirical literature measuring returns to tenure,[23] I estimate the following earnings equation:

$$\ln w_{ijmnt} = \beta_1 EmpTen_{ijt} + \beta_2 OccTen_{imt} \tag{A-1}$$
$$+ \beta_3 IndTen_{int} + \beta_4 WorkExp_{it} + \alpha X_{ijmnt} + \kappa_{ijmnt},$$

where $w_{ijmnt}$ is the real hourly wage of worker $i$ at employer $j$ in occupation $m$ and industry $n$. $WorkExp$ denotes overall labour market experience, while $EmpTen$, $OccTen$ and $IndTen$ denote tenure with the current employer, occupation and industry, respectively. $X$ is a set of observables which influence wages independently of tenure: gender, race, educational attainment, union status, firm size, 1-digit industry and occupation affiliation, and state and year fixed effects. $\kappa_{ijmnt}$ an error term decomposed as follows:

$$\kappa_{ijmnt} = \mu_i + \lambda_{ij} + \xi_{im} + \nu_{in} + \epsilon_{it},$$

where $\mu_i$ is an individual-specific component and $\lambda_{ij}$, $\xi_{im}$, $\nu_{in}$ are job-match, occupation-match, and industry-match components, respectively. These unobserved components pose a potentially serious challenge in estimating the returns to tenure consistently; workers with good employer (occupation/ industry) matches, for example, may be more likely to have remained with their employer (occupation/ industry) longer while at the same time receiving a higher wage due to the excellent match quality. Estimating (A-1) using Ordinary Least Squares will therefore likely result in upward-biased estimates. Thus, I follow the approach developed by Altonji and Shakotko (1987), which has been widely adopted in the literature and employ an instrumental variable estimation strategy.

The standard instruments for experience and the three tenure variables are the deviations of experience/tenure for individual $i$ from the individual's mean experience/tenure in the observed spell. If $T_{it}$ is the current tenure of worker $i$, the corresponding instrument is $\widetilde{T_{it}} = \left( T_{it} - \overline{T_i} \right)$, where $\overline{T_i}$ is the average tenure of individual $i$ in the current spell. The instruments are orthogonal to their respective match components by construction. Unfortunately, they are not necessarily orthogonal to the other match components; e.g. the instrument for occupation tenure, $\widetilde{OccTen}_{imt} = \left( OccTen_{imt} - \overline{OccTen_{im}} \right)$, are potentially still be correlated with the job-match unobserved effect $\lambda_{ij}$. For example, an individual with a good em-

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[23]See, among others: Altonji and Shakotko (1987), Neal (1995), Altonji and Williams (2005), and Kambourov and Manovskii (2009b).

ployer, but bad occupation match might be less inclined to switch occupations than an otherwise identical individual with a bad job match because switching occupations most likely also results in loosing the good employer match.

Table A.1 presents the resulting coefficient estimates of a specification of (A-1) which includes quadratic and cubic terms for all tenure (3-digit classification level) and experience terms. The returns to occupational tenure reported in 3.2 are computed from these results.

## Data

The dataset of individual employment profiles used to estimate (A-1) comes from the 1996 and 2001 waves of the Survey of Income and Program Participation (SIPP). The advantage of using the SIPP is the relatively large sample size in comparison with other panel data sets, which unfortunately results in a trade-off with relatively short panel length (4 and 3 years, respectively). The size of the dataset allows an estimation of the returns despite the relatively short sample and ensures a justified departure from using data from the 1980s and early 1990s, which is advantageous for three reasons. Firstly, many of the occupations now exposed to offshoring were neither fully developed nor common some 20 years ago; secondly, since there is no reason to believe that the returns to tenure are constant over time even as the returns to schooling have evolved, including earlier years of data would likely not produce estimates most relevant to current discussions on offshoring. Finally – and most importantly – the SIPP data was collected at a monthly frequency, with individuals responding to one interview every four months. This allows a much more reliable identification of job switchers – something that posed a significant challenge in previous studies using the Panel Study of Income Dynamics, PSID (Brown and Light, 1992), and the National Longitudinal Survey of Youth, NLSY.

Respondents in the SIPP are asked to give the start- (and end-) dates for every job, allowing me to obtain very reliable information on employer tenure and thus circumvent the issue of initialization. In the very first interview, the respondent is asked how long she has been working in the current "line of work", which allows me to initialize occupational tenure as well. There is, unfortunately, no information on initial industry tenure; here initialize industry tenure together with occupation tenure. Finally, since I do not observe an individual from the time she enters the labour market, I have no information on her actual acquired overall work experience. However, the SIPP provides very detailed information on schooling, so I can use potential experience - age less 6 less numbers of years of schooling - as a proxy for actual experience. To minimize the resulting bias, I restrict the sample to male full-time workers.

In each interview, the respondent is asked retrospectively about the past four months, and the responses are recorded for each month individually. The individual reports employer, occupation and industry classifications, hours worked, and total income. She also reports start- and end-dates for each job, which allows me to identify job switches and calculate employer tenure with comparatively high precision.[24] Following Kambourov and Manovskii (2009b), occupation and industry switches are only coded as "true" switches if they coincide with employer switches. Using this convention, 20.2% of participants switch their employers at least once per 12 months; 14.5% switch occupations, and 13.5% industries. These shares are somewhat lower than their PSID equivalents in Kambourov and Manovskii (2009b) and Sullivan (2009) - a possible explanation is that workers who lose their job may be more likely to leave the sample. Since the SIPP has relatively high sample attrition, this could explain fewer job, occupation, and industry switches in this sample.

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[24]Nevertheless, there is a significant seam bias in the data; more switches happen "at the seam", or between interviews (e.g. between months 4 and 5, 8 and 9) than within interviews (e.g. between months 1 and 2, 2 and 3). However, since I am not interested in estimating a hazard function, this bias is a minor issue and causes only a small error when calculating tenure - at the most 3 months.

## Table A.1: Results IV

| | All Occupations | Executive Occupations | Professional Occupations | Technical Occupations | All High Skill Occupations | Post Secondary Degree | Manufacturing Occupations | Craft Occupations | Administrive Occupations |
|---|---|---|---|---|---|---|---|---|---|
| Job Tenure | -0.00436951 | 0.00855666 | -0.01277289 | -0.01793417 | -0.00114156 | -0.01036377 | 0.00695998 | -0.00431984 | -0.01679791 |
| | [0.002100472]* | [0.006325729] | [0.008153095] | [0.010881728] | [0.004260790] | [0.004059372]* | [0.004074787] | [0.003950654] | [0.009590593] |
| Job Tenure$\hat{2}$ | -0.00019861 | -0.00156688 | -0.00010233 | 0.00107554 | -0.00079853 | -0.00036829 | -0.00050148 | -0.000241 | 1.4458E-05 |
| | [0.000182943] | [0.000557624]** | [0.000732806] | [0.000941776] | [0.000382462]* | [0.000376878] | [0.000314193] | [0.000343842] | [0.000774614] |
| Job Tenure$\hat{3}$ | 3.081E-06 | 3.3271E-05 | 1.0508E-05 | -4.5615E-05 | 1.8465E-05 | 9.864E-06 | 4.474E-06 | 5.048E-06 | -1.2048E-05 |
| | [0.000003821] | [0.000011641]** | [0.000016193] | [0.000021766]* | [0.000008204]* | [0.000008353] | [0.000006041] | [0.000007013] | [0.000015927] |
| Occupation Tenure | 0.0135746 | 0.00720406 | 0.02581094 | 0.04790938 | 0.01764079 | 0.0288128 | 0.01762865 | 0.01030009 | 0.06342592 |
| | [0.003325959]** | [0.010808798] | [0.013844037] | [0.019524868]* | [0.007007010]* | [0.006799191]** | [0.006986100]* | [0.007649082] | [0.016574425]** |
| Occupation Tenure$\hat{2}$ | -0.00075059 | 0.00148627 | -0.00173914 | -0.00232766 | -0.00034473 | -0.00160339 | -0.0012528 | -0.00097523 | -0.00561127 |
| | [0.000280883]** | [0.000902756] | [0.001312258] | [0.001886455] | [0.000621028] | [0.000646115]* | [0.000553421]* | [0.000616564] | [0.001684786]** |
| Occupation Tenure$\hat{3}$ | 1.2287E-05 | -0.0000544 | 1.8724E-05 | 5.6727E-05 | -9.392E-06 | 2.7036E-05 | 0.00002334 | 0.00002654 | 0.00013825 |
| | [0.000005769]* | [0.000019083]** | [0.000031703] | [0.000046874] | [0.000013838] | [0.000014875] | [0.000010931]* | [0.000012309]* | [0.000041667]** |
| Industry Tenure | 0.00574895 | 0.00321059 | -0.01964428 | -0.003345 | -0.00922771 | -0.00775457 | -0.00932931 | 0.01617515 | -0.02021382 |
| | [0.003457900] | [0.011406544] | [0.014641378] | [0.019872172] | [0.007258862] | [0.007090624] | [0.007750068] | [0.008092782]* | [0.017585053] |
| Industry Tenure$\hat{2}$ | -4.0109E-05 | -0.00123168 | 0.00169324 | 0.00089363 | 0.0003776 | 0.00102238 | 0.00074108 | 4.9934E-05 | 0.00320341 |
| | [0.000277290] | [0.000939881] | [0.001375216] | [0.001946829] | [0.000639505] | [0.000649785] | [0.000562660] | [0.000600728] | [0.001705409] |
| Industry Tenure$\hat{3}$ | -6.532E-06 | 3.8246E-05 | -3.7643E-05 | -3.1341E-05 | -2.914E-06 | -2.8824E-05 | -1.7153E-05 | -1.2192E-05 | -9.2274E-05 |
| | [0.000005633] | [0.000019295]* | [0.000032931] | [0.000047546] | [0.000013955] | [0.000014786] | [0.000010927] | [0.000011836] | [0.000041269]* |
| Potential Experience | 0.04765768 | 0.05898373 | 0.06444721 | 0.04040336 | 0.06285077 | 0.05845773 | 0.03928994 | 0.0452217 | 0.03970313 |
| | [0.001685287]** | [0.006824186]** | [0.006935209]** | [0.010430483]** | [0.005077852]** | [0.003665438]** | [0.003444443]** | [0.003755317]** | [0.006186902]** |
| Potential Experience$\hat{2}$ | -0.00147254 | -0.00196861 | -0.00232992 | -0.00146757 | -0.00204401 | -0.0020082 | -0.00103275 | -0.00157327 | -0.00100923 |
| | [0.000095693]** | [0.000377403]** | [0.000433801]** | [0.000624951]* | [0.000288476]** | [0.000229873]** | [0.000186784]** | [0.000209583]** | [0.000356328]** |
| Potential Experience$\hat{3}$ | 1.6756E-05 | 2.4734E-05 | 3.5514E-05 | 1.5891E-05 | 2.4764E-05 | 2.4131E-05 | 1.0593E-05 | 1.7844E-05 | 1.0077E-05 |
| | [0.000001532]** | [0.000006132]** | [0.000007887]** | [0.000010750] | [0.000004859]** | [0.000004075]** | [0.000002967]** | [0.000003382]** | [0.000005935] |
| Observations | 168345 | 23026 | 16007 | 5452 | 44485 | 58574 | 27832 | 25673 | 9366 |
| Number of IDs | 29771 | 4569 | 3298 | 1172 | 8605 | 10181 | 5438 | 5533 | 2235 |

Standard errors in brackets

* significant at 5%; ** significant at 1%