The Welfare and Labor Market Effects of Occupational Licensing*

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August 23, 2020

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Abstract

Close to 25 percent of workers in the United States are required to have an occupational license in order to perform their job, fueling the debate on the trade-off generated by this policy. Licensing policy can provide social benefits by protecting consumers from purchasing low quality goods and services due to an information asymmetry between consumers and producers. However, licensing can be costly as it acts as a barrier to entry that distorts the occupational choice of workers in the labor market. This paper studies the effect of occupational licensing on consumer welfare, the allocation of labor, and the wage premium between licensed and unlicensed workers. To analyze the trade-off generated by licensing, I develop a framework with adverse selection in the product market, occupational choice in the labor market, and a licensing policy composed of an entry fee and occupation-specific training requirements. I calibrate this model to the US labor market using the 2008 Survey of Income and Program Participation (SIPP) panel and the O*NET databases. I find that removing licensing training requirements leads to a 3.9 percent reduction in consumer welfare, since the positive welfare effect of removing barriers to entry is offset by a negative welfare impact of lower quality licensed goods. In addition, when training is removed, the wage premium falls by more than half. *JEL Codes:* D82, J24, J31, K23, K31, L51.

*For helpful comments, I thank Anmol Bhandari, David Bradley, Marcos Dinerstein, Keyvan Eslami, Carlos Esquivel, Salomón García, Rafael R. Guthmann, Kyle Herkenhoff, Loukas Karabarbounis, Jeremy Lise, Ellen McGrattan, Agustin Sámano, Jim Schmitz, and the participants of the Quantitative Macro Workshop at the University of Minnesota. The views expressed herein are those of the author and not necessarily those of the World Bank Group. All mistakes are my own.

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1 Introduction

Occupational licensing and its impact on the United States economy is at the heart of the current policy agenda. Close to 25 percent of workers in the United States are required to have an occupational license in order to perform their job. Furthermore, as highlighted by Carpenter, Knepper, Erickson, and Ross (2012) and Kleiner and Krueger (2013), the share of licensed workers in the US labor market has increased fivefold since the 1950s. Understanding the social benefits and costs of occupational licensing are topics of much debate as this policy has implications for consumer welfare and for labor market outcomes.

Licensing policy generates a trade-off. On the one hand, licensing can have a positive effect on consumer welfare by alleviating an information asymmetry in the markets of goods and services. In particular, when consumers purchase goods from producers, consumers are less informed than the producers about the quality of the product. On the other hand, licensing policy acts as a barrier to entry that prevents individuals from working in licensed occupations. Workers that wish to enter licensed professions are typically required to pay a licensing fee and undergo occupation specific training. Hence, licensing lowers incentives for workers to enter licensed occupations as it is costly in terms of resources, time, and effort.

This paper studies the effect of occupational licensing on welfare, the allocation of labor, and the wage premium between licensed and unlicensed workers. My first contribution is to develop a framework with the key ingredients that highlight the trade-off generated by licensing policy. Earlier literature pioneered by Leland (1979) and Shapiro (1986) carried out theoretical analyses of the effect of licensing policy on consumer welfare. They determine that licensing can be welfare improving in the presence of information asymmetries in the product market, since buyers know less about the quality of goods relative to sellers. I build on this earlier theoretical literature by developing a framework with adverse selection in the product market, occupational choice in the labor market, and a licensing policy composed of a fee and training. In the model, changes in the licensing policy affect consumer welfare through two forces. As licensing requirements are higher, the quality of the goods that are produced increases, which raises welfare. However, welfare falls since less resources are allocated towards consumption and more towards license costs.

My second contribution is to quantify the welfare and labor market effects of reforming occupational licensing in the US. For this, I estimate the parameters of the theoretical model to match moments of the US labor market, focusing only on occupations that are predominantly composed of workers with less than college education. The conventional view of the literature on the effects of occupational licensing policy on consumer welfare is that the social costs are larger than the benefits. However, the literature's assessment of these benefits has been limited. I provide the first estimates of the welfare consequences of occupational licensing within a theoretical framework that explicitly models a market failure: adverse selection in the product market. I find that removing the training requirements of licensing results in a reduction of 3.9 percent in consumer welfare. Although consumption rises as lower resources are allocated towards license cots, lower quality goods are produced resulting in the consumer welfare loss. Hence, I find that the quality effect dominates when training requirements are removed.

In addition, this paper contributes to the vast literature on wage differences between licensed and unlicensed workers. Using the calibrated model, I decompose the wage premium between licensed and unlicensed workers into components explained by the composition of ability of workers between occupations, occupation-specific skills obtained from licensing training requirements, and information rents. I find that under different licensing training requirements, changes in the wage premium are explained mainly by changes in the composition of workers between licensed and unlicensed occupations.

To determine the effects of occupational licensing on consumer welfare and labor market outcomes, I set up a static model in which the economy has two productive sectors. In one of the sectors, the good produced is heterogeneous in its quality, an attribute that is unobserved by consumers. In the other sector, a homogeneous good is produced. Workers choose between producing in either sector based on their ability. Licensing policy is modeled as an entry barrier workers face when entering the sector with the information asymmetry, which I refer to as the *licensed sector*. Specifically, workers that choose to enter the licensed sector must incur in an entry fee as well as sector-specific (i.e. occupation-specific) training. Training is costly in terms of time, the *opportunity cost of licensing*, and in terms of the effort, the *effort training cost of licensing*. The effort training cost is increasing in the amount of training content and decreasing in the ability of workers. Intuitively, workers must exert more effort the greater the training content. Also, given a level of training content, workers of higher ability have to exert less effort in relation to their lower ability counterparts. The training requirements of licensing provide sector-specific skills that augment workers' productivity in that sector. Workers in the licensed sector produce goods with a quality that is determined by their ability and also by sector-specific skills obtained from training. I denote the homogeneous good sector as the *unlicensed sector*, and there is free entry of workers into this sector. Consumers obtain utility from consuming quantities of the goods from both sectors and from the quality of the licensed sector good.

In an economy without licensing the standard result of Akerlof (1970) holds: lower quality goods are produced in the sector with the information asymmetry. The reason for this is that the information asymmetry in the product market affects the allocation of workers in the labor market. In the licensed sector, worker's earnings are the same regardless of their ability. This is because the price of licensed goods is the same, as shoppers cannot differentiate the qualities of these goods. As a result, in the licensed sector, high ability workers are undercompensated and low ability workers are overcompensated for their ability. On the contrary, in the unlicensed sector, workers are always fully compensated for their ability as there are no information asymmetries in that sector. Under no licensing requirements, high ability workers enter the unlicensed sector and low ability workers enter the licensed sector.

The training component of licensing plays an important role in alleviating the negative effects of the information asymmetry on the quality of the licensed good. When a licensing policy with training is introduced into the economy, it affects the quality of licensed goods through two channels: the *sorting channel* and the *sector-specific skills channel.* The sorting channel refers to the ability composition of workers between the licensed and unlicensed sectors, as a result of the licensing policy with training. That is, as training requirements increase, workers of lower ability select out of licensed occupations, since it is more costly for them to carry out the training. Given this, quantity falls which increases the price of licensed goods. Thus, higher ability workers find it more profitable to enter the licensed sector, improving the overall quality of licensed goods. The sector-specific skills channel impacts quality directly as workers' quality production is augmented by the skills workers obtain through training. Thus, higher training requirements increase the quality of licensed goods, which raises consumer welfare and increases the wage premium. However, as license costs increase, households must spend more resources on these costs, resulting in lower quantities of both goods being consumed. Hence, higher training requirements reduce the quantities of goods traded, which lowers the welfare of households. In summary, although increasing training requirements of licensing may alleviate the adverse selection problem by improving the quality of licensed goods, it generates a higher deadweight loss through less resources being spent on quantity consumption.

I use the 2008 SIPP panel and the O*NET database to estimate the model. More specifically, I analyze occupations that are similar in the education level of their workers, by focusing on occupations that are predominantly made up of workers with less than college education. I refer to these occupations as *low-skilled occupations.* In this manner, I am controlling for differences in education that may have a clear impact on occupational choice. For workers in these occupations, I document that only 15 percent of them are licensed and, on average, the wages of licensed workers is 16 percent higher. Next, I decompose this wage premium and find that 9 percentage points are accounted for by skill observables in the data, which I refer to as the skill component.

I estimate the model to moments from my sample of workers in low-skilled occupations. Using the estimated model, I determine how much of the skill component is explained by the sorting channel and how much is explained by the sector-specific skills channel. I find that skills obtained from training play an important role in explaining the 9 percentage point skill component. I also use the estimated model to carry out counterfactual policy analysis. In particular, I compare the current US economy, which I refer to as the benchmark economy, to alternative economies with different licensing policies. The main counterfactual policy analysis I carry out is to eliminate the training requirements of licensing, while keeping the homogeneous fee constant. I find that under this counterfactual, consumer welfare falls in 3.9 percent and the wage premium falls by more than half. Although consumer welfare improves as more quantities are traded in equilibrium, this is offset by a reduction in the quality of licensed goods. The fall in the quality is driven mainly by the sorting channel. With respect to the wage premium, the drastic fall is driven by a fall in the skill component. Furthermore, the decrease in the skill component is explained in 78 percent by the sorting channel and in 22 percent by the removal of sector-specific skills. I also consider counterfactual licensing policies in which the training requirements vary. I find that an optimal licensing training policy, leads to an increment in consumer welfare of 2.6 percent. Last, I evaluate the case in which training requirements are kept the same as in the benchmark economy and the fee component of licensing is eliminated. Under this counterfactual scenario, welfare only improves in 0.1 percent.

This paper is organized as follows. Section 2 describes this paper's relation and contribution to the literature. Section 3, develops the theoretical framework. Section 4 presents the data and the estimation strategy used for the quantitative analysis. Section 5, assesses the current licensing policy in the United States and its implications for the allocation of workers between licensed and unlicensed sectors. Section 6 analyzes the welfare and labor market effects of changing the license requirements of the current policy. Last, section 7 concludes.

2 Related Literature

This paper contributes to the growing literature on occupational licensing and its effects on the product and labor markets. The traditional argument in favor of a licensing policy is that there exists an information asymmetry between consumers and producers in the products markets. In this manner, a licensing policy can improve welfare of consumers if it can raise the quality of goods and services traded. Leland (1979), Shaked and Sutton (1981a, 1981b, 1982a, 1982b), and Shapiro (1983, 1986) develop models to qualitatively analyze product markets associated with information asymmetries in the quality of goods. Moreover, this earlier literature evaluates the welfare and earnings implications of regulating the producers of these goods. In particular, Shapiro (1986) proposes a model with moral hazard, in which professionals underinvest in the quality of goods they produce. By raising investment requirements, licensing alleviates the information asymmetry and raises the quality of products. Leland (1979) sets up a model, in the spirit of Akerlof (1970), in which there is adverse selection in the product market as quality of goods cannot be observed. Under this market structure, he evaluates the welfare implications of introducing a minimum quality standard for products. Furthermore, Leland (1979) points out that licensing standards chosen by a professional group can lead to other inefficiencies, such as market power of the licensing group.

The theoretical framework I develop in this paper most closely relates to Leland (1979), as the information asymmetry is adverse selection. The main difference between the previous theoretical work and my framework, is that licensing policy not only has implications for the quality of goods that are produced, but also affects the occupational choice of workers. Shaked and Sutton (1981a, 1981b) evaluate the coexistence of competing professions, but in their analysis workers do not endogenously choose to enter the different professions. In my theoretical framework, workers choose to allocate into different occupations based on ability, the licensing policy, and the effects of the information asymmetry that carries over from the product market to the labor market.

More recent work has tried to determine the quantitative implications of licensing for welfare. An extensive list of articles have analyzed the effects of licensing on the quality of goods produced. The main argument is that if licensing policy raises the quality of goods, then consumer welfare increases. These papers have mainly focused on analyzing the licensing effects on quality for specific occupations and conclusions vary according to each case study.[1] For example, Kleiner and Kudrle (2000) and Wiswall (2007) find that stricter licensing requirements do not improve the quality of dentists and teachers, respectively. On the other hand, Adams III, Ekelund Jr, and Jackson (2003) and Anderson et al. (2016) find opposite results on the quality of services provided by midwives. Kleiner and Soltas (2018) develop a richer theoretical framework to explain the welfare effects of occupational licensing, without modeling a market failure. In particular, they argue that the quantity of labor hours is a sufficient statistic for welfare analysis and find that the welfare costs of licensing offset its benefits.

A caveat of the work highlighted above is that the theoretical framework used for quantitative analysis abstracts from modeling any market failure which can be corrected by occupational licensing. I contribute to this literature by explicitly modeling an information asymmetry in the product market. Incorporating an information problem into the theoretical model is key in exemplifying the role of licensing in the economy and the trade-off it generates. More specifically, the interaction between the information problem and the licensing policy has a direct impact on the quality of goods produced in the licensed sector as well as the allocation of workers between licensed and unlicensed occupations. To my knowledge, I am the first to quantitatively evaluate this trade-off.

I also contribute to the extensive empirical analysis of the effects of licensing on labor market outcomes. The main consensus is that licensing acts as a barrier to entry that restricts the quantity of goods sold in licensed occupations, as highlighted by Blair and Chung (2018a),

1. Papers that have analyzed the effects of licensing on quality are Adams III, Jackson, and Ekelund (2002), Adams III, Ekelund Jr, and Jackson (2003), Anderson et al. (2016), Barrios (2018), Carroll and Gaston (1981), Kleiner and Kudrle (2000), Kleiner and Petree (1988), Kugler and Sauer (2005), Larsen (2013), Wiswall (2007), among others.

Friedman (1962), Gittleman, Klee, and Kleiner (2017),Kleiner (2000), Kleiner and Krueger (2013), Kleiner and Soltas (2018), Thornton and Timmons (2013), among others. Another related topic that has been vastly studied is the wage differential between licensed and unlicensed workers. Work by Blair and Chung (2018b), Kleiner and Krueger (2013, 2010), Kleiner and Soltas (2018), Thornton and Timmons (2013), among others, have estimated a wage premium of licensed workers between 6 and 15 percent, for different data sets. Most studies find that controlling for observables of skills explain some of the wage premium but not all. The remaining difference has been attributed to rents generated by quantity restrictions (Kleiner and Krueger 2013) or by information asymmetries (Blair and Chung 2018b).

By modeling an endogenous occupational choice, I contribute to the literature by providing a selection mechanism of workers into occupations, which depends on the physical environment, the worker's ability, and the licensing policy. Hence, I am able to analyze the effect of licensing on the quantity supply of labor and on the quality (ability) supply of labor into licensed occupations. I also complement the wage premium analysis of the literature by decomposing it into components that are attributed to differences in workers' ability between sectors, training requirements of licensing, and information rents.

3 Theoretical Framework

This section provides a description of the theoretical framework. First I describe the physical environment of the model in absence of licensing. I characterize the equilibrium for this case. Then, I extend the model to include licensing policy and characterize the equilibrium for this case.

3.1 Environment

I consider a static model with adverse selection in the goods market and occupational choice in the labor market. The economy is populated by a continuum measure 1 of identical households. Each household is composed of one shopper and a continuum of measure 1 of workers. There are two productive sectors, $j = 1, 2$, in the economy. Workers are heterogeneous in their ability, a. Given their ability, workers choose to produce between the two sectors. Within each sector, a worker is self-employed and uses his ability and equipment, m, to produce. Households own all the equipment in the economy and supply it inelastically. In sector 1, the goods produced are differentiated in their quality. A worker in this sector produces goods of a specific quality which depends on his ability. In sector 2, workers produce a homogeneous good. The good produced in sector j will be referred to as good j. The shopper cannot observe the specific quality, x_1, produced by a worker in sector 1. He randomly chooses a worker and buys quantity c_1 from that self-employed worker. In sector 2, the good's quality is homogeneous and the shopper purchases quantity c_2 in the market. Households have preferences over the quantities of goods produced in each sector and over the quality of good 1.

3.2 Workers and Production

Workers are heterogeneous in their ability $a \in [\underline{a}, \bar{a}]$, which is distributed according to $\mu(a)$. A production unit is made up of a single worker with ability a, who acts as an entrepreneur. This worker uses his ability and rents equipment, m, in order to produce. In sector 1, a worker of ability a produces a quantity of goods with technology:

$$f_1(m) = m^{\theta}, \tag{3.1}$$

where θ is the output elasticity of equipment. The goods produced by worker of ability a have quality:

$$x_1(a) = a. \tag{3.2}$$

In sector 2, a worker uses his ability and equipment for quantity production

$$f_2(a, m) = am^{\theta}. \tag{3.3}$$

3.3 Occupational Choice

A worker of ability a, must choose between producing in sector 1 or sector 2. In sector 1, a worker obtains earnings $w_1(a)$:

$$w_1(a) = \max_m p_1 f_1(m) - rm, \tag{3.4}$$

where r is the price of equipment. It is important to note that since quality is not observed for the sector 1 good, then there exists only one price for that good, p_1. Hence, workers in sector 1 are not compensated for the specific quality that they produce with technology (3.2). This quality is produced at no cost. In sector 2, a worker obtains earnings $w_2(a)$:

$$w_2(a) = \max_m f_2(a, m) - rm. \tag{3.5}$$

The sector 2 good is the numeraire good of the economy. I denote $m_j(a)$ as the amount of equipment demanded by the production unit with worker of ability a in sector j. Given the quantity production technologies (3.1) and (3.3), the share of output of a production unit that corresponds to a worker is $1-\theta$. Last, a worker's occupational choice is given by:

$$w(a) = \max_{d \in \{1,0\}} d\left[w_1(a)\right] + \left[1-d\right] w_2(a). \tag{3.6}$$

3.4 Household Problem

Good 1 is differentiated in its quality level $x_1(a)$, which depends on the ability, a, of the worker that produces it. Ex ante, the household's shopper cannot differentiate the specific quality produced by a worker in sector 1. Due to the information problem, shoppers have beliefs $\sigma(a)$ about the distribution of qualities of good 1, i.e. the different abilities of workers in sector 1. Given his beliefs, the shopper chooses to buy a quantity c_1 of good 1 and randomly chooses a worker to buy it from. Good 2 is homogeneous and the shopper buys quantity c_2 of this good in a competitive market. Ex post, the household obtains utility $U(c_1, x_1(a), c_2)$ from consuming both goods of the economy.[2] The sources of income of the household are the earnings of its workers, $w(a)$, and the income from renting equipment.

The household's problem is given by:

$$\max_{c_1, c_2} \quad \mathbb{E}_\sigma \left[U\left(c_1, x_1(a), c_2\right) \right] \tag{3.7}$$

$$s.t.$$

$$p_1 c_1 + c_2 = \int_{\underline{a}}^{\bar{a}} w(a)\, \partial\mu(a) + r \int_{\underline{a}}^{\bar{a}} \left[d(a)\, m_1(a) + \left[1 - d(a)\right] m_2(a) \right] \partial\mu(a).$$

Households choose $\{c_1, c_2\}$ to maximize their utility. By assumption, there is perfect consumption insurance within each household. This is because all workers pay out their earnings to be shared equally in the household. The combination of this with the law of large numbers across households, allows for the construction of a representative household.

2. A result of Akerlof (1970) is that in certain cases, markets can completely shut down when there exists adverse selection. The intuition of why this happens is as follows. The price, p_1, determines the quality of goods produced in sector 1. In particular, higher ability workers may not be willing to produce in sector 1, given that they may be underpaid in terms of their ability given a value of p_1. Without any assumptions on the demand of good 1, it can be the case that all workers are underpaid in sector 1 and decide to produce in sector 2. To avoid this issue, I assume that households always consume positive quantities of both goods: $\lim_{c_j \to 0} \frac{\partial U(c_1, x_1(a), c_2)}{\partial c_j} = \infty$.

3.5 Characterization of Equilibrium

Since households are identical, they all demand the same quantities of each good. Given that the measures of households and workers are 1, any household's consumption of c_j is equal to aggregate consumption of good j. Likewise, the demand of equipment for a worker of ability a is equal to the aggregate demand of equipment for all workers with that ability. I denote uppercase letters as aggregate quantities. The competitive equilibrium is defined as follows.

Definition 1. Given the ability distribution $\mu(a)$, a competitive equilibrium consists of relative price p_1, workers' occupational choice $d(a)$ and equipment choice $m_j(a)$, households' consumption choices $\{c_1, c_2\}$ and beliefs $\sigma(a)$ such that:

1. Given $\sigma(a)$ and p_1, $\{c_1, c_2\}$ solve the households' problems.

2. Given p_1, $d(a)$ and $m_j(a)$ solve the workers' problems.

3. Markets clear:

$$C_1 = \int_{\underline{a}}^{\bar{a}} m_1(a)^{\theta} \mathbb{I}_{\{d(a)=1\}} d\mu(a),$$

$$C_2 = \int_{\underline{a}}^{\bar{a}} a m_2(a)^{\theta} \mathbb{I}_{\{d(a)=0\}} d\mu(a).$$

4. Beliefs are consistent:

$$\mathbb{E}_{\sigma}[x_1(a)] = \frac{\int_{\underline{a}}^{\bar{a}} a m_1(a)^{\theta} \mathbb{I}_{\{d(a)=1\}} d\mu(a)}{\int_{\underline{a}}^{\bar{a}} m_1(a)^{\theta} \mathbb{I}_{\{d(a)=1\}} d\mu(a)}.$$

The consistency condition on beliefs has the following interpretation. In equilibrium, the expected value of quality for households given their beliefs is equal to the average quality of good 1 that is produced. As can be seen from the right hand side of the consistency condition, the average quality in sector 1 is equivalent to the total quality-adjusted output divided by the total output in that sector.

Due to the information structure, the competitive equilibrium defined above is characterized by having workers of low ability in sector 1 and workers of high ability in sector 2.

Proposition 1. *Let $U(c_1, x_1, c_2)$ satisfy Inada conditions. There exists a cut-off ability, $\tilde{a} \in [\underline{a}, \bar{a}]$, such that workers with $a \leq \tilde{a}$ enter sector 1 and workers with $a > \tilde{a}$ enter sector 2.*

Proof. See section A.1 in the Appendix. $\square$

Proposition 1 highlights important implications of the adverse selection problem on the goods and the labor markets. The households' demands for both goods as well as the equilibrium conditions determine cut-off $\tilde{a}$, which defines the allocation of workers between productive sectors. In equilibrium, this cut-off is equal to the equilibrium price, p_1. Workers below this cutoff are overcompensated by p_1, since they receive extra rents due to the information problem. On the other hand, workers above the cut-off $\tilde{a}$ are undercompensated by p_1. For this reason they decide to enter sector 2, where their earnings fully reflect their ability. Hence in equilibrium, sector 1 is characterized by having the least able workers, as predicted by Akerlof (1970).

3.6 Licensing Policy

As highlighted in section 3.5, due to the information problem, only low ability workers enter sector 1, producing low quality goods. Given households preferences, a policy that increases the quality of good 1 in the market has the potential to improve welfare. Therefore, I analyze the effects of introducing a licensing policy into the economy. I assume there exists a government agency that sets up a licensing policy to alleviate the effects of adverse selection on the quality of goods produced in sector 1. For the remainder of the paper, I will also refer to sector 1 and sector 2 of the theoretical model as the licensed and unlicensed sectors, respectively.

Licensing is made up of two components, a fee that a worker must pay to enter sector 1 and a training requirement for all workers. I define the licensing policy as $\Gamma = (F, T, \tau)$, where F is the licensing fee, T is per period equivalent of the required amount of time in training, and τ is the per period equivalent of the required amount of training content[3]. Workers that wish to enter sector 1 must pay a cost $\psi(a, \Gamma)$, that depends on their ability and the licensing policy Γ. I assume that the license cost is paid in terms of the numeraire good. I explicitly define the cost as:

$$\psi(a, \Gamma) = \underbrace{F}_{Fee} + \underbrace{\psi^o(a, T)}_{\text{Opportunity Cost of Training}} + \underbrace{\psi^e(a, \tau)}_{\text{Effort Cost of Training}}, \tag{3.8}$$

where ψ^o is the flow value of the opportunity cost of training and ψ^e is the flow value of the effort cost of training.[4] I make the following assumptions on the opportunity cost of training: $\frac{\partial \psi^o(a,T)}{\partial a} > 0$ and $\frac{\partial \psi^o(a,T)}{\partial T} > 0$. This implies that training is costlier the higher the time requirement and the higher the ability of the worker. Further, I assume that the effort cost of training has the following properties: $\frac{\partial \psi^e(a,\tau)}{\partial a} < 0$, $\frac{\partial^2 \psi^e(a,\tau)}{\partial a^2} > 0$, and $\frac{\partial \psi^e(a,\tau)}{\partial \tau} > 0$. Given a level of training content, workers of lower ability must exert more effort in training relative to their higher ability counterparts. Also, as the required training content increases, the effort cost of training rises.

Although training is costly, it also has benefits as it improves the productivity of workers within sector 1. More specifically, I assume that a worker that undergoes training through licensing augments his ability in sector 1 with an exogenous level of sector-specific skills, $g(\tau)$, which is only useful in the quality production of sector 1. Equation (3.2) becomes:

$$x_1(a, \tau) = ag(\tau). \tag{3.9}$$

3. Many workers that get a license must earn a certain amount of education or specialized training as well as passing one or multiple exams.

4. In the US, workers incur in the costs of licensing before they enter the licensed occupation. Given that I have a static framework, I assume that the cost of licensing is paid once as a flow value. For simplicity, I measure the effort cost of training in terms of resources.

3.7 Characterization of Equilibrium with Licensing Policy

In an economy with licensing, workers that enter the licensed occupation must pay $\psi(a, \Gamma)$. As a result, earnings in sector 1 are:

$$w_1(a) = \max_m p_1 f_1(m) - rm - \psi(a, \Gamma). \tag{3.10}$$

Earnings in sector 2 are given by (3.5), and a worker of ability a solves the problem defined by (3.6). I denote $\Psi(a, \Gamma)$ as the aggregate license cost of workers of type a. I assume that the aggregate license cost in the economy, $\int_{\underline{a}}^{\bar{a}} \Psi(a, \Gamma) \mathbb{I}_{\{d(a)=1\}} d\mu(a)$, is not rebated back to the households, representing the deadweight loss from licensing. In an economy characterized by licensing, the competitive equilibrium is given by the following definition.

Definition 2. Given the ability distribution $\mu(a)$ and licensing policy Γ, a competitive equilibrium of the economy with licensing consists of relative price p_1, workers' occupational choice $d(a)$ and equipment choice $m_j(a)$, households' consumption choices $\{c_1, c_2\}$ and beliefs $\sigma(a)$ such that:

1. Given $\sigma(a)$ and p_1, $\{c_1, c_2\}$ solve the households' problems.

2. Given p_1 and Γ, $d(a)$ and $m_j(a)$ solve the workers' problems.

3. Markets clear:
$$C_1 = \int_{\underline{a}}^{\bar{a}} m_1(a)^\theta \mathbb{I}_{\{d(a)=1\}} d\mu(a),$$
$$C_2 + \int_{\underline{a}}^{\bar{a}} \Psi(a, \Gamma) \mathbb{I}_{\{d(a)=1\}} d\mu(a) = \int_{\underline{a}}^{\bar{a}} a m_2(a)^\theta \mathbb{I}_{\{d(a)=0\}} d\mu(a).$$

4. Beliefs are consistent:
$$\mathbb{E}_\sigma[x_1(a, \tau)] = \frac{\int_{\underline{a}}^{\bar{a}} a g(\tau) m_1(a)^\theta \mathbb{I}_{\{d(a)=1\}} d\mu(a)}{\int_{\underline{a}}^{\bar{a}} m_1(a)^\theta \mathbb{I}_{\{d(a)=1\}} d\mu(a)}.$$

Similar as in section 3.5, the consistency of beliefs implies that the expected value of quality for households given their beliefs is equal to the average quality of good 1 that is produced.

Equation (3.8) shows that the entry fee, F, affects all workers homogeneously despite their ability, a. On the contrary, training affects workers heterogeneously through the opportunity cost of training, $\psi^o(a,T)$, and the effort cost of training, $\psi^e(a,\tau)$. The assumptions on the effort training cost are essential for alleviating the negative effects of the information asymmetry in sector 1. This is portrayed in Proposition 2 below.

Proposition 2. *Let $U(c_1,x_1,c_2)$ satisfy Inada conditions. If $\psi(a,\Gamma)>0$ such that $\psi^e(a,\tau)>0$, $\frac{\partial\psi^e(a,\tau)}{\partial a}<0$, and $\frac{\partial^2\psi^e(a,\tau)}{\partial a^2}>0$, then there exists two ability cut-offs, $\tilde{a}_L$ and $\tilde{a}_H$, where $\underline{a}\leq\tilde{a}_L\leq\tilde{a}_H\leq\bar{a}$, such that workers with $a\in[\tilde{a}_L,\tilde{a}_H]$ enter sector 1, and workers with $a\notin[\tilde{a}_L,\tilde{a}_H]$ enter sector 2.*

Proof. See section A.1 in the Appendix. □

Proposition 1 shows that given the adverse selection problem, low-ability workers will enter sector 1 and high-ability workers will enter sector 2. As a result of this, low quality goods are produced in equilibrium. Proposition 2 highlights the importance that the effort training cost has on alleviating the negative effects adverse selection has on the quality of goods traded in sector 1. If the effort training cost satisfies $\frac{\partial\psi^e(a,\tau)}{\partial a}<0$ and $\frac{\partial^2\psi^e(a,\tau)}{\partial a^2}>0$, then it is too costly for low ability workers to enter sector 1. As a result, they self-select out of this sector and enter sector 2 (i.e. $a\leq\tilde{a}_L$). Given this, the quantity of goods produced in sector 1 falls, which increases the price of this good. This provides the incentive for higher ability workers to enter sector 1, which improves the overall quality of sector 1 goods. However, for very high ability workers the increase in the price of good 1 is not enough to compensate them to enter sector 1 (i.e. $a>\tilde{a}_H$). Hence, they will continue to produce in sector 2 given that the information asymmetry in sector 1 implies that they are not fully compensated for their ability. Although, the effort training cost does not eliminate the adverse selection problem in sector 1, it does alleviate its negative effects on quality by excluding low ability workers from producing low quality products. In this manner, training is a mechanism that places a minimum quality standard for goods in sector 1.

4 Data and Calibration

The model is calibrated to match features of the labor market for low-skilled occupations, i.e. occupations comprised mainly of workers with low education levels. By focusing on these occupations, I use the theoretical model developed in section 3 to study product markets associated with workers of similar skill levels. In this manner, I control for the effect that educational attainment can have on occupational choice.[5] I use data from the Survey of Income and Program Participation (SIPP) 2008 panel and from the O*NET 23.0 Database to construct the sample of workers in low-skilled occupations. Below, I first describe the construction of my sample, and then I explain the estimation of my theoretical model.

4.1 Data

I use three data sources to define the calibration target moments. The first data set I use is the 2008 panel of the Survey of Income and Program Participation (SIPP). This panel is a nationally representative data set, which was carried out in 16 quarterly waves covering the period between September 2008 and December 2013. The data set has information on wages, employment, and occupations for a large number of individuals. Each wave has a corresponding topical module. I link the core data from wave 13 of the SIPP with the data of its corresponding topical module, the Professional Certifications, Licenses, and Educational Certificates module. This specific wave corresponds to the period between May and November of 2012 and has been used in two empirical pioneer studies of the occupational

5. By doing this, I do not consider unreasonable comparisons like an individual choosing to work either as a medical doctor or a waitress, where the former is a high-educated licensed occupation and the latter is a low-educated unlicensed occupation.

licensing literature, Blair and Chung (2018b) and Gittleman, Klee, and Kleiner (2017).[6] Using two specific questions from this topical module, I define a worker as licensed in the same manner as Gittleman, Klee, and Kleiner (2017). That is, I classify a worker as licensed if he possesses a professional credential and if this credential was awarded by a federal, state, or local government.[7]

I follow the criterion of Gittleman, Klee, and Kleiner (2017) when constructing my sample. I focus on individuals with ages between 18 and 64 years that are in the civilian labor force. Using data on monthly earnings, weeks worked, and weekly hours worked, I construct hourly wages and include in the sample only respondents with hourly wages between $5 and $100. The SIPP collects information on up to two jobs or up to two businesses for each worker, but does not clarify which of these jobs or businesses is the relevant one for the credential of the worker. I assume that the credential is relevant to the job or business for which the worker has the highest wage. Last, I exclude from the sample workers with imputed data for wages and worker's who did not provide a response for the credential relevant questions.[8, 9]

To determine whether an occupation is low or high skilled I use the O*NET 23.0 Database. This database describes 968 occupations using 277 descriptors. These descriptors are classified into 9 broad categories.[10] Information for each descriptor is gathered from either a survey of workers or from a survey "occupational analysts". Respondents of the worker survey are asked to report the required level of education for their occupation. I classify an occupation as low-skilled if "less than college" is the most common required level of education for the survey respondents of that occupation, and as high-skilled if "at least college" is the

6. Gittleman, Klee, and Kleiner (2017) explain with strong arguments the advantages of using the SIPP data set.

7. The two questions that allows me to identify a worker as licensed are: 1) "Do/Does you/he/she have a professional certification or state or industry license?" and 2) "Who awarded this certification or license?"

8. Including imputed wages in the estimation of the wage premium and the skill component in section 4.2 would bias estimates of these premiums towards 0 as explained by Hirsch and Schumacher (2004).

9. The non-respondence rate of workers for questions about credential status is 3.3 percent.

10. The categories are: Knowledge, Skills and Abilities; Education, Experience, and Training; Interests, Work Values, Work Styles; Tasks; Tools & Technology; Work Activities; Work Context; Related Occupations; Green Occupations.

most common response. I link this classification of occupations by education to the panel of workers of wave 13 of the SIPP.[11] Out of the 460 occupations in the SIPP, 325 are low-skilled occupations. These account for 68 percent of all workers.

For my sample of workers in low-skilled occupations, the average monthly earnings is $3,986. Table 1 presents a set of descriptive statistics for the observations in my sample, separately for licensed and unlicensed workers. On average, licensed workers have higher wages, are older, and are more educated, relative to their unlicensed counterparts. Also, licensed workers have a higher participation of women and have a higher number of workers in the government, in a service industry, and in unions. These patterns are consistent to those found by Blair and Chung (2018b) and Gittleman, Klee, and Kleiner (2017).

Table 1: Descriptive Statistics

	Licensed	Unlicensed
Number of Observations	8,696	47,831
Mean - Monthly Wage	4,523	3,886
Age	42.8	41.0
Share:		
Men	0.49	0.53
Government Workers	0.22	0.11
Services	0.82	0.74
Less than College	0.76	0.83
Union	0.18	0.11

Source: Wave 13 of the SIPP Panel 2008.
Number of observations: 56,527

Note: This table reports summary statistics by licensing status using data from wave 13 of the SIPP Panel 2008. I restrict the sample to workers with age between 18 to 64 and with hourly wage from $5 to $100. Observations with imputed wages are dropped.

11. Occupations in the O*NET are classified according to the Standard Occupational Classification - SOC. On the other hand, occupations in the SIPP 2008 are classified with the 2002 Census Code Classification. Using a crosswalk between these two different occupation code systems, I am able to link my classification of occupations by education to the worker data of the SIPP panel.

Carpenter et al. (2012) carry out an in depth analysis of licensing burdens and costs for 102 occupations. They choose occupations that earn less than the national average of income and are at least licensed in one state. For each of these occupations they gather information on the different measures of licensing burdens. In particular, they gather information on different burdens of licensing like fees, amount of time spent on training prior to obtaining a license, number of exams, and minimum age requirements. As explained in section A.2.1 of the appendix, I parametrize the fee and opportunity cost component of the license cost specified in equation (3.8) using both my sample of the SIPP and the database of Carpenter et al. (2012). On average, licensed workers in low-skilled occupations pay a fee of \$91 and train for 9 months before they enter a licensed occupation.

4.2 Wage Premium Decomposition

The empirical literature on occupational licensing has focused a great deal in understanding the differences in wages between licensed and unlicensed occupations. Studies such as Blair and Chung (2018b), Kleiner (2000), Kleiner and Krueger (2013, 2010), Kleiner and Soltas (2018), among others have documented a wage premium for licensed workers, even after controlling for skill observables. They explain these differences as coming from monopoly or information rents. I document that, for low-skilled occupations, the average wage of licensed workers is 16 percent higher than the average wage of their unlicensed counter parts. Similar to Kleiner (2000), I decompose this wage difference using a Oaxaca-Blinder decomposition, by regressing monthly wages, $w_{i,j}$ on skill observables, $x_{i,j}$ separately for licensed, $j = L$, and unlicensed, $j = NL$, workers:

$$w_{i,j} = x_{i,j}^{'}\beta_j + u_{i,j}. \tag{4.1}$$

The skill observables which I control for are gender, education, age, and indicators for union membership, government workers, and service workers. I decompose the average wage premium into a skill component and a residual component. The skill component corresponds to differences in skills between licensed and unlicensed workers that are accounted for by the human capital observables (gender, education, industry, among others). That is, this component captures observable differences in the general ability of workers between licensed and unlicensed professions, as well as the specific skills that licensed workers acquire through the training requirements of licensing. On the other hand, the residual component accounts for monopoly rents, information rents, and any unobservable skill differences between licensed and unlicensed workers:

$$\bar{w}_L - \bar{w}_{NL} = \underbrace{\left(\bar{x}_L^{'} - \bar{x}_{NL}^{'}\right)\beta_L}_{\text{Skill Component}} + \underbrace{\bar{x}_{NL}^{'}\left(\beta_L - \beta_{NL}\right)}_{\text{Residual Component}}. \tag{4.2}$$

Table 2: Wage Premium Decomposition

Wage Premium	0.164
	(0.007)
Skill Component	0.090
	(0.003)
Residual	0.074
	(0.003)

Source: Wave 13 of the SIPP Panel 2008.
Number of observations: 56,527
Estimates are significant at the 1% confidence level. Standard errors in parentheses.
Note: This table reports the Oaxaca-Blinder decomposition of the average wage premium between licensed and unlicensed workers. The unit of observation is person-month. The dependent variable is monthly wage. The human capital regressors are gender, education, age, and indicators for union membership, government workers, and service workers. I restrict the sample to workers with age between 18 to 64 and with hourly wage from \$5 to \$100. Observations with imputed wages are dropped. Wages are normalized by the mean wage of unlicensed workers.

Table 2 presents the average wage decomposition results. Of the 16 percent difference in average wages between licensed and unlicensed workers, 9 percentage points are explained by differences in skill observables between licensed workers and unlicensed workers.

4.3 Calibration

4.3.1 Functional Forms and Assigned Parameters

To calibrate the model, I first specify the ability distribution of workers as a non-standard beta distribution, betacdf $\left(\frac{a-\underline{a}}{\bar{a}-\underline{a}}; \alpha_a, \beta_a\right)$, with shape parameters α_a and β_a. The advantage of the beta distribution is that it has a bounded support as well as being flexible in the shapes it can take, regardless of only depending on two parameters. Next, I choose functional forms for households' utility $U\left(c_1, x_1\left(a,\tau\right), c_2\right)$, the ability augmenting training technology $g\left(\tau\right)$, and the license cost $\psi\left(a,\Gamma\right)$. I assume that the utility function is of the following form:

$$U\left(c_1, x_1\left(a,\tau\right), c_2\right) = \rho \times x_1\left(a,\tau\right) \times \log\left(c_1\right) + \log\left(c_2\right). \tag{4.3}$$

By assuming a functional form linear in $x_1\left(a\right)$, I nest Leland (1979)'s analysis, such that the expected utility in the households' problem 3.7 is given by:[12]

$$\mathbb{E}_\sigma\left[U\left(c_1, x_1\left(a\right), c_2\right)\right] = \rho \times \mathbb{E}_\sigma\left[x_1\left(a,\tau\right)\right] \times \log\left(c_1\right) + \log\left(c_2\right). \tag{4.4}$$

Household's expected utility Parameter ρ determines how important sector 1 good is for the household. I define the ability augmenting training technology for quality production as:

$$g\left(\tau\right) = \max\left\{\tau^{\nu}, 1\right\}. \tag{4.5}$$

12. Similar to Leland (1979), the quantity demanded of good 1 satisfies the following properties under this utility specification:

$$\frac{\partial c_1^*}{\partial p_1} < 0, \ \frac{\partial c_1^*}{\partial \mathbb{E}_\sigma\left[x_1\left(a,\tau\right)\right]} > 0.$$

This functional form implies that the quality produced by a worker in a licensed occupation cannot be lower than his ability a, as can be see from (3.2). Thus, training cannot lower a worker's ability. I define the opportunity cost of licensing and the effort training cost licensing as:

$$\psi^{o}\left(a,T\right)=w_{2}\left(a\right)T, \tag{4.6}$$

$$\psi^{e}\left(a,\tau\right)=\tau\left(\frac{\bar{a}-a}{\bar{a}}\right)^{\gamma}. \tag{4.7}$$

The opportunity cost is the product of a worker's wage in sector 2, the unlicensed sector, and the per period equivalent of the training time requirement. The effort training cost is decreasing in ability, a, and increasing in the per period equivalent of the training content requirement, τ. Parameter γ governs how much more effort a worker of ability a must exert in training relative to the highest ability worker, $\bar{a}$.

Table 3: Assigned Parameters

Parameter	Value	Description	Source
r	0.003	Price of Equipment	Implies discount rate of 0.996
$1-\theta$	0.54	Labor income share	BEA 2010-2016
T	0.04	Training time requirement	SIPP, Carpenter et al. 2012
F	3.94	License fee	SIPP, Carpenter et al. 2012

r is monthly real interest rate. F is the per period equivalent of the present discounted value of total licensing fees and T is the per period equivalent of the training time requirement.

The list of assigned parameters are given in Table 3. I set r, the price of equipment, so that it implies a period discount rate of 0.996.[13] Hence the price of renting equipment is equal to 0.003. I set the output elasticity of equipment, θ, to match the average of the labor

13. This discount rate is used to calculate the flow values of the license cost components, as explained in section A.2.1 of the appendix.

income share between 2010 and 2016 for the United States. Using my sample from the SIPP and the database provided by Carpenter et al. (2012), I calculate the per period equivalent of the license fee, F, and the per period equivalent of the training time requirement, T. This is explained in further detail in section A.2.1 of the appendix.

4.3.2 Internally Calibrated Parameters

I calibrate the parameters associated with the ability distribution, the utility function, and training to match wages and employment moments from my sample. I report the parameter values from the calibration in Table 4. Although parameters are jointly calibrated, there are some data moments that are more informative about specific parameters. The ability distribution parameters, α_a and β_a are pinned down primarily by the mean and standard deviation of wages from my sample. The parameter ρ controls the weight that the sector 1 good has in the utility function. Hence, ρ determines the quantity demanded of good 1. In equilibrium, the quantity demanded of good 1 is directly related to the amount of workers that supply that good. For this reason, this parameter is primarily pinned down by the share of licensed workers.

The effort training cost, (4.7), acts as an heterogeneous barrier to entry of workers into licensed occupations. Both τ, the training content requirement, and γ, the parameter that governs the relative effort exerted in training by a worker, shape the severity of the heterogeneous barrier to entry. In the model, there is a direct implication that changes in the severity of the effort training cost of licensing yields changes in the composition of ability between licensed and unlicensed sectors. Furthermore, changes in the ability composition result in changes in the wage premium and in the share of household income that corresponds to licensed workers. Hence these parameters are primarily pinned down to match the 16 percent wage premium between licensed and unlicensed workers and the income share of licensed workers of 18 percent.

Training also provides benefits for licensed workers. As can be seen from equations (3.2) and (4.5), the quality a worker produces is determined by his ability a and sectors-specific skills $g(\tau)$. Parameter ν determines the amount of sector-specific skills that licensed workers obtain from the training content requirement, τ. In section 4.2, I decompose the wage premium of licensed workers into differences in skills between sectors, the skill component, and a residual component. In the model, differences in skill between sectors is determined by the composition of ability between these and by the sector-specific skills obtained through training. Given this, parameter ν is mainly pinned down by the skill component of the wage premium decomposition.

Table 4: Internally Calibrated Parameters

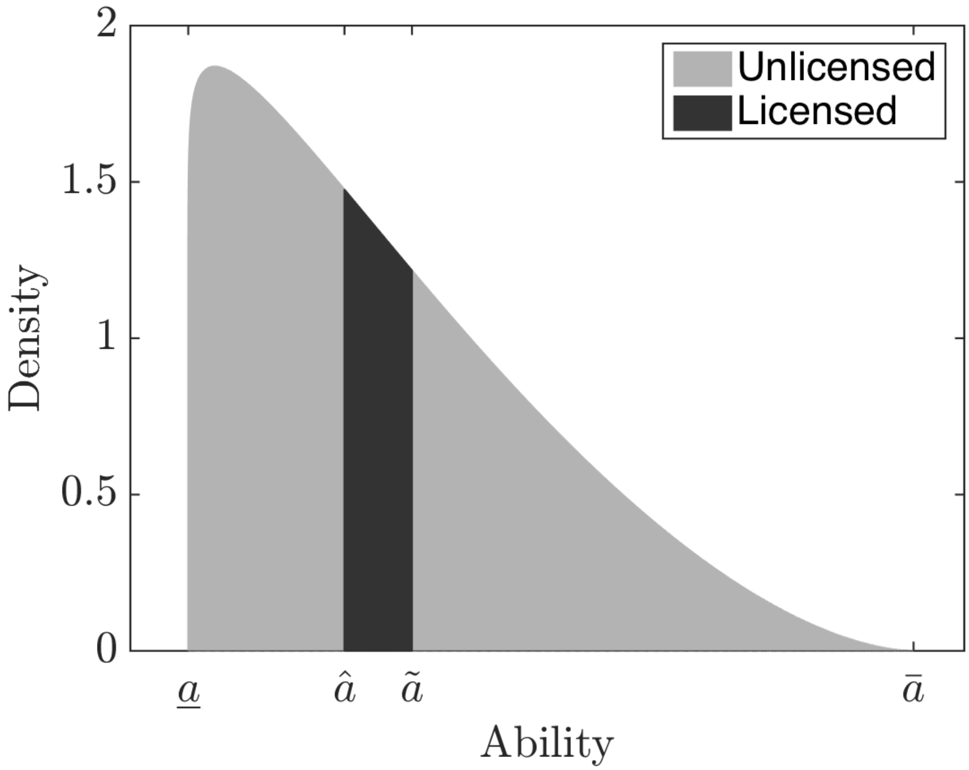
Parameter	Value	Target Moments	Model	Data
Distribution:				
α_a	1.06	Mean - wages	3,986	3,986
β_a	2.71	St. Dev. - wages	2,194	2,194
Utility:				
ρ	0.24	Share of lic. workers	0.154	0.154
Training:				
τ	888	Wage premium	1.164	1.164
γ	7.54	Income share of lic. workers	0.175	0.175
ν	0.02	Skill component	1.090	1.090

5 Licensing Policy in the US

As I explained in section 4, I set parameters of my model to match labor market moments of low-skilled occupations. Using this calibration, I am able to characterize the allocation of workers between licensed and unlicensed occupations for the United States. Figure 1 portrays the distribution of ability for my model calibration. Workers with ability $a \in [\hat{a}, \tilde{a}]$ are allocated in the licensed sector, ability interval that accounts for 15 percent of all workers.

Workers below ability $\hat{a}$ are those for which obtaining the license is too costly. Hence, the licensing policy excludes workers of very low ability from entering the licensed sector, as licensing is more costly for them in terms of effort. On the other hand, workers with ability above $\tilde{a}$ enter the unlicensed sector. The reason for this is that, in the licensed sector, the earnings of these workers do not not fully compensate them for their high ability. Thus, they choose to enter the unlicensed sector where their earnings fully reflect their productivity.

Figure 1: Ability Composition of Workers - Current US Licensing Policy



The current licensing policy ameliorates the effects of the information asymmetry on the quality of licensed sector goods, in comparison to a no licensing policy. It does this through two channels. First, licensing policy has effects on the quality of licensed goods, as licensing requirements determine the ability composition of workers between the licensed and unlicensed sectors. This is the sorting channel I introduced earlier. As shown in Figure 1, the current US licensing policy improves the quality of licensed goods in the market by excluding the low ability workers from entering the licensed sector and by incentivizing higher ability workers to enter that sector. Of the workers in the licensed sector, only 27 percent have ability that is higher than the average ability of all workers. Second, quality also improves due to the specific skills obtained through the content of training, which augments ability of workers in the licensed sector in 13 percent. I refer to this channel as the sector-specific skills channel.

In my calibration strategy, I match the skill component between the licensed and unlicensed sector, which I estimate in section 4.2. Using my model, I decompose how much of the skill component is explained by the sorting channel and how much is explained by the sector-specific skills channel. For the sorting channel, the average ability of workers in the licensed sector is 15 percent lower than the average ability of unlicensed workers. With respect to the sector-specific skills channel, training improves the productivity of workers in the licensed sector by 24 percent. The sum of these two components gives the 9 percentage point difference in skills between licensed and unlicensed workers.

Licensing policy also generates a deadweight loss for the economy as households have to spend a portion of their income in license costs. Given the current licensing policy, licensed workers spend 25 percent of their gross earnings on license costs. Of the total license costs in the economy, the effort cost of training accounts for 88 percent, the opportunity cost of training training for accounts for 11 percent, and license fees only account for 1 percent. Hence, the training components of licensing are the entry barriers which account for most of the deadweight loss of licensing. Given that license costs are paid in units of good 2, I find that they account for 2.8 percent of the output of this good.

6 Counterfactual Policy Analysis

In this section, I evaluate the effects of changing the current licensing policy on welfare, the allocation of labor, and the wage premium. First, I explain the measure of welfare I use. Then, I study different counterfactual licensing policies in which I vary training requirements as well as license fees.

6.1 Welfare Measure

To study the effects of different licensing policies on welfare I consider the following welfare measure. I define the current licensing policy in the US as Γ^B. I compare all the counterfactual results to this benchmark. Let Γ^N be any counterfactual licensing policy. I measure the difference in welfare between the two economies using a consumption equivalent transfer, ω, in terms of the unlicensed good:

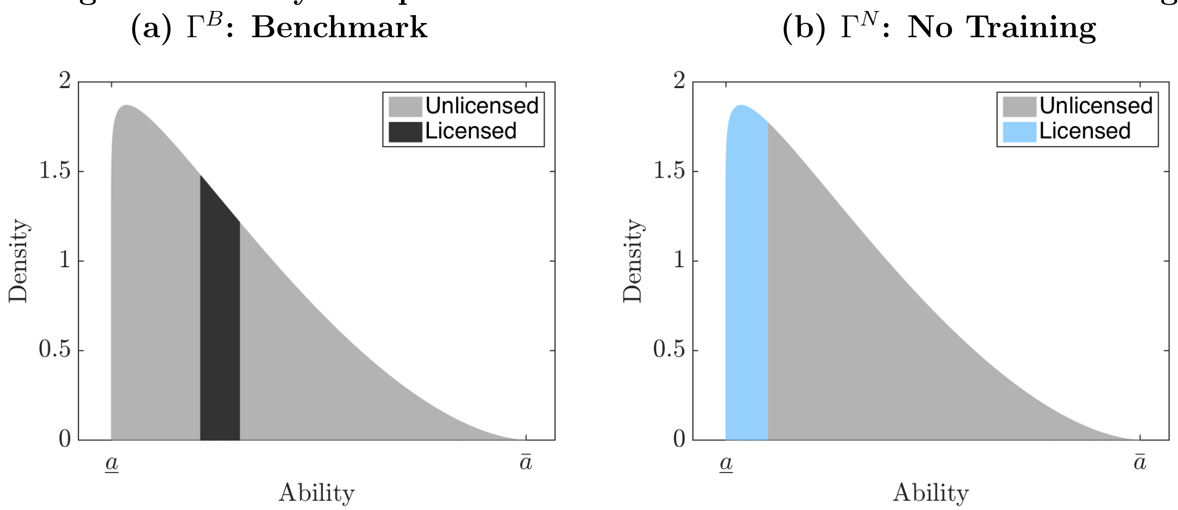
$$\rho \times \mathbb{E}_\sigma \left[x_1\left(a, \tau\right)\right]^B \times \log\left(c_1^B\right) + \log\left(c_2^B\left(1+\omega\right)\right) = \rho \times \mathbb{E}_\sigma \left[x_1\left(a, \tau\right)\right]^N \times \log\left(c_1^N\right) + \log\left(c_2^N\right).$$

The interpretation of ω is the following. Consider two economies, one under the benchmark policy, Γ^B, and another under the new licensing policy, Γ^N. Welfare between the two economies would be equal if the households' consumption of the unlicensed good changed in $\omega \times 100$ percent for the current US economy under the benchmark licensing policy, Γ^B. In the model, the license cost is paid in terms of the numeraire good, which is the unlicensed good. For this reason, I choose the consumption equivalent to be in terms of this good.

6.2 No Training

In this section, I evaluate the effects of eliminating training from the licensing requirements. That is, I set the training time requirement to $T = 0$ and the training content requirement to $\tau = 0$, while keeping the license fee, F, at its calibrated value. Figure 2 shows the ability allocation of workers for the benchmark policy and for the no training counterfactual policy. A change in the licensing policy generates a change in the composition of ability between the licensed and the unlicensed sector. In particular, a no training policy shuts off the heterogeneous portion of the license cost in (3.8). By eliminating the effort training cost, lower ability workers become licensed since they only have to pay a small licensing fee instead of paying the large training cost associated with their ability type in the benchmark licensing policy. As a result, the relative price falls since the supply of the licensed good increases as more workers enter this sector. Given this, higher ability workers are not fully compensated anymore in the licensed sector, and decide to produce in the unlicensed sector.

Figure 2: Ability Composition of Workers - Benchmark vs. No Training



By eliminating training, quality is affected through both the sorting channel and the sector-specific skills channel. The sorting channel is clearly depicted in Figure 2. By eliminating the effort training cost, low ability workers are no longer excluded from the licensed sector. Also, a lower equilibrium relative price incentivizes higher ability workers to exit the licensed sector. This change in the composition of ability between both sectors results in lower quality goods being produced, since the licensed sector is now comprised of lower ability workers. When training is eliminated, the sector-specific skills channel is shut-off so that $g(\tau) = 1$. Thus, quality also falls since ability is not augmented by training anymore. It is important to note that the license fee by itself is not able to generate the sorting effect seen in Figure 2. This is due to the fact that the fee affects all workers homogeneously as well as its present value being very small in terms of resources. Thus, the current licensing fee in the United States cannot exclude low ability workers from entering the licensed sector, making it inefficient in alleviating the information friction in the licensed sector.

Moving from the benchmark policy to a counterfactual policy leads to a change in welfare that is due to changes in the average quality of the licensed good, $\mathbb{E}_\sigma [x_1(a, \tau)]$ and in the consumption quantities of both goods, $\{c_1, c_2\}$. As shown in Table 5, if the US was to implement a no training counterfactual policy, then consumer welfare would fall in 3.9 percent. When moving from the benchmark to the no training policy, the sorting channel and the sector-specific skills channel are eliminated. This results in a reduction in average quality that implies a 11.1 percent drop in welfare. On the other hand, the quantities consumed of both goods increase. For the licensed sector good, c_1 increases since there is a larger number of workers producing in the licensed sector, as can be seen in the first column of Table 6. Although there is a larger number of units consumed of the licensed good, the fall in welfare that comes from the reduction in quality is only offset by 0.1%. On the contrary, consumer welfare improves by 7.1 percent through a higher consumption of good 2. In equilibrium there is a higher quantity of good 2 because both demand and supply is higher for that good. Since quality falls, the relative weight of good 2 in the expected utility (4.4) increases, which implies a higher demand for that good relative to the benchmark policy. Supply for that good increases since higher ability workers are now allocated in sector 2, which implies that output is larger. Overall, I find that eliminating training requirements from the licensing policy has a negative impact on the economy. Although welfare increases since more resources are now allocated towards quantity consumption, removing training requirements is also costly since lower quality licensed goods are produced. The latter effect is stronger than the former, resulting in the overall fall in consumer welfare.

Table 5: Decomposition of Change in Welfare - No Training (%)

Δ Welfare	Quality of $j = 1$	Quantity of $j = 1$	Quantity of $j = 2$
-3.9	-11.1	0.1	7.1

There are large effects on the labor market from eliminating training from the licensing policy as can be observed from Table 6 and Table 7. There is an increase in 7 percentage points in the share of licensed workers. Since lower ability workers allocate into the licensed sector, average ability of that sector falls in 38 percent. Furthermore, licensed workers' average productivity falls even more, in 51 percent, since sector-specific skills have been eliminated. On the other hand, as workers of higher ability enter sector 2, the average ability of its workers improves which implies a higher production of sector 2 goods.

Table 6: Change in Labor Allocation - No Training (%)

Share of Workers $j = 1$	Average Ability in $j = 1$	Average Ability in $j = 2$
37.9	-38.3	8.8

The fall in the wage premium is large, when moving from the benchmark policy to the no training policy. Under this counterfactual policy, workers in the unlicensed sector are paid more than twice as much as their licensed counterparts. The fall in the wage premium is mainly driven by a considerable drop in the skill component. Furthermore, 78 percent of the reduction in the skill component is accounted for by the sorting channel and the other 22 percent corresponds to sector-specific skills channel. The effect of the fall of the skill component on the wage premium is offset by an increase in information rents of 12.9 percent, which is explained by the fact that lower ability workers are overcompensated more in the absence of training.

Table 7: Decomposition of Change in Wage Premium - No Training (%)

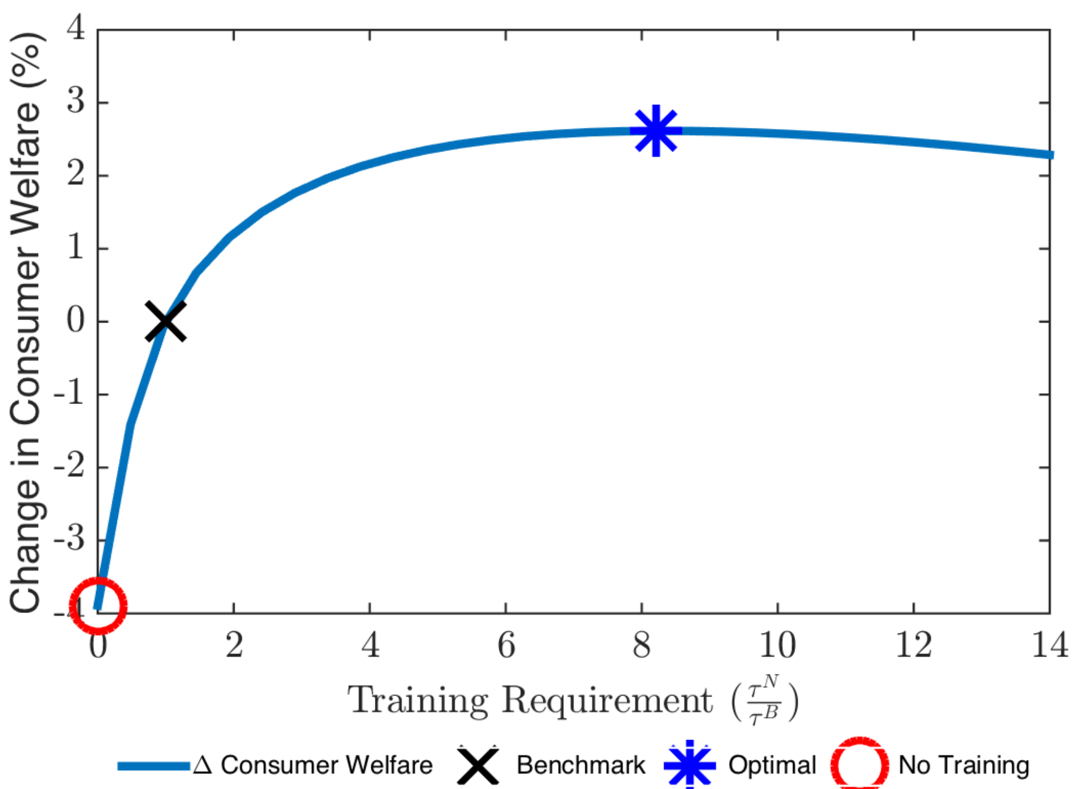
Δ Wage Premium	Δ Skill Component	Δ Information Rents
-94.9	-107.8	12.9

6.3 Different Levels of Training Content

In this section, I consider different counterfactual licensing policies that vary on the training requirement $\left(\tau^N, T^N\right)$ while keeping the license fee fixed at its calibrated value. In particular, a policy that doubles the training requirement means that both the training content, τ^N, and time, T^N, requirements are doubled with respect to the benchmark policy, $\left(\tau^B, T^B\right)$. Figure 3 portrays the percent change in consumer welfare for different levels of training requirements relative to the benchmark licensing policy. I find that the optimal training policy is to increase training requirements by a factor of eight. This number is relatively big, but this is a result of two assumptions I have made on the opportunity cost and license fees when carrying out the quantitative analysis.

First, as explained in section A.2.1 of the appendix, I assume that workers only train once throughout their lifetimes. In doing so, I am taking a conservative stance on the calibration of the opportunity cost of training. Many licensing boards require workers to carry-out continuous training in order for them to renew their license. Hence, the value of T^B in my calibration exercise acts as a lower bound. I have made this assumption given that there is no reliable data on the amount of time workers have to spend on training in order to renew their license. Second, also as explained in section A.2.1, when I calculate the per period equivalent of license fees and training time requirements, I assume that workers on average spend 40 years working. By assuming this, the per period equivalents of license fees and the opportunity cost of licensing are small throughout my quantitative analysis.

Figure 3: Effect of Training Requirements on Consumer Welfare



If the US was to move to the optimal training requirement, then consumer welfare would increase in 2.6 percent as seen in Table 8. The mechanics behind this welfare change is similar to the no training counterfactual policy analysis. Quality improves due to the sorting channel and the sector-specific skills channel. With respect to the sorting channel, as the effort training cost becomes higher relative to the benchmark, it becomes even costlier for lower ability workers to pay the license cost. As a result, less workers enter the licensed sector which leads to a reduction in the supply of licensed goods and a higher relative price. The increment in the price incentivizes higher ability workers to enter the licensed sector. As can be seen in Figure 5 of the appendix, higher ability workers enter the licensed sector under the optimal licensing policy in comparison to the benchmark. The effect of the sector-specific skills channel on quality is straight forward. Since workers receive higher content requirements, then they produce higher quality goods. This increase in the quality raises welfare by 7.9 percent.The positive effect on welfare from raising quality is offset by a reduction in the consumption of quantities of both goods. By raising training requirements to the optimal level, household's have to spend more resources on license costs. Given this, they consume less of both goods and welfare is reduced by 5.3 percent.

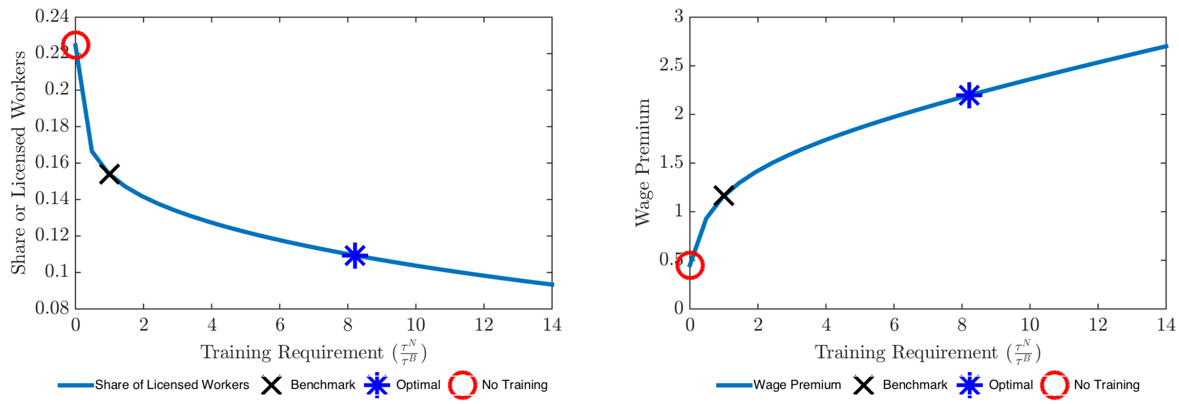
Table 8: Decomposition of Change in Welfare - Optimal Training (%)

Δ Welfare	Quality of $j = 1$	Quantity of $j = 1$	Quantity of $j = 2$
2.6	7.9	-1.7	-3.6

Figure 4 portrays the effects of different training policies on the labor market. Panel (a) of Figure 4 shows that as training requirements become higher, less workers enter the licensed sector resulting a drop in the share of licensed workers. As training requirements become higher, it is costlier for lower ability workers to enter the licensed sector and it is more profitable for higher ability workers to become licensed. Since higher ability workers have a lower density then the number of licensed workers reduces as license training requirements rise. Panel (b) of Figure 4, shows that as training requirements rise the wage premium also rises. This result is driven by the fact that higher training requirements increase the skill component of the wage premium.

Figure 4: Effect of Training Requirements on the Labor Market

(a) Share of Licensed Workers **(b) Wage Premium**



Moving to the optimal training policy implies a reduction of 4.4 percentage points in the share of licensed workers. Tables 10 and 11 in the appendix show the effects on the labor market of moving to the optimal licensing policy. Average ability in the licensed sector increases in 22.7 percent while average ability of unlicensed workers falls by 3.2 percent. Also, under the optimal training policy, the wage premium increases in 63.5 percent relative to the benchmark, mainly driven by a 55.9 increase in the skill component. The increase in the skill component is driven in 86 percent by the sorting channel and in 14 percent by sector-specific skills channel.

6.4 No License Fee

In this section, I evaluate the effects of eliminating the license fee, while keeping the training requirements at the same level as in the benchmark licensing policy. As stated in section 5, license fees only account for 1 percent of total license costs. For this reason, a licensing policy that only removes license fees generates little effect on the economy. Table 9 shows that eliminating license fees only yields a 0.1 percent increase in welfare relative to the benchmark economy. This change in welfare is driven by a higher quantity of licensed goods being consumed, as eliminating fees implies that more workers enter licensed occupations. However, since fees are small, then only very few workers switch from the unlicensed to the licensed sector. The ability composition of workers remains very similar to the benchmark economy as can be seen in Figure 6 in the appendix. This shows that changes in license fees are less important for the sorting channel in comparison to changes in training requirements. This is because license fees affect all workers homogeneously, while training affects workers differently depending on their ability. As a result, the heterogeneous training costs have larger effects on the composition of abilities between sectors. For this reason, eliminating only license fees has very little effect on the labor market, as can be seen in Tables 12 and 13 of the appendix.

Table 9: Decomposition of Change in Welfare - No Fee (%)

Δ Welfare	Quality of $j = 1$	Quantity of $j = 1$	Quantity of $j = 2$
0.1	0.0	0.1	0.0

7 Conclusion

The objective of this paper is to evaluate the effects of occupational licensing on welfare and labor market outcomes. To do this, I set up a theoretical framework with information asymmetries in the product market and occupational choice in the labor market. Workers choose occupations based on their ability and the licensing policy. By explicitly modeling the information asymmetry, there is a potential welfare improving role for licensing in the economy. Licensing is modeled as an entry fee and as costly training. I calibrate the model to match specific moments of the US using the 2008 SIPP panel and the O*NET database. I control for differences in education, by calibrating the model to only occupations composed mainly of workers with less than college education. Using the calibrated model, I carry out counterfactual licensing policy analysis. I find that implementing a no training policy leads to a welfare loss of 3.9 percent. Also, the wage premium drops by more than half. I find that these results are driven by changes in the composition of ability of workers between the licensed and unlicensed sectors, which I refer to as the sorting channel.

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A Appendix

A.1 Model

Proposition 1. *Let $U(c_1, x_1, c_2)$ satisfy Inada conditions. There exists a cut-off ability, $\tilde{a} \in [\underline{a}, \bar{a}]$, such that workers with $a \leq \tilde{a}$ enter sector 1 and workers with $a > \tilde{a}$ enter sector 2.*

Proof. Define $p_1^* = p_1^*(\mu(a), \sigma(a), c_1^*, c_2^*)$ as the equilibrium relative price. Given that $U(c_1, x_1, c_2)$ satisfies Inada conditions, then positive quantities of both goods are demanded in equilibrium, $c_1^* > 0$ and $c_2^* > 0$. Hence, p_1^* is determined by the households' demands of good 1 and good 2 and the equilibrium conditions. Earnings in sector 1 and 2 are given by:

$$w_1(a) = \left(\frac{\theta p_1^*}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right) \text{ and}$$

$$w_2(a) = \left(\frac{\theta a}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right).$$

Define $\tilde{a}$ as the worker which is indifferent between sector 1 and sector 2:

$$\left(\frac{\theta p_1^*}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right) = \left(\frac{\theta \tilde{a}}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right)$$

$$\Longrightarrow \tilde{a} = p_1^*.$$

Hence, for workers $a \leq \tilde{a} = p_1^*$, $d(a) = 1$ since $w_1(a) \geq w_2(a)$. On the other hand, for $a > \tilde{a} = p_1^*$, $d(a) = 0$ as $w_2(a) > w_1(a)$. $\square$

Proposition 2. *Let $U(c_1, x_1, c_2)$ satisfy Inada conditions. If $\psi(a, \Gamma) > 0$ such that $\psi^e(a, \tau) > 0$, $\frac{\partial \psi^e(a,\tau)}{\partial a} < 0$, and $\frac{\partial^2 \psi^e(a,\tau)}{\partial a^2} > 0$, then there exists two ability cut-offs, $\tilde{a}_L$ and $\tilde{a}_H$, where $\underline{a} \leq \tilde{a}_L \leq \tilde{a}_H \leq \bar{a}$, such that workers with $a \in [\tilde{a}_L, \tilde{a}_H]$ enter sector 1, and workers with $a \notin [\tilde{a}_L, \tilde{a}_H]$ enter sector 2.*

Proof. Define $p_1^* = p_1^*(\mu(a), \sigma(a), c_1^*, c_2^*)$ as the equilibrium relative price. Given that $U(c_1, x_1, c_2)$ satisfies Inada conditions, then positive quantities of both goods are demanded in equilibrium, $c_1^* > 0$ and $c_2^* > 0$. Hence, p_1^* is determined by the households' demands of good 1 and good 2, the equilibrium conditions, and the licensing policy. For simplicity let's assume that $F = 0$ and $\psi^o(a, T) = 0$. Earnings in sector 1 and 2 are given by:

$$w_1(a) = \left(\frac{\theta p_1^*}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right) - \psi^e(a, \tau) \text{ and}$$

$$w_2(a) = \left(\frac{\theta a}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right).$$

A worker of ability a is indifferent between working in sector 1 or sector 2 if:

$$\left(\frac{\theta p_1^*}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right) - \psi^e(a, \tau) = \left(\frac{\theta a}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right)$$

$$\Longrightarrow \left(\frac{\theta}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right) \left(p_1^{*\frac{1}{1-\theta}} - a^{\frac{1}{1-\theta}}\right) = \psi^e(a, \tau).$$

Define $h(a) = \left(\frac{\theta}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right) \left(p_1^{*\frac{1}{1-\theta}} - a^{\frac{1}{1-\theta}}\right)$, such that $\frac{\partial h(a)}{\partial a} < 0$, and $\frac{\partial^2 h(a,)}{\partial a^2} < 0$ for all $a \in [\underline{a}, \bar{a}]$. For certain values for parameters θ, r, and τ, and given that $\frac{\partial \psi^e(a,\tau)}{\partial a} < 0$, and $\frac{\partial^2 \psi^e(a,\tau)}{\partial a^2} > 0$ for all $a \in [\underline{a}, \bar{a}]$, then there exists $\tilde{a}_L$ and $\tilde{a}_H$ such that:

$$\left(\frac{\theta}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right) \left(p_1^{*\frac{1}{1-\theta}} - \tilde{a}_L^{\frac{1}{1-\theta}}\right) = \psi^e(\tilde{a}_L, \tau), \text{ and}$$

$$\left(\frac{\theta}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right) \left(p_1^{*\frac{1}{1-\theta}} - \tilde{a}_H^{\frac{1}{1-\theta}}\right) = \psi^e(\tilde{a}_H, \tau).$$

Since $\frac{\partial \psi^e(a,\tau)}{\partial a} < 0$, $\frac{\partial^2 \psi^e(a,\tau)}{\partial a^2} > 0$, $\frac{\partial h(a)}{\partial a} < 0$, and $\frac{\partial^2 h(a,)}{\partial a^2} < 0$, if $a < \tilde{a}_L$ or if $a > \tilde{a}_H$ then:

$$\left(\frac{\theta}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right) \left(p_1^{*\frac{1}{1-\theta}} - a^{\frac{1}{1-\theta}}\right) < \psi^e(a,\tau).$$

On the other hand, if $a \in [\tilde{a}_L, \tilde{a}_H]$, then:

$$\left(\frac{\theta}{r}\right)^{\frac{1}{1-\theta}} \left(\frac{r}{\theta} - r\right) \left(p_1^{*\frac{1}{1-\theta}} - a^{\frac{1}{1-\theta}}\right) \geq \psi^e(a,\tau).$$

□

A.2 Data

A.2.1 License Cost Components

Carpenter et al. (2012) carry out an in depth analysis of occupational licensing for the Institute for Justice. Specifically, they create a database and use it to evaluate the licensing burdens and costs for 102 lower-income occupations across all states and the District of Columbia. These occupations earn less than the national average and are at least licensed in one state. For each of these occupations they gather information on the different measures of licensing burdens at the state level. In particular, they gather information on licensing fees, amount of time spent on training prior to obtaining a license, number of exams, and minimum age requirements.

I use their burden measures of fees and amount of time spent training to back out the fee and opportunity cost components of the license cost in equation (3.8). For each occupation, I construct averages across states for the license fees and for the training time requirements. I match this data on fees and amount of time spent training to all the licensed workers within my sample from the SIPP data set. On average, the license fees paid by workers within my sample is \$91. According to a report by The Foundation for Government Accountability, licensing boards typically require renewal fees every one or two years. I construct the discounted value of total licensing fees within a worker's lifetime by making three assumptions. First, since my sample includes workers between the ages of 18 and 64 years, I assume that workers on average spend 40 years working. Second, I assume that workers have to renew fees every two years and every time they renew they must pay \$91. Third, I use the calibrated value of $r = 0.003$ to discount future license fees; this value of r implies a discount rate of $\delta = 0.996$. As my model is static, the calibrated value of the fee component, F, corresponds to the per period equivalent of the present discounted value of total fees across a worker's career. To calculate F, I use the following formula:

$$F = \text{PDV of lifetime fees} \times \frac{(1-\delta)}{(1-\delta^{(40\times 12)})}$$

Although the theoretical model is static, including the opportunity cost of training in terms of resources is important as it also acts as a barrier to entry of workers into licensed occupations. Furthermore, this cost also varies with a worker's ability, which is the main distinction between the opportunity cost and the license fee. I use the average amount of time spent training to calibrate T in the opportunity cost component of the license cost. On average, licensed workers in low-skilled occupations train 9.1 months before they enter a licensed occupation. I assume that workers only train once within their working lifetime. Hence, T corresponds to the per period equivalent of the training time requirement, which is calculated using:

$$T = 9.1 \text{ months} \times \frac{(1-\delta)}{(1-\delta^{(40\times 12)})}.$$

A.3 Counterfactual Policy Analysis

A.3.1 Optimal Training

Figure 5: Ability Composition of Workers - Benchmark vs. Optimal Training

(a) Γ^B: Benchmark **(b) Γ^N: Optimal Training**

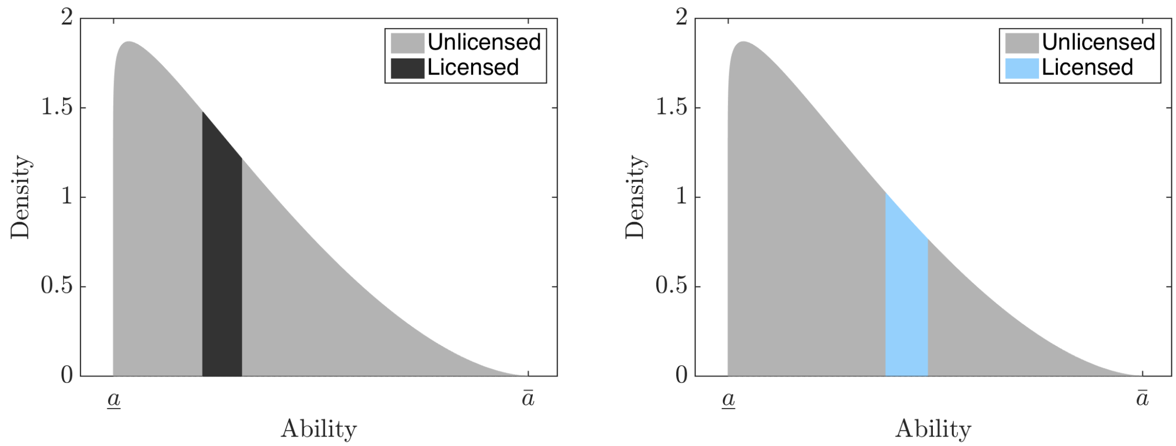

Table 10: Change in Labor Allocation - Optimal Training (%)

Share of Workers $j = 1$	Average Ability in $j = 1$	Average Ability in $j = 2$
-34.3	22.7	-3.2

Table 11: Decomposition of Change in Wage Premium - Optimal Training (%)

Δ Wage Premium	Δ Skill Component	Δ Information Rents
63.5	55.9	7.6

A.3.2 No Fee

Figure 6: Ability Composition of Workers - Benchmark vs. No Fee

(a) Γ^B: Benchmark **(b) Γ^N: No Fee**

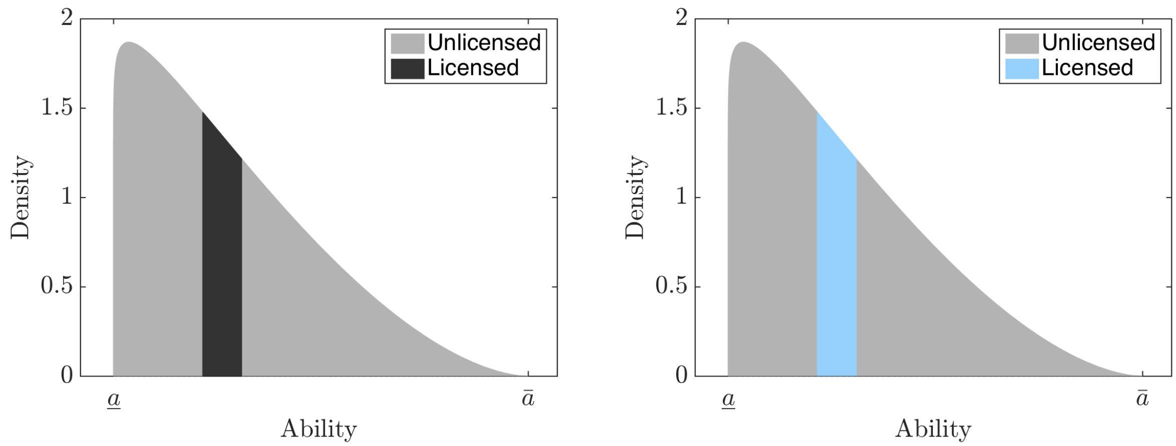

Table 12: Change in Labor Allocation - No Fee (%)

Share of Workers $j = 1$	Average Ability in $j = 1$	Average Ability in $j = 2$
0.1	0.0	0.0

Table 13: Decomposition of Change in Wage Premium - No Fee (%)

Δ Wage Premium	Δ Skill Component	Δ Information Rents
0.0	-0.1	0.1