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Effects of Qualification in Expert Markets with Price Competition and Endogenous Verifiability

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Abstract

We investigate a market in which experts have a moral hazard problem because they need to invest in costly but unobservable effort to identify consumer problems. Experts have either high or low qualification and can invest either high or low effort in their diagnosis. High skilled experts are able to identify problems with some probability even with low effort while low skilled experts here always give false recommendations. Experts compete for consumers by setting prices for diagnosis and service. Consumers can visit multiple experts, which enables an endogenous verifiability of diagnosis. We show that with a sufficient number of high skilled experts, stable second-best and perfectly non-degenerate equilibria are possible even with flexible prices, although they depend on transactions costs being relatively low. By contrast, with a small share of high skilled experts in the market, setting fixed prices can be beneficial for society.

Keywords: credence goods; expert market; moral hazard; qualification; competition; second opinions; diagnostic effort

JEL: L10; D82; D40

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1 Introduction

Expert markets are a constant feature in economic transactions: visiting a doctor or a car mechanic, taking a cab in a foreign city, engaging financial services or home improvement contracts are suitable examples. The issue underlying all these interactions is given by consumers' uncertainty about the specifics of their demand, being only aware that some service or good is required. Commonly, consumers are neither able to identify ex ante on their own the severity of their problem nor ex post - in the case of a solved problem - which service actually solved it. With consumers lacking the necessary knowledge, they have to visit an expert for diagnosis and treatment. By contrast, experts can not only identify consumer problems but also determine and carry out necessary services. This particular kind of information asymmetry enables fraud, as experts might exploit their informative edge to increase their own monetary payoff at consumers' expense. This can result in either inefficiencies or market breakdowns with consumers anticipating potential fraud and refraining from contracting (Akerlof, 1970; Dulleck, Kerschbamer, 2006; Dulleck et al., 2011; Emons, 2001; Mimra et al., 2016).

Due to this potential for market failure, markets for expert services are commonly regulated by entry barriers with specific requirements like completed studies and vocational training. In most fields, it appears quite easy for consumers to identify someone as actually being an expert. By contrast, it is much more difficult to identify whether an expert is high or low skilled in comparison to colleagues. Consider, for instance, ordering a tradesman to estimate the costs for repairing a washing machine. While I can be expected to identify whether the arriving person is a mechanic per se, as I interact in a regulated market and called a professional provider, I cannot easily determine whether he is of high or low skill. In most cases, I am not aware of his individual talent, years of experience, additional training or specializations, but will only observe his recommendation for service as the result of his diagnosis. Consequently, without irrational costs and effort, in a market for expert services, consumers cannot distinguish experts of different skill, as has been previously outlined, e.g. by Emons (2001), Pesendorfer, Wolinsky (2003), as well as Feser, Runst (2015).

Experts with different skill sets vary in their ability to diagnose consumer problems. For example, in a model with second opinions and price competition, Pesendorfer, Wolinsky (2003) let experts' skill levels directly determine their ability to recommend an appropriate treatment. They show that the mechanism of multiple opinions for mitigating the information problem can solve this only partially and needs additional institutions for full efficiency. In contrast to them, we argue that the assumption of low skilled experts unanimously providing low quality in diagnosis does not capture real life circumstances. While it is plausible that there are qualitative differences in the ability to diagnose, a low skilled expert can also be expected to succeed in correctly identifying consumer problems if he is willing to invest sufficient effort. Therefore, rather than high skilled experts always giving correct recommendations and low skilled experts always giving wrong ones, a diagnosis' accuracy should depend on individuals' willingness to invest effort in it. Accordingly, a high skilled expert might provide a wrong diagnosis if he only invests minimal effort, while a low skilled expert who invests a great amount of resources can give a correct recommendation.

Most of the credence goods literature assumes that experts can determine consumers' problems perfectly at no costs (Wolinsky, 1993; Dulleck, Kerschbamer, 2006; Dulleck et al., 2011; Hyndman, Ozerturk, 2011; Mimra et al., 2016). However, this does not represent real-life circumstances, as diagnosis is actually costly for experts - at least time consuming. Experts have to choose how much effort they are willing to invest in their diagnosis: is someone only interested in faking a genuine diagnosis by presenting a plausible story or is he really concerned for consumers' well-being and willing to invest a substantial effort to make a more precise diagnosis? Due to the credence goods character, consumers are in general unable to determine experts' effort levels without irrationally high costs (Emons, 2001; Feser, Runst, 2015), which results in a moral hazard problem. This might prompt experts to underinvest in diagnosis to maximize their own utility. This, in turn, would lead to inferior service recommendations based on guesses rather than real diagnosis.

In this paper, we are primarily concerned with the moral hazard problem of experts in providing truthful but costly diagnosis, due to the unobservability of their effort choices. We examine a market with heterogeneous experts regarding their ability to identify problems, while consumers are able to verify experts' recommendations through multiple opinions. We extend the framework of Pesendorfer, Wolinsky (2003) by introducing heterogeneously-qualified experts. In accordance with Brush et al. (2017) and Norman et al. (2007), we incorporate the notion that high skilled experts have an edge in diagnosis by being able to identify consumer problems with less effort than low skilled experts. Our model allows for a more detailed view on experts' willingness to invest in costly diagnosis, consumers' willingness for contracting and how this affects overall welfare. Moreover, it enables us to provide policy implications concerning how to adapt prices for diagnosis and service to maximize overall welfare in reaction to different market conditions, i.e. experts' costs for high effort and transaction costs for consumers to visit an expert, as well as market composition, i.e. the share of high skilled experts in the market and their edge in qualification in comparison to low skilled experts. To our best knowledge, there is no other model that analyzes how qualification levels affect markets for expert services.

To introduce our model, imagine again the aforementioned tradesman scenario. In our model a consumer is in need of a service, as she notices that she has some issue, whereby she wants to get her washing machine repaired. However, she is unaware which kind of service would actually solve her problem. We model the continuum of possible services by $b \in [0, 1]$. Let $V > 0$ be a consumer's utility when the problem is solved appropriately, i.e. the service carried out corresponds to b, and zero otherwise. Experts can identify consumer problems depending on their individual skill level and their effort choice. For simplification, let experts be of either high or low skill and able to only choose between high and low effort. Notice that we do not let experts decide on their recommendation strategy, implying that whether a recommendation is correct or not is being determined by an expert's effort choice and degree of qualification only. This let us also derive conclusions about experts' propensity for undertreatment, as in this case an underprovision of diagnosis due to low effort is driven only by experts having a financial incentive for it. In order to model high skilled experts' edge in diagnosis, they have some probability $y \in (0,1)$ of providing a correct diagnosis even with low effort, while low skilled experts always give a false recommendation in this case. When an expert chooses high effort, he will always give a correct recommendation irrespective of his skill. However, all experts have to incur costs $c > 0$ for high effort.

We assume a market with a finite number of N experts and M consumers. Let $a \in [0,1]$ be the share of high skilled experts in the market, which is common knowledge. Each consumer is free to visit up to N experts for diagnosis. A visited expert offers a contract comprising fees for diagnosis and service. Additionally, let $s > 0$ be the transactions costs that arise for consumers by contacting an expert. However, we assume that informing oneself about diagnosis and service costs is free and consumers only have to bear the transaction costs s in case they actually receive a diagnosis. When a consumer decides to get diagnosed, she automatically receives a service recommendation conditionally on the visited expert's effort choice and skill. Subsequently, the consumer can either buy the corresponding service or get further diagnoses to potentially confirm her first recommendation. Notice that we assume that experts can only provide services that they have formerly recommended. This design enables an endogenous verifiability of diagnosis. With the possibility to search for matching opinions consumers can verify a recommendation on their own but have to bear higher search costs in this case.

We analyze expert and consumer behavior as well as overall welfare regarding their reactions to different market compositions, i.e. the share of high skilled experts in the market a, their degree of qualification y, and market circumstances, i.e. consumer valuation V, transaction costs s and costs for high-effort choices c. We are particularly interested in experts' high effort choices and consumers' search behavior, as for the latter there is no possibility for a unique strategy to make all experts choose their mixed strategy due to heterogeneous qualification. We find that consumers will adapt their search behavior according to market composition, as they need to search for matching opinions more often to make high skilled experts choose high effort with a positive probability. However, if a is sufficiently high, there is the possibility for a second best equilibrium, in which welfare is maximized even without the intervention of a policy-maker, e.g. by fixing prices for service and diagnosis. By contrast, with a being relatively low, a stable second best equilibrium requires fixed prices as outlined by Pesendorfer and Wolinsky before. In sum, the optimal price level for service - and whether a stable second best equilibrium is possible - depends on the share of high skilled experts in the market, their degree of qualification, as well as whether prices are fixed or flexible and the amount of transactions costs consumers have to bear for diagnoses.

Related Literature

The central aspect in our model is experts' moral hazard problem to costly but unobservable diagnosis effort. In a model, where experts compete with discounters, Dulleck, Kerschbamer (2009) show that the former undertreat consumers to avoid free-riding behavior. Moreover, Bonroy et al. (2013) find that risk averse experts are less likely to invest in costly diagnosis. Pesendorfer, Wolinsky (2003) show that only with fixed prices and consumers being able to receive multiple opinions, a stable second best outcome can be realized where consumers' welfare is maximized. Furthermore, Bester, Dahm (2017) argue that by introducing unobservable subjective evaluation of consumers regarding service success, even first-best outcomes can be achieved by separating diagnosis and treatment. However, as they do not incorporate transactions costs in their model, this first-best solution needs to be seen as rather special case.

Additionally, it appears decisive whether consumers can consult more than one expert for diagnosis. Wolinsky (1993) shows that depending on the costs for visiting multiple experts this can lead to an overall welfare increase. This is in line with the results of Mimra et al. (2016), showing that the rate of overtreatment decreases significantly with the possibility of second opinions. Here, market efficiency increases depending on additional search costs. Nevertheless, in their experiment the willingness to search for second opinions was significantly lower than theory had predicted. Mimra et al. (2016) attribute this to consumers might thought that honest expert types are prevailing in the market or to consumers' risk aversion. It seems, therefore, that already the threat of second opinions might lead experts to less fraudulent behavior. However, Pesendorfer, Wolinsky (2003) show theoretically that the possibility for multiple opinions, in a market where experts decide on their effort for diagnosis, does not lead to Pareto optimal outcomes due to incentive incompatibility and transactions costs for consumers.

Another relevant institution in our model is given by price competition. Dulleck et al. (2011) show when experts compete for consumers through price setting, this drives down overall prices and increases trade volume. Additionally, in case that experts are liable, price competition has a positive effect on market efficiency. Mimra et al. (2016) confirm the price reducing effect and show that price competition significantly drives down experts' profits, shifting surplus to consumers. However, with price competition, experts seem to show more willingness for undertreatment and overcharging.

The remainder of the paper is structured as follows. Section two introduces our model. Section three presents our analysis and discusses our results and section four concludes.

2 Model

Our theoretical model builds closely on Pesendorfer, Wolinsky (2003) which we apply to the case of heterogeneously qualified experts and a limited number of players.

We assume a finite number of N experts and M identical consumers in the market. In general, consumers need some service for a problem which can be identified and treated by experts. However, an expert needs to exert effort for a correct diagnosis. We assume consumers are unable to observe experts' actual effort choices, as well as their degree of qualification and experts do not know a consumer's history, i.e. whether she has consulted other experts before her visit. Additionally, we exclude reputation as experts are not identifiable and are contacted in random order.

Consumers receive a positive payoff $V > 0$, if they purchase a service $b \in [0, 1]$ matching their problem type $i \in [0, 1]$, otherwise they get a payoff of zero. Since consumers do not know about their actual type i, they need to consult one or more experts. Each expert offers a contract (d, p) to consumers with d as the diagnosis costs and p as the costs of service. Experts provide diagnosis by recommending a service to consumers conditional on their effort choice. In return, consumers decide whether they are willing to accept the recommendation which would automatically lead to the execution of the recommended service. Consumers can consult up to N experts but have to bear transaction costs s for each consulted expert in addition to diagnosis costs d.

In contrast to Pesendorfer, Wolinsky (2003), we assume experts with varying degrees of qualification which affect their ability for correct diagnosis. For simplification, we assume experts are either high or low skilled. Let an expert's skill type be $q_t \in \{0, 1\}$ with $t \in \{h, l\}$, where $q_h = 1$ denotes high skill and $q_l = 0$ denotes low skill. Notice that by introducing heterogeneous experts in the market, there are two dimensions which can affect market outcome:

> Firstly, there is the magnitude of how much high skilled and low skilled experts differ in their degree of qualification, i.e. to which extent high skilled experts are better in diagnosis. For our model, we assume that to diagnose a consumer, experts need to decide on their effort level $e \in \{0, 1\}$ with $e = 1$ denotes high effort and $e = 0$ denotes low effort. High effort always leads to correct recommendations, regardless of the individual level of qualification. In contrast, low effort always leads to a wrong recommendation, if an expert is low skilled. If an expert is high skilled he makes a correct diagnosis by low effort with probability $y \in (0, 1)$. Consequently, the variable y defines the magnitude of the difference in qualification to which we will refer as the degree of qualification in the following. Moreover, experts do not decide over their recommendation strategy: if an expert chooses high effort, his recommendation is always correct, i.e. he recommends a service $b = i$.
>
> Secondly, there is the share of high skilled and low skilled experts in the market. We assume a share $a \in [0, 1]$ of high skilled experts and a share $1 - a$ of low skilled experts.

All experts have to bear costs $c > 0$ for high effort. For simplification, we assume that low effort, as well as all services performed are free. All information about market composition and payoff functions are common knowledge across all players.

The game consists of an infinite number of periods with the following identical course:

1. Each consumer is randomly matched with one of the N experts who proposes a contract (d, p).
2. Assuming a consumer has visited $n \geq 0$ experts so far, she decides whether she will (i) accept the offered contract and get diagnosed by this expert; (ii) if $n \leq N$, visit another expert; (iii) buy the service from any expert whose diagnosis has been received previously; (iv) leave the market without purchase and/or diagnosis. With decisions (iii) and (iv) the game ends.

3. If the contract is accepted, the consumer pays the diagnosis costs d to the expert and also has to bear the transactions costs $s > 0$.
4. Each visited expert chooses his diagnostic effort $e \in \{0, 1\}$. We denote the probability of experts type q_t for high diagnostic effort by $x_t \in [0, 1]$.
5. Each consumer receives a recommendation conditionally on her visited expert's effort choice and skill
6. Each consumer has to decide how to proceed further (see stage 2).

In sum, a consumer's expected utility is determined by how many experts she consults for diagnosis, the offered contracts by experts and whether a potentially bought service matches her actual problem type i. Suppose a consumer has contacted n experts, her expected utility is given by

$$U(a, s, t) = \begin{cases} V - p - \sum_{j=1}^{n} d_j - ns & \text{if } a = i \\ -p - \sum_{j=1}^{n} d_j - ns & \text{if } a \neq i \\ -\sum_{j=1}^{n} d_j - ns & \text{no purchase} \end{cases} \tag{1}$$

In contrast, an expert's profit function depends on how many consumers consult him for diagnosis, his effort choices and whether some consumers are buying his service, conditional his offered contract (d, p). An expert's expected payoff who is contacted by m consumers with $r \leq m$ consumers buying his service is given by

$$\pi(c, e) = \begin{cases} m(d - ec) + rp & \text{r consumers buy service} \\ m(d - ec) & \text{any consumer buys service} \\ 0 & \text{not consulted} \end{cases} \tag{2}$$

3 Analysis

Experts cannot observe how many experts a consumer has contacted before. They maximize their expected profit by choosing their contracts (d, p) as well as their effort level $e(t) \in \{0, 1\}$, conditional on their beliefs of consumers' searching strategy. According to symmetry, identically qualified experts will choose the same strategy profile (d_t, p_t, ϵ_e) with ϵ_t being denoted as the probability for high diagnostic effort x_t, conditional on the offered contract (d_t, p_t).
Consumers condition their choices on experts' expected probability to choose high diagnostic effort $x_t \in [0, 1]$, the share of high skilled experts in the market a, the degree of qualification of high skilled experts y, and the offered contracts (d_t, p_t). Sampling a random expert will give a consumer a correct recommendation with the following probability

$$z = x_h a + (1 - a)x_l + (1 - x_h)ay, \tag{3}$$

where $x_h, x_l \in [0,1]$ determine the probabilities that an expert with high or low qualification chooses high effort.
Let $f \in [0,1]$ be the probability for a consumer to stop after her first recommendation. If $f = 1$, her expected payoff is given by

$$U(z|f=1) = zV - p - (s+d). \tag{4}$$

In contrast, with probability $1-f$ a consumer searches for two matching opinions. Since a randomly sampled expert makes a correct recommendation with probability z, the expected duration for a correct diagnosis is given by $1/z$. Consequently, the expected duration for two matching recommendations is $2/z$. The underlying search and diagnosis costs for matching diagnosis are, therefore, $2(s+d)/z$. The expected utility for a consumer, in this case, is given by

$$U(z|f=0) = V - p - 2\frac{s+d}{z} + \theta. \tag{5}$$

For a consumer to enter the market in the first place, the expected payoff from either (4) or (5) need to be positive.

Lemma 1: *A consumer's best response to (d_t, p_t, x_t) will always be one of the following strategies: (i) quit without any action; (ii) get exactly one diagnosis and purchase its service; (iii) get diagnosis until two recommendations match and buy the service from one of the two experts with matching recommendations.*

Proof of Lemma 1: *see Appendix A.*

□

On the other side, experts have to decide how much effort they are willing to invest in diagnosis. For their best response, they have to build a belief about consumers' search behavior. Let B be an expert's belief about the probability that a consumer has not been diagnosed by another expert, conditional on this consumer accepting to be diagnosed by him. When an expert is consulted and decides for high diagnostic effort, he will get an expected payoff given by

$$\pi(f, B|e=1) = d_q + p_q fB + (1-fB)\frac{p_q}{2} - c, \tag{6}$$

with fB being the probability that a consumer has not contacted another expert before and stops after the first recommendation and $(1-fB)$ being the probability that a consumer is searching for matching opinions. We assume that in the latter case, a consumer purchases with probability $1/2$ from an expert who provides a correct recommendation, as she has no preferences regarding the sampling order.
In contrast, if a consulted expert invests low effort for diagnosis by not incurring the costs c, his expected profit is given by

$$\pi(f, q_t, B|e = 0) = d_q + p_q fB + qp_q(1 - fB)\frac{y}{2}. \quad (7)$$

With low effort, an expert will only sell his service to a consumer if she is either on her first visit and stops afterwards or with probability $y/2$, if a consumer searches for matching recommendations and the expert is high skilled. For a pure best response, experts choose high effort, i.e. $e = 1$, when (6) is strictly greater than (7). In case of indifference, any $x_t \in [0, 1]$ is optimal. Notice that by introducing different degrees of qualification, high skilled experts' incentive for high diagnostic effort has decreased. This implies that in order to make high skilled experts indifferent between high and low effort, consumers need to search ceteris paribus for matching opinions more often.

3.1 Equilibria with Fixed Prices

In the first step, we assume prices to be fixed with all experts offering identical contracts (d, p). According to Pesendorfer, Wolinsky (2003), (d, p, z, f) is a fixed price equilibrium, if consumers' choices for f are optimal given (d, p, z) and experts' effort decisions $x_t \in [0, 1]$ are optimal given (d, p, f) and their beliefs B. We define an equilibrium as perfectly non-degenerate when all experts choose high diagnostic effort with positive probability, i.e. $x_h, x_l > 0$. In contrast, in a degenerate equilibrium, all experts always opt for low diagnostic effort, i.e. $x_h, x_l = 0$. Furthermore, there can be a partial non-degenerate equilibrium with only low skilled experts choosing high effort.[1] As mentioned before, the expected duration of search depends on consumers' applied strategy. With probability f, a consumer stops after her first diagnosis and buys in which case the duration is one period. In contrast, with probability $1 - f$, a consumer searches for matching opinions resulting in a duration of $2/z$. Consequently, the expected duration of search S for consumers is given by

$$S = f + (1 - f)\frac{2}{x_h a + (1 - a)x_l + (1 - x_h)ay}. \quad (8)$$

For being a Bayesian fixed price equilibrium, B needs to be consistent according to f and z which is fulfilled, if it equals the inverse of the expected duration of search.

Lemma 2: *Experts' beliefs are consistent with (d, p, z, f) if and only if*

$$B = \frac{x_h a + (1 - a)x_l + (1 - x_h)ay}{f(x_h a + (1 - a)x_l + (1 - x_h)ay) + 2(1 - f)} = \frac{z}{fz + (2(1 - f)}. \quad (9)$$

Proof of Lemma 2: *see Pesendorfer, Wolinsky (2003).*

□

[1] As high skilled experts demand higher searching rates for matching opinions to be indifferent in their effort choice, there is only the possibility for partial non-degenerate equilibrium with low skilled experts choosing $x_l \in]0, 1]$.

For a non-degenerate equilibrium of any kind, experts need to get an expected payoff from high effort at least equal to low effort, given by

$$d + fBp + (1 - fB)\frac{p}{2} - c \geq d + fBp + q_t p(1 - fB)\frac{y}{2}. \tag{10}$$

From (10) follows that $p \geq \frac{2c}{(1-q_t y)}$ needs to be fulfilled for a non-degenerate equilibrium. Notice that the less often consumers are willing to search for matching recommendations and/or when experts are higher qualified, the greater needs to be experts' markup, i.e. the difference of high effort costs c and service price p, in order to attract them for high effort.

If consumers would always buy after their first recommendation, i.e. $f = 1$, (10) would not hold, since in this case $fB = 1$ and $1 - fB = 0$. Consequently, for a non-degenerate equilibrium consumers need to weakly prefer searching for matching opinions, i.e. $f < 1$. This will only be the case, if their expected payoff from (5) is at least equal to their payoff from (4), which results in

$$V - p - 2\frac{s + d}{z} \geq zV - p - (s + d). \tag{11}$$

Three market conditions for a non-degenerate equilibrium follow from (11): (i) z has to lie within a determined interval, i.e. $z \in [\underline{z}, \overline{z}]$; (ii) the costs for diagnosis and the transaction costs may not exceed a specific threshold $s + d \leq \overline{s} \equiv V(3 - 2\sqrt{2})$; (iii) consumers will only search for matching recommendations, if $N \geq \frac{2}{z}$.[2] Finally, to be willing to choose $f < 1$, consumers need to get a positive expected utility searching for matching opinions at all by

$$V - p - 2\frac{s + d}{z} > 0. \tag{12}$$

If experts would always provide correct diagnosis by high effort, consumers would never search for matching recommendations and, therefore, (10) would not hold. If experts would always choose low effort, this would be a degenerate equilibrium by definition. For $0 < x_t < 1$, (10) must hold with equality, making experts indifferent between high and low effort choice.

$$d + fBp + (1 - fB)\frac{p}{2} - c = d + fBp + q_t p(1 - fB)\frac{y}{2}. \tag{13}$$

Solving (13) for f by substituting B we can determine f^*, making experts indifferent between high and low effort

$$f^*(q_t) = \frac{1 - \frac{2c}{p(1-q_t y)}}{1 + \frac{c(z-2)}{p(1-q_t y)}}. \tag{14}$$

Since experts differ in their degree of qualification, i.e. $q_t \in \{0, 1\}$, and have a different expected utilities depending on e_t, consumers are not able to choose a uniform f making all experts indifferent at the same time. As noticed before, (14) shows that for making high skilled experts

[2] For detailed calculations see Appendix B.

indifferent in their effort choice, consumers need to search for matching opinions more often, since $\frac{\partial f^*}{\partial q_t} < 0$. Consumers will choose f according to what yields them the highest expected payoff. Experts will react to consumers' choice depending on their degree of qualification, i.e. qy, and the fixed ratio of the price for service p and the costs for high effort c. We determine f_l^* $[f_h^*]$ as the search rate which makes low [high] skilled experts indifferent.
It is important to emphasize that in order to establish a mixed strategy equilibrium, experts need to choose their effort level in accordance to make consumers indifferent between buying after one recommendation and searching for matching opinions. Otherwise, if consumers choose a pure strategy while $p > 2c$, there cannot be a non-degenerate equilibrium. Suppose consumers would never search for matching opinions. This would make all kind of experts strictly preferring low effort. As counter, consumers would not enter the market in the first place, unless there is a very high share of extremely well qualified high skilled experts that $V - p - 2\frac{s+d}{z} > 0$ which we shelve for the moment. On the other side, if consumers always search for matching opinions, experts would strictly prefer high effort, as long as $p > 2c/(1 - q_t y)$. As reaction, consumers would switch to never search for matching opinions with the same consequences as before. Consequently, for getting to a non-degenerate equilibrium, it is necessary that experts choose their effort according to make consumers indifferent in their search behavior.

Lemma 3: *If $x_h = 0$, low skilled experts will balance z that $z \in [\underline{z}, \overline{z}]$, as long as $a(1-y) \leq 1-z$ and $y \leq \frac{z}{a}$. If $x_l = 1$, high skilled experts will balance z that $z \in [\underline{z}, \overline{z}]$, as long as $a(1-y) \geq 1-z$.*

Proof of Lemma 3: From (11) follows that the probability z for getting a correct diagnosis by sampling a random expert must lie in the determined interval $z = x_h a + (1-a)x_l + (1-x_h)ay \in \{\underline{z}, \overline{z}\}$. If, for example, all high skilled experts choose only low effort when $f > f_h^*$, low skilled experts in the market will balance the downshift in z, as $x_h = 0$, by increasing their own effort level. In contrast, high skilled experts will, as well, adapt their effort choice in equilibrium when all low skilled experts choose only high effort. Consequently, we can define the threshold values for x_t in reaction to a chosen f and x_{-t} by $x_t^* \in [\underline{x_t}, \overline{x_t}]$. Only if x_t^* lies within the defined interval, a non-degenerate equilibrium is possible. This adaptation will always take place as long as market composition is not too one-sided regarding the values for a and y. We can determine the threshold values by

$$\underline{x_l^*}, \overline{x_l^*} = \frac{\frac{V+d+s}{2V} - ay \pm \sqrt{(\frac{V+d+s}{2V})^2 - \frac{2(s+d)}{V}}}{1-a}, \tag{15}$$

and

$$\underline{x_h^*}, \overline{x_h^*} = 1 + \frac{1 + \frac{V+d+s}{2V} \pm \sqrt{(\frac{V+d+s}{2V})^2 - \frac{2(s+d)}{V}}}{a(y-1)}. \tag{16}$$

Note that x_t can only take values between 0 and 1. Consequently, if x_t^* falls below or exceeds this, an adaptation of z to the equilibrium interval $z \in [\underline{z}, \overline{z}]$ becomes impossible. By extracting the necessary conditions from (15) and (16), we receive for low skilled expert adaptation

$$a(1-y) \leq 1-z, \tag{17}$$

$$ay \leq z, \tag{18}$$

and for high skilled expert adaptation

$$a(1-y) \geq 1-z, \tag{19}$$

with $z \in \{\underline{z}, \overline{z}\} = \frac{V+d+s}{2V} \pm \sqrt{(\frac{V+d+s}{2V})^2 - \frac{2(s+d)}{V}}$. In the following, we will refer to these equations as the adaptation conditions for high and low skilled equilibria, since they need to be fulfilled in order to make consumers choose their mixed strategy. Conditions (17) and (18) account for low skilled experts while (19) is required for high skilled ones.[3] It follows that the share a of high skilled experts in the market and their degree of qualification y has opposed effects on high skilled experts' ability to adapt their effort choice. While an increase in a increases the possibility for adaptation, an increase in y decreases it, respectively. In contrast, for low skilled experts, an increase of a decreases the possibility for adaptation. The effect of y on low skilled experts adaptation is mixed and depends on its ratio to the other parameters.

If $a(1-y) > 1-z$, low skilled experts loose their ability for adaptation. With $a(1-y) > 1-z$, only high skilled experts will be able to adapt their effort level that $z \in [\underline{z}, \overline{z}]$. This implies that at this point, there are so many high skilled experts in the market that the existing low skilled experts cannot balance $x_h = 0$ anymore. In return, high skilled experts become able to balance $x_l = 1$ which changes the possible non-degenerate equilibrium from a partial to a perfect one. However, it is important to mention that z can take at least two values in equilibrium, i.e. $z \in [\underline{z}, \overline{z}]$. It follows that not the full range of the interval $z \in [\underline{z}, \overline{z}]$ have to be continuously one type of equilibrium. If (11) holds, i.e. $z \in [\underline{z}, \overline{z}]$, there exist some values for y and a that $\underline{z}$ is a partial non-degenerate equilibrium and $\overline{z}$ a perfect non-degenerate equilibrium. Consequently, there exist a value $z = 1 - a(1-y)$ where both high and low skilled experts' condition for adaptation hold.

□

Expert's reaction function, i.e. their probability of choosing high effort in non-degenerate equilibria, according to f is given by

$$x_e(f) = \begin{cases} x_t = 0 & \text{if } f > f_t^* \\ x_t \in \{\underline{x_t^*}, \overline{x_t^*}\} & \text{if } f = f_t^* \neq 0 \\ x_t \in [\underline{x_t^*}, \overline{x_t^*}] & \text{if } f = f_t^* = 0 \\ x_t = 1 & \text{if } f < f_t^* \end{cases} \tag{20}$$

[3]Notice that we leave out condition $z \leq 1$ for high skilled expert adaptation, as it is always fulfilled.

We return to the influence of a and y, as well as which equilibria type will be preferred by experts or consumers in the welfare section section.

Lemma 4: *Depending on the fixed price ratio $2c/p$ there exist several types of non-degenerate equilibria with the fixed profile (d,p,z,f), if $N \geq \frac{2}{z}$, $s+d < \overline{s} = V(3-2\sqrt{2})$, and $V-p-2\,\frac{s+d}{z} > 0$: (i) With $2c \leq p$, consumers will choose $f = f_l^*$, if (17) and (18) are holding, resulting in a partial non-degenerate equilibrium. Low skilled experts will choose either $x_l \in \{\underline{x_l^*}, \overline{x_l^*}\}$ if $p = 2c$, or $x_l \in [\underline{x_l^*}, \overline{x_l^*}]$ if $p > 2c$ while high skilled experts always choose $x_h = 0$; (ii) with $2c/(1-y) \leq p$, if (19) holds, consumers will choose $f = f_h^*$, resulting in a perfect non-degenerate equilibrium. There high skilled experts will choose either $x_h \in \{\underline{x_h^*}, \overline{x_h^*}\}$ if $p = 2c/(1-y)$, or $x_h \in [\underline{x_h^*}, \overline{x_h^*}]$ if $p > 2c/(1-y)$ while low skilled experts always choose $x_l = 1$.*

Proof of Lemma 4: See Appendix A.

□

As outlined by the proof of Lemma 4, the feasibility of non-degenerate equilibria types depends not only on market composition, outlined by the adaptation conditions, but also on parameter values, i.e. the ratio of service price and high effort costs in combination with high skilled experts' degree of qualification. With an increasing markup for service, a perfect non-degenerate equilibrium becomes possible. However, with experts always need to adapt their effort choices according to market composition to keep consumers indifferent, in any equilibrium the possible interval for z remains constant in high skilled, as well as in low skilled equilibria and only changes, if V, d and s, change.

3.2 Equilibria with Flexible Prices

In the next step, we turn to equilibria under flexible prices. Experts now have the possibility to choose their contracts (d_t, p_t) individually. For being an equilibrium, it is necessary that all experts choose a strategy profile (d_t, p_t, ϵ_t), conditional on their consistent belief B, and consumers adapt a corresponding searching behavior, described by f.
As before, there is always the possibility for degenerate equilibria, if the defined market conditions are not fulfilled. In this case, consumers will not enter the market unless $ay > \frac{2(s+d)}{V-p}$.

Lemma 5: *For the profile (d,p,z,f) being a non-degenerate flexible price equilibrium, similar market conditions as for fixed price equilibria must hold, i.e. $N \geq \frac{2}{z}$, and $V-p-2\,\frac{s+d}{z} > 0$. All experts offer identical contracts with $d = 0$. Moreover, $s \in [0, \tilde{s}]$ with $\tilde{s} = V(2\sqrt{5}-2)/8 + 4\sqrt{5}$, $z = \underline{z} = \frac{V+s-\sqrt{(V+s)^2-8sV}}{2V}$, and $f = f^*(q_t) = 1 - \frac{2c}{p(1-q_t y)}/1 + \frac{c(z-2)}{p(1-q_t y)}$. According to market composition, there are two possible outcomes: (i) with $ay \leq z$ and $a(1-y) < 1-z$, there will be $x_h = 0$, $x_l = \underline{x_l^*} = (\underline{z} - ay)/(1-a)$ and $f = f_l^*$ with the possible price range given by $p \in [2c, V - \frac{2c}{z}]$. (ii) with $a(1-y) \geq 1-z$ there will be $x_l = 1$, $x_h = \underline{x_h^*} = (\underline{z} - 1 + a(1-y))/(1-a)$*

and $f = f_h^*$ with the possible price range given by $p \in [\frac{2c}{1-y}, V - \frac{2c}{z}]$

Proof of Lemma 5: Our proof of Lemma 5 is based on Pesendorfer, Wolinsky (2003) and adapted for our case with heterogeneous experts. However, while we do not replicate every single calculation in the beginning, the interested reader can find it there.
Again, an equilibrium in pure strategies is not feasible due to the formerly stated reasons. In order to enable a mixed strategy equilibrium, consumers need to choose $f \in]0,1[$. Consequently, (11) needs to hold with equality, which requires $z \in \{\underline{z}, \overline{z}\}$.
There will be no competition in diagnosis fee d. Using a standard Bertrand argumentation, d must be zero for all experts, as from the moment on a consumers agrees to being diagnosed, these costs are sunk. Accordingly, d has no effect on experts' effort choice, irrespective of their skill. If $d > 0$, experts' would be able to accumulate full market demand on their own by setting $d' < d$. Therefore, the only feasible equilibrium outcome with flexible prices is $d = 0$.

In contrast to the diagnosis fee, the price for service directly affects experts' effort choices. However, there is no incentive for any expert to increase a given price p. Recall that

$$d + fBp + (1 - fB)\frac{p}{2} - c \geq d + fBp + qp(1 - fB)\frac{y}{2}$$

is necessary in order to attract an expert for high effort. If he increases his price to $p' > p$, he will loose all consumers who are looking for matching opinions, as they could buy the same service cheaper elsewhere. Consequently, there is no incentive for experts of any kind to increase their price above an established equilibrium level. However, there might be an incentive to undercut prices for accumulating full demand from consumers who are looking for matching opinions. For an expert to deviate from a given situation $(d = 0, p, z, f)$, two conditions need to be fulfilled: it needs to be profitable for the deviating expert and consumers need to prefer the deviating offer (d', p') as well.
Let a consumer's difference in expected continuation value for contacting the deviating expert be given by

$$\Delta(d', p'; 0, p, z) = \left(\frac{s}{z} + p - p'\right) \frac{V - 2(s/z) + p' - p}{V - (s/z) + p' - p} - s - d'. \tag{21}$$

For being an equilibrium, consumers must not have an incentive for accepting the deviating offer. As outlined before, a price deviation with $p' > p$ is not feasible, as experts would always choose low effort which makes it unattractive for consumers to follow. However, it might be profitable for a consumer to follow a price reduction with $p' < p$. This depends on whether the price reduction (over-)compensates a deviating expert's reduction in high effort. Assuming that p' is arbitrarily close to p, we receive

$$\frac{\partial}{\partial p'}\Delta(d', p'; 0, p, z | p' = p) = -1 + \frac{Vs}{z(V - \frac{s}{z})^2}. \tag{22}$$

From (22) follows that $\frac{\partial}{\partial p'}\Delta(d', p'; 0, p, z|p' = p) \geq 0$ if $z \in [\frac{s(3-\sqrt{5})}{2V}, \frac{s(3+\sqrt{5})}{2V}]$. If z does not lie

within this interval, consumers would strictly prefer a price $p' < p$.
According to the equality of (11), z can only take the two roots of the determined interval. As there is no possibility for $\overline{z}$ to lie within $z \in [\frac{s(3-\sqrt{5})}{2V}, \frac{s(3+\sqrt{5})}{2V}]$, only $\underline{z}$ might be a flexible price equilibrium.[4] Consequently, it requires that

$$s(3-\sqrt{5}) \leq V + s - \sqrt{(V+s)^2 - 8sV} \leq s(3+\sqrt{5}). \tag{23}$$

Solving (23) gives the possible range for the transaction costs $s \in [0, \frac{V(2\sqrt{5}-2)}{8+4\sqrt{5}}]$.[5] In sum, given the profile $(d = 0, p, \underline{z}, f)$, with $s \leq \frac{V(2\sqrt{5}-2)}{8+4\sqrt{5}}$, there is no incentive for consumers to follow a deviating expert who offers $p' < p$. With consumers restrain from following a price reduction, there is no incentive for experts to choose $p' \neq p$.[6]
The minimum price for an equilibrium is $p = 2c/(1 - q_t y)$. According to (10), experts would strictly prefer low effort, if it falls below which would make consumers to stay away from the market from the beginning. The maximum price for an equilibrium is $p = V - 2s/z$ which represents the total surplus for consumers who are searching for matching recommendations. In sum, if there would be only low skilled experts in the market, i.e. $a = 0$, any price within $p \in [2c, V - \frac{2c}{z}]$ could be an equilibrium, depending on the formerly defined conditions.
In a given equilibrium with both high skilled and low skilled experts choosing $x_t > 0$, low skilled experts might have an incentive fur undercutting an existing price level to accumulate full demand of consumers who are searching for matching opinions on their own. Imagine there is an established price $p = \frac{2c}{(1-y)}$. For high skilled experts, there is no possibility to reduce this price any further while credibly committing to $x_h > 0$. In contrast, low skilled experts could undercut this price level while still choosing $x_l > 0$. With $p' < \frac{2c}{(1-y)}$, they would force high skilled experts to follow the price reduction and, as a consequence, to always choose low effort which would make them lose all consumers searching for matching opinions. Notice that in case high skilled experts would not follow the price reduction, they are clearly distinguishable from low skilled experts with the consequence of being abandoned altogether, since in this case $x_h = 0$. The only possibility for getting a positive expected payoff would be to follow the price reduction.
However, as long as conditions (17) and (18) hold, consumers anticipate experts' adaptation behavior and choose the partial non-degenerate equilibrium strategy from the beginning, i.e. $f = f_l^*$. This implies that the full price range $p \in [2c, V - \frac{2c}{z}]$ is feasible and there is no possibility for a perfect non-degenerate equilibrium. According to (22), low skilled experts will never undercut a given price within this interval, as long as $s \in [0, \frac{V(2\sqrt{5}-2)}{8+4\sqrt{5}}]$, and will choose $x_l = \underline{x_l^*} = (\underline{z} - ay)/(1 - a)$.

[4]This derives from the boundary of s in all non-degenerate equilibrium with $s \leq \overline{s} = V(3 - 2\sqrt{2})$.

[5]Notice that the lower bound for z resulting from (22), is fulfilled if $s = 0$ or $s \leq \frac{V(2+2\sqrt{5})}{4\sqrt{5}-8}$. Since $\frac{V(2+2\sqrt{5})}{4\sqrt{5}-8} > \overline{s} = V(3 - 2\sqrt{2})$, this is fulfilled in every non-degenerate equilibrium.

[6]Notice that according to (22) with $z \in]\frac{s(3-\sqrt{5})}{2V}, \frac{s(3+\sqrt{5})}{2V}[$, consumers would prefer $p' > p$. However, since we assume services being perfect substitutes, consumers are always buying the service with the cheapest price and, therefore, would buy at p. This implies that with $p' > p$ an expert would loose all consumers searching for matching opinions. Consequently, there is no incentive for experts to offer higher prices.

If (17) no longer holds, low skilled consumers are no longer able to balance $x_h = 0$. Consequently, a partial non-degenerate equilibrium becomes impossible. With $V - p - 2\,\frac{s+d}{z} > 0$, consumers strictly prefer a perfect non-degenerate equilibrium. As high skilled experts will always choose low effort if $p < \frac{2c}{1-y}$, the possible price range for equilibrium reduces to $p \in [\frac{2c}{1-y}, V - \frac{2c}{z}]$. Again, experts do not have an incentive to undercut a given price as long as (22) holds and $s \in [0, \frac{V(2\sqrt{5}-2)}{8+4\sqrt{5}}]$, since consumers would not follow a deviation.

□

Notice that different price levels are compatible with equilibrium due to consumers' adaptation of their search behavior f. As outlined by Pesendorfer, Wolinsky (2003), higher price levels, which are associated by increased incentives for high effort must be counterbalanced in equilibrium by lower rates of searching for matching opinions.

3.3 Welfare

In this section, we will analyze welfare implications, depending on formerly determined equilibria. We will focus on the influence of market composition, i.e. the share a of high skilled experts in the market and their degree y of qualification, how this influences the possibility for welfare maximization and its determinants.

The present model does not allow for Pareto optimality. Since search is costly with all transaction costs being lost, optimality would require consumers to stop and to buy after one recommendation, as well as experts always choosing high effort. As this is not incentive compatible by also the introduction of high qualified experts in the market, there is no possibility for a first best outcome. Instead, we will focus on potential second best outcomes. We define an equilibrium (d, p, z, f) as second best, if it maximizes overall welfare under fixed market composition, i.e. a, y and the proportion of consumers in the market $k = M/(M + N)$, as well as under fixed market conditions, i.e. c, s and V, in comparison to any other equilibrium (d', p', z', f'). Consequently, we assume that only d, p, z and f are endogenous.

In the following, we first analyze consumer and expert welfare separately and how it can be maximized for certain groups. Afterwards, we show how overall welfare would be maximized, given market conditions and composition.

Consumer Welfare

In any non-degenerate equilibrium with the profile (d, p, z, f), consumer welfare is given by

$$\pi_c(f, z) = f(zV - p - (s + d)) + (1 - f)(V - p - \frac{2(s + d)}{z}), \tag{24}$$

with $f = f^*(q_t) = 1 - \frac{2c}{p(1-q_t y)} / 1 + \frac{c(z-2)}{p(1-q_t y)}$ and $z = ax_h + (1-a)x_l + (1-x_h)ay \in [\underline{z}, \overline{z}]$. As long as $z \in \{\underline{z}, \overline{z}\}$ and $p < V - 2(s+d)/z$, consumers are indifferent between any kind of non-degenerate equilibrium, since (11) holds with equality. Consequently, depending on the ratio of service price p, costs for high effort c and high skilled expert qualification y, there is no effect of either y or a on consumer welfare. Notice that this result is independent of the defined adaptation conditions.

As this payoff represents the minimum payoff for consumers in equilibrium to participate in a given market, we determine it as $\underline{\pi_c}$.

For consumers to realize a higher expected payoff than $\underline{\pi_c}$, two conditions, among market conditions for non-degenerate equilibria, need to be fulfilled: (11) needs to hold with strict inequality enable $z \in]\underline{z}, \overline{z}[$, and depending on the price ratio for service p, the adaptation conditions must hold.

As we have outlined in the former section that only $z = \underline{z}$ can be a non-degenerate flexible price equilibrium, there is no possibility for consumers to realize a higher than their minimum payoff with flexible prices.

Assuming fixed prices, there is the possibility for $\pi_c > \underline{\pi_c}$ in scenario (ii) and scenario (iv). In scenario (ii) $p = 2c$. Assuming adaptation conditions (17) and (18) hold, low skilled experts are able to balance $x_h = 0$. Moreover, with $p = 2c$, low skilled experts are indifferent between any value for x_l within $[\underline{x_l^*}, \overline{x_l^*}]$, since they get an expected payoff of zero, which enables (11) to hold with strict inequality, if $z \in]\underline{z}, \overline{z}[$. As a consequence, consumers will opt for $f_l^* = 0$ which leads to $\pi_c^l > \underline{\pi_c}$, since $\partial \pi_c / \partial f < 0$.

A similar argumentation holds for scenario (iv), $p = \frac{2c}{1-y}$. Assuming $a > \frac{1-z}{1-y}$, high skilled experts can balance $x_l = 1$ and the price level is high enough to attract them for $x_h > 0$. Moreover, with $p = \frac{2c}{1-y}$, high skilled experts are indifferent between any value for x_h within $[\underline{x_h^*}, \overline{x_h^*}]$, since they get an expected payoff of zero, which enables (11) again to hold with strict inequality. As a consequence, consumers will opt for $f_h^* = 0$ instead of $f_l^* > 0$, since $\partial \pi_c / \partial f < 0$, implying $\pi_c^h > \underline{\pi_c}$.

In sum, assuming a benevolent policy maker, consumers payoff can be increased by setting prices according to market composition, i.e. the share of high skilled experts a and their degree of qualification y. This can increase consumer welfare to $\pi_c^l, \pi_c^h > \underline{\pi_c}$. Since $\partial \pi_c / \partial p < 0$, consumer welfare is maximized with $p = 2c/(1 - q_t y)$.

Expert Welfare

With all experts offering identical contracts (d, p), the probability for an expert for being visited by a single consumer depends on the total number of experts and consumers in the market and is given by its ratio M/N. Moreover, notice that the formerly used expert payoffs, i.e. (6) and (7), were conditional on a consumer accepting his contract. Since consumers accept on average S_t contracts, each experts is expected to get consulted for $(M/N)S_t$ times, receiving the diagnosis fee d and bearing the potential costs for high effort $x_t c$ every time. Consequently, in any non-degenerate equilibrium with the profile (d, p, z, f), individual expert welfare depending on qualification q_t is given by

$$\pi_e(x_t, q_t, f) = \frac{M}{N}[S_t(d - x_t c) + fBp + (1 - fB)\frac{p}{2}(x_t(1 - q_t y) + y)], \tag{25}$$

with $fB = f^*(q_t)B = 1/(1 + \frac{2c}{p(1-q_t y)-2c})$, $S_t = f^*(q_t) + 2(1 - f^*(q_t))/z$, N as the total number of experts and M as the total number of consumers in the market. Since $\partial \pi_e / \partial p > 0$, experts welfare strictly increases in p, irrespective of individual qualification. Moreover, with $d > c$, expert welfare strictly increases with consumers consulting more experts on average, i.e. with an increasing S_t. Consequently, since $\partial S_e/\partial f < 0$ and $\partial \pi_e/\partial S_e > 0$ in combination with $d > c$, it follows that $\partial \pi_e/\partial f < 0$.

Assume a situation with $a(1-y) \leq 1-z$ and $ay \leq z$, consumers will choose $f = f_l^*$, resulting in $x_l = x_l^*$ and $x_h = 0$, if $p \geq 2c$. In this situation, a low skilled expert gets an expected payoff of

$$\pi_e^l(x_l^*, f_l^*) = \frac{M}{N}[S_l(d - x_l^* c) + f_l^* Bp + x_l^*(1 - f_l^* B)\frac{p}{2}]. \tag{26}$$

In contrast, a high skilled expert's expected payoff amounts to

$$\pi_e^h(x_h = 0, f_l^*) = \frac{M}{N}[S_l d + f_l^* Bp + (1 - f_l^* B)\frac{py}{2}]. \tag{27}$$

If low skilled adaptation fails and only high skilled experts are able to adapt with $a(1-y) > 1-z$ with $p' \geq \frac{2c}{1-y}$, consumers will choose $f = f_h^*$, resulting in $x_h = x_h^*$ and $x_l = 1$. Now, low skilled experts gain an expected payoff of

$$\pi_e^l(x_l = 1, f_h^*) = \frac{M}{N}[S_h(d - c) + f_h^* Bp' + (1 - f_h^* B)\frac{p'}{2}]. \tag{28}$$

In contrast, high skilled expert expected payoff amounts to

$$\pi_e^h(x_h^*, f_h^*) = \frac{M}{N}[S_h(d - x_h^* c) + f_h^* Bp' + (1 - f_h^* B)\frac{p'y + p'x_h^*(1-y)}{2}). \tag{29}$$

In building the difference, we can analyze which equilibrium gain the higher expected payoff for experts by assuming identical contracts $(d, p = p')$. With $f^*(q_t)B = 1/(1 + \frac{2c}{p(1-q_t y)-2c})$ we get a difference for low skilled experts, given by

$$\Delta\pi_e^l = \frac{M}{N}[\Delta S(d - (1 - x_l^*)c) - cx_l^* + c\frac{1-2y}{1-y}], \tag{30}$$

with $\Delta S = S_h - S_l$. Whether low skilled experts gain in terms of welfare by a switch to the high skilled equilibrium depends primarily on the ratio of d and c, as well as on the absolute value of y. Since $\Delta S > 0$ as long as $y > 0$, low skilled expert welfare strictly increases by an equilibrium switch, as long as $d > c$ and $y < 0.5$. Under these circumstances, this increase stems from additional gains by higher income from diagnosis fees and a higher probability for selling services to consumers searching for matching recommendations, outperforming the increase in high effort costs and the decrease in selling services to consumers being on their first visit. With $d > c$, low skilled consumers are strictly worse off by an increase in y, since $\partial \Delta S/\partial y < 0$ and the fraction of the equation also decreases in y.

In contrast, the difference for a high skilled expert is given by

$$\Delta\pi_e^h = \frac{M}{N}[\Delta S d - cx_h^*(S_h - 1) - \frac{2cy}{1-y}(1 - \frac{y}{2})]. \tag{31}$$

Whether high skilled experts gain in welfare by a switch to the high skilled equilibrium is also primarily determined by the ratio of d and c and the absolute value of y. It is quite surprising that they strictly lose welfare by an increasing degree of qualification, since both ΔS and the last term of the equation decreases in y. It can be easily seen that the additional gains due to their higher qualification y happen in both kind of equilibria with $(1 - f^*(q)B)p/2$. However, with increasing y the term $(1 - f^*_h)px^*_h(1 - y)/2$ decreases which implies a reduction for high skilled experts in the high skilled equilibrium. Consequently, with d being relatively low and high skilled experts are well qualified, i.e. with y being relatively high, high skilled experts prefer the low skilled equilibrium.

Overall Welfare

In former sections, we have outlined how the separate welfare of consumers and experts are affected by various factors and whether they gain or lose by a switch to the high skilled equilibrium. Since, so far, it remains questionable how societies welfare can be maximized in our setting and whether an equilibrium switch would be worthwhile, we analyze how overall welfare reacts to changes in the setting. We assume that there is a share $k = \frac{M}{M+N}$ of consumers and a share $1 - k = \frac{N}{M+N}$ of experts in the market. Therefore, overall welfare, as a combination of consumer and expert welfare, is given by

$$\pi = k[f(zV - p - (s + d)) + (1 - f)(V - p - \frac{2(s + d)}{z})] \tag{32}$$

$$+ (1 - k)\frac{M}{N}[S_e(d - c(ax_h + (1 - a)x_l) + fBp + \frac{2}{z}(1 - fB)\frac{pz}{2}]. \tag{33}$$

The first line of the equation is determined by consumer welfare. Its relative influence is given by the share of consumers in the market k. The second line is given by expert welfare. However, notice that expert welfare is directly determined by how many experts are consulted by consumers, which is displayed by the term M/N. As outlined in the section for expert welfare, each consumers consults on average S_t experts for a recommendation. Moreover, from Lemma 1 follows that each consumer will buy exactly one service in case she enters the market. Consequently, each experts sells on average M/N services with the individual probability depending on f, x_t and y. Since in case a consumer searches for matching opinions, she will visit in sum $2/z$ experts who have on average the probability $(1 - fB)z/2$ for selling a service.

In equilibrium, $f = f^*(q_t)$, $fB = f^*(q)B = 1/(1 + \frac{2c}{p(1-qy)-2c})$ and $ax_h + (1-a)x_l + (1-x_h)ay = z \in \{\underline{z}, \overline{z}\}$. Moreover, note that $(1 - k)MS_t/N = kS_t$ and $S_t = f^*(q_t) + (1 - f^*(q_t))2/z$. Accordingly, we receive the following equilibrium outcome for overall welfare

$$\pi(f^*, z, a, y, k) = k[f^*_q(zV - s - c(z - (1 - x_h)ay) \tag{34}$$

$$+ (1 - f^*_q)(V - \frac{2s}{z} - 2c + \frac{2c}{z}(1 - x_h)ay)]. \tag{35}$$

Overall welfare in equilibrium depends on the endogenous factors z and $f^*(q_t)$, which are determined in equilibrium by offered contracts (d, p), as well as by market composition, i.e. k, a and y. While the former variables are influenced within a given equilibrium, the market composition factors are assumed to be external and only amendable in the long run.
We investigate how the possible range for z is determined in equilibrium and how it affects overall welfare. In every non-degenerate equilibrium, z is determined by the values of V, d and s only. In contrast to the transaction costs s and the valuation for consumers of a solved problem V which directly affect overall welfare, d is welfare neutral but affects whether experts will become better off by a change to a high skilled equilibrium. However, with decreasing d, the possible range for $z \in [\underline{z}, \overline{z}]$ increases. Consequently, when overall welfare should be maximized, independently whether z has a positive or negative effect, d needs to be minimized.
We now analyze how z affects overall welfare. Since in all non-degenerate equilibrium with $f^*(q_t) > 0$, z which will be determined only by market conditions, i.e. d, V and s. Consequently, in this cases, we can treat z as being independent in equilibrium from x_h and x_l. By building the f.o.c. we get

$$\frac{\partial \pi}{\partial z} = k[f_q^*(V-c) + 2(1-f_q^*)(\frac{s - c(1-x_h)ay}{z^2}). \tag{36}$$

By inserting $f = f^*(q_t) = (p(1-q_t y) - 2c)/(p(1-q_t y) + (z-2)c)$ and solving for p, we receive

$$p > p^* = \frac{2c + \frac{c(2c(1-x_h)ay - 2s)}{z(V-c)}}{1 - q_t y}. \tag{37}$$

Notice that in a market with only few and/or relatively lowly qualified high skilled experts, i.e. with $ay < s/c(1-x_h)$, (37) always holds, since $p \geq 2c/(1-q_t y)$.
However, independently of whether an increase in z increases or decreases overall welfare, the only choice for d, in order to maximize welfare, is given by $z(d = 0)$, since a decrease in d strictly widens the interval for z in any non-degenerate equilibrium. Depending on market composition, either $\underline{z}(0)$ or $\overline{z}(0)$ will maximize overall welfare.

In the next step, we now turn to the optimal value for f_q^*. In every non-degenerate equilibrium, the possible values for $f^*(q_t)$ are determined by p, c, y and z. We have already shown that in all welfare maximizing states $z \in [\underline{z}(0), \overline{z}(0)]$. This implies that (11) needs to hold with equality. Since $d = 0$, we get

$$zV - p - s = V - p - \frac{2s}{z}. \tag{38}$$

By using (34) and (38), we get the following inequality equation as condition for $\partial \pi / \partial f > 0$

$$-c(z - (1-x_h)ay) > -2c(1 - \frac{(1-x_h)ay}{z}). \tag{39}$$

Solving for ay gives

$$ay < \frac{z}{1 - x_h}. \tag{40}$$

This corresponds to the second adaptation condition for low skilled equilibria. Consequently, as long as $ay < z$, which is given in all non-degenerate low skilled equilibria, there is $\partial\pi/\partial f > 0$. However, if the relative amount of high skilled experts, as well as their qualification increases above the defined threshold, this relationship turns to $\partial\pi/\partial f < 0$ but cannot be a low skilled equilibrium anymore.

According to Lemma 3, in a non-degenerate equilibrium the probability for consumers to stop and purchase after their first recommendation $f^*(q_t)$ is given by (14) which increases strictly in p. Consequently, in every welfare maximizing equilibrium, p needs to be either $\underline{p} = 2c/(1 - qy)$ or $\overline{p} = zV - (d + s)$ in order to maximize or minimize $f^*(q_t)$. With an increasing price in service, it becomes more attractive for experts to invest high effort which, furthermore, increases consumers' tendency to stop after their first visit.

According to (40), in every low skilled welfare maximizing equilibrium, it is necessary that $\overline{p} = zV - (d + s)$ and $d = 0$, which results in

$$\overline{f_l^*} = \frac{z(0)V - s - 2c}{z(0)V - s + c(z(0) - 2)}. \tag{41}$$

In a corresponding high skilled equilibrium, we receive either $\underline{p} = 2c/(1 - qy)$ with $\underline{f_h^*} = 0$ or $\overline{p} = zV - (d + s)$ with

$$\overline{f_h^*} = \frac{(1 - y)(z(0)V - s) - 2c}{(1 - y)(z(0)V - s) + c(z(0) - 2)}. \tag{42}$$

Proposition 1: *If (d, p, z, f) is second best, then $z \in \{\underline{z}, \overline{z}\}$ and $d = 0$. According to market composition, there are the following possible second best equilibria (SBE):*

(i) *if $p > p^*$, $a(1 - y) \leq 1 - z$ and $ay < z$, $(0, \overline{p}, \overline{z}(0), \overline{f_l^*})$;*

(ii) *if $p > p^*$, $ay < z/(1 - x_h^*)$ and $a(1 - y) \geq 1 - z$, $(0, \overline{p}, \overline{z}(0), \overline{f_h^*})$;*

(iii) *if $p < p^*$, $ay > z/(1 - x_h^*)$ and $a(1 - y) \geq 1 - z$, $(0, \underline{p}, \underline{z}(0), \underline{f_h^*})$.*

Proof of Proposition 1: See Appendix C.

SBE (i) is feasible with adaptation conditions for a low skilled equilibrium holding, while SBE (ii) and (iii) correspond to high skilled equilibria. Whether and which SBE is actually feasible will be determined by market composition, as well as market conditions. For a social planer to maximize welfare by intervention, for example by stipulating some price level for services, it is essential to know about the market. As long as such a social planer is assumed to be only able to determine price levels for diagnosis d and service p, to maximize welfare she needs to apply to the outlined SBE conditions. Notice that according to the dependence of p^*, which determines the optimal level for z in any SBE, on z itself, there is the possibility that a given market can reach two different kinds of SBE, with either $\underline{z}$ or $\overline{z}$. In the next step, we investigate whether the outlined SBEs are stable.

According to Pesendorfer, Wolinsky (2003), in any given equilibrium (d, p, z, f) with $p > p^*$, the level $\overline{z}$ for consumers to receive a correct diagnosis cannot hold with flexible prices, since experts have an incentive to deviate to a lower price or reduce their effort level. Assuming a service price $p = 2c/(1-y)$, with flexible prices, z must get reduced to prevent price undercutting and cannot be second best. We do not replicate their full discussion, as the interested reader can find it there. However, they conclude due to this reduction in effort levels in a non-degenerate flexible price equilibrium, that price regulation might be beneficial in order to achieve SBE (i).

In a market with only low skilled experts, i.e. $a, y = 0$, there is only one potential SBE. As we introduced high skilled experts in the model, the variety for possible SBE increases to three. Nevertheless, the argumentation of Pesendorfer, Wolinsky (2003) regarding the instability of any flexible price equilibrium with $p > p^*$ and $\overline{z}$ still holds. Consequently, only SBE (iii) might be stable in this case.

In any SBE $d = 0$ and, therefore, s needs to be relatively large in SBE (iii), as otherwise $\underline{z}$ becomes close to zero which would make the possibility for a high skilled equilibrium, i.e. $f = f_h^*$ with $x_h = x_h^*$ and $x_l = 1$, more improbable. We have outlined that in any non-degenerate equilibrium with flexible prices, $s \in [0, \frac{V(2\sqrt{5}-2)}{8+4\sqrt{5}}]$. In contrast, with fixed prices, $s \leq V(3 - 2\sqrt{2}) > \frac{V(2\sqrt{5}-2)}{8+4\sqrt{5}}$. This implies that a market with flexible prices, needs a greater share a of high skilled experts for being an equilibrium with $(0, \underline{p}, \underline{z}(0), \underline{f_h^*})$, as otherwise an adaptation of high skilled experts is not possible. Moreover, since $\underline{z}$ is relatively small, the condition regarding the necessary number of experts in the market to enable an equilibrium $N > 2/z$ increases. Consequently, SBE (iii) is only feasible in markets with relatively large transaction costs and a relatively large number of contactable experts.

In SBE (iii) p equals the minimum price $\underline{p} = 2c/(1-y)$ for a non-degenerate high skilled equilibrium. This implies that experts will make zero profits and all generated welfare is shifted to consumers. Moreover, $f = f_h^* = 0$ implies that consumers will always search for matching opinions. Referring to Pesendorfer, Wolinsky (2003), this small probability $\underline{z}$ results in high costs to verify an expert's recommendation. This makes it less attractive for consumers to accept an expert's offer who deviates from equilibrium price. As we have outlined in 3.2, with $z = \underline{z}$ and $s \leq \frac{V(2\sqrt{5}-2)}{8+4\sqrt{5}}$, a non-degenerate equilibrium is possible which also would be second best to our definition. However, notice that from (19) follows that in markets with relatively low transaction costs, the possibility for a stable SBE becomes the more improbable the more $\underline{z}$ approaches to zero and the higher qualified high skilled experts are.

4 Conclusion

Even though there is a broad literature on credence goods markets, analysis with experts having to invest in costly diagnosis to identify consumers' problems are rare. In such markets, consumers are neither able to observe effort decisions nor whether an expert is high or low skilled, which results in a moral hazard problem. Instead of assuming a homogeneous level of qualification, in reality there are considerable differences in skills among experts of any given field. While Pesendorfer, Wolinsky (2003) assume low skilled experts to always deliver an incorrect diagnosis, we argued that this will depend on their willingness to invest effort in their diagnosis. High skilled experts' advantage, therefore, only consists in being able to carry out diagnosis with less effort but not having monopoly power for correct diagnosis. For this reason, we introduce heterogeneous experts into the model of Pesendorfer, Wolinsky (2003) where consumers can visit multiple experts to verify recommendations. For simplification, we assume experts being either high or low skilled. We model this by high skilled experts having some probability to identify consumer problems even with low effort while low skilled experts always give a false recommendation in this case.

Our results show that second best equilibria are possible in the presence of high skilled experts, even with flexible prices. However, for such an equilibrium being stable requires special market circumstances, whereby transaction costs for consumers must lie under a specific threshold. Additionally, the share of high skilled experts needs to be relatively large and their edge in qualification relatively low. If these conditions are not fulfilled, it might be worthwhile for policy-makers to intervene by fixing service prices to increase overall welfare. According to our results, there might be an incentive for policy makers to regulate service prices in markets with only few or rather extremely heterogeneously qualified experts. However, if one drops the assumption that market composition cannot be influenced externally, there can be an incentive to regulate the share of high skilled experts. As not only the possibility of SBEs but of any non-degenerate equilibrium in general depends on consumers' transactions costs not exceeding the given threshold, market breakdowns might be prevented by reducing consumers' costs for visiting an expert. However, in any second best equilibrium, all welfare surplus is either accumulated completely with consumers or with experts, which might make welfare maximization complicated.

Even though our model incorporates many dimension regarding market conditions and market composition, it has some open space for further research. Our assumption that there is always only one service which yields consumers a positive payoff is quite strict. It appears much more realistic that consumers value undertreatment and overtreatment differently, as the latter actually solves their problem. However, while this would make the model more complicated, it would not change its form in general (Pesendorfer, Wolinsky, 2003). Moreover, in a next step, it would be interesting to drop the assumption that market composition cannot be influenced externally. While this would be accompanied by introducing some costs for qualifying experts, it might be worth this investment with regard to the potential gains in overall welfare by enabling a SBE.

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Appendix A - Proof of Lemmas

Proof of Lemma 1:

Since $s + d > 0$, receiving recommendation(s) without purchase cannot be optimal for a consumer. This implies, to enter the market she must get a positive expected utility from purchasing, which is only possible with buying a service based on a correct diagnosis. Moreover, it cannot be optimal for consumers to continue searching after having received two matching recommendations, since searching is costly and matching recommendations reveal a correct diagnosis.[7]

By adapting the proof of Pesendorfer, Wolinsky (2003), we show that stopping and purchasing after two or more non-matching recommendations cannot be optimal.

Suppose a consumer has contacted $2 \leq n < N$ experts who gave all different recommendations. Let $\phi(n)$ be the probability that exactly one randomly drawn recommendation out of these n resembles the correct diagnosis.

$$\phi(n) = \frac{(1-z)^{n-1}z}{(1-z)^n + n(1-z)^{n-1}z} = \frac{z}{1+(n-1)z}.$$

Let $\tau(n)$ be the probability that the next recommendation, i.e. the (n+1)-st, will match one of the former n recommendations.

$$\tau(n) = nz\frac{z}{1+(n-1)z}.$$

While still assuming this consumer has contacted n experts who gave distinct recommendations, to continue searching for matching opinions she needs her expected continuation value W^n to be at least equal her outside option, i.e. $W^n \geq -\sum_{j=1}^{n} d_j - ns$. Since she can always decide to buy from the last contacted expert, continuation in searching also requires

$$W^n \geq zV - p - (s+d),$$

For being a best response, a consumer needs to maximize W^n. This maximization problem stems from consumers always having the choice to (i) leave the market without purchase; (ii) buy a service based on any former recommendation; (iii) get a new recommendation if $n < N$. Consequently, assuming $n < N$, consumers face the following maximization problem

$$max(W^n) = max\{-\sum_{j=1}^{n} d_j - ns, \phi(n)V - p, -(s+d) + (1-\tau(n))W^{n+1} + \tau(n)(V-p)\},$$

As consumers' outside option shrinks by the number of contacted experts, it decreases in n. Consequently, if a consumer's expected profit by entering the market is positive with $n = 0$ contacted experts, it could never be optimal to leave the market for the outside option after $n > 0$ consulted experts.

[7] Due to extreme improbability of matching wrong signals we exclude this case from analysis.

If a consumer decides for getting another recommendation, she will receive matching ones with probability $\tau(n)$ and will buy the service from one of the two experts. With probability $1-\tau(n)$ she gets another recommendation.
Assuming it would be optimal if she buys the service in $n+1$ while still having different recommendations only, her expected utility would be

$$W^{n+1} = \phi(n+1)V - p.$$

Inserting this into the former maximization problem gives

$$\begin{aligned} max(W^n) &= max\{-\sum_{i=1}^{n} d_i - ns, \phi(n)V - p, -(s+d) + (1-\tau(n))(\phi(n+1)V - p) + \tau(n)(V-p)\} \\ &= max\{-\sum_{i=1}^{n} d_i - ns, \phi(n)V - p, -(s+d) + Vz - p\} \end{aligned}$$

According to the assumption $\phi(n+1)V - p = W^{n+1} \geq max\{-\sum_{i=1}^{n} d_i - ns, -(s+d) + Vz - p\}$. Since $\phi(n)$ is decreasing in n, we get

$$\phi(n)V - p > max\{-\sum_{i=1}^{n} d_i - ns, -(s+d) + Vz - p\}.$$

This reveals that it would be optimal to buy after n distinct recommendations instead after $n+1$. Consequently, it could never be optimal for a consumer to purchase after two or more different recommendations.
In contrast to Pesendorfer, Wolinsky (2003), we introduced a limited number of N experts in the market. This might change consumers' behavior as they are no longer able to search infinitely long for matching recommendations. If a consumer has consulted $n = N$ experts and received distinct recommendation only, she is not able to continue searching for matching opinions. In this case, she has to decide whether to purchase a service from any formerly visited expert or leave the market without purchase. In this case, a consumer's maximization problem becomes

$$max(W^{n=N}) = max\{-\sum_{i=1}^{N} d_i - ns, \phi(n)V - p\}$$

Setting outcomes equal, we receive a critical threshold for z, given by

$$z^* = \frac{p - n(s+d)}{V - (n-1)[p - n(s+d)]}.$$

In maximizing her welfare, a consumer will opt for purchasing from a random expert if $n = N$ and $z > z^*$. Otherwise she will choose to leave the market without purchase. However, ending up with $n = N$ distinct recommendations cannot be optimal, as not only the outside option decreases in n but it would have been better to purchase the service from any of the $n-1$ consulted expert before as well. Consequently, ending up with $n = N$ non-matching recommendations cannot be an equilibrium. A consumer will only opt to search for matching opinions if its expected duration $\frac{2}{z}$ does not exceed the available number of N experts in the market.

In sum, if consumers decide to enter the market, they will...

- never leave the market without purchase if $n < N$;
- never stop and buy after receiving different recommendations only, if $n < N$ or $z < z_{crit}$;
- either stop after the first recommendation with purchasing;
- or search until two recommendation coincide and then purchase;
- will leave without purchasing, if they have received $n = N$ distinct recommendations and $z < z^* = \frac{p-n(s+d)}{V-(n-1)[p-n(s+d)]}$.

Proof of Lemma 4:

As outlined before, feasibility of non-degenerate equilibria and their kind depend on parameter values p, c, a and y. We, therefore, have to define the following scenarios where we assume that the market conditions for non-degenerate equilibria are fulfilled.

(i) *Scenario (i)*

$$p < 2c \rightarrow \left\{ \; x_h, x_l = 0 \right.$$

In scenario (i), there is no possibility for a non-degenerate equilibrium of any kind, since the fixed price for service is too low in comparison to high effort costs. Even if consumers are searching for matching opinions all the time, they cannot make any kind of experts willing to choose high effort, since (10) is not fulfilled. Consequently, there will be a degenerate fixed price equilibrium in which all experts would always choose low effort and consumers do not enter the market. However, if there is a substantial high share of very well qualified experts in the market, consumers are willing to enter the market by searching for matching opinions, i.e. if $ay > \frac{2(s+d)}{V-p}$. This does not change experts effort choice, though.

(ii) *Scenario (ii)*

$$2c = p < 2c/(1-y) \rightarrow \begin{cases} x_l \in [\underline{x_l^*}, \overline{x_l^*}], x_h = 0 & \text{if } f = f_l^* = 0 > f_h^* \\ x_h, x_l = 0 & \text{if } f > 0 \end{cases}$$

In scenario (ii), consumers prefer to make low skilled experts indifferent between high and low effort by always searching for matching opinions, i.e. $f = f_l^* = 0$. In this case, any solution for x_l within the defined interval that $x_l \in [\underline{x_l^*}, \overline{x_l^*}]$ is possible. Since $f > 0$ would lead to all experts choosing low effort, consumers strictly prefer to search for matching opinions as long as $V - p - 2\,\frac{s+d}{z} > 0$. However, if adaptation conditions (17) and (18) for low skilled experts are not fulfilled, $x_l \in [\underline{x_l^*}, \overline{x_l^*}]$ is not feasible and there will be a degenerate equilibrium.

(iii) *Scenario (iii)*

$$2c < p < 2c/(1-y) \rightarrow \begin{cases} x_l \in \{\underline{x_l}, \overline{x_l}\}, x_h = 0 & \text{if } f = f_l^* > f_h^* \\ x_h, x_l = 0 & \text{if } f > f_l^* \end{cases}$$

In scenario (iii), there is a great difference between low skilled and high skilled experts in their ability for diagnosis, i.e. y is relatively large. This implies that even while consumers can make low skilled experts indifferent between high and low effort, there is no possibility to achieve a perfect non-degenerate equilibrium, as high skilled experts will never choose high effort. For consumers choosing a mixed strategy with $f = f_l^* \in\,]0, 1[$, (11) must hold with equality. Therefore, in equilibrium x_l can take only the extreme values of the determined interval $\{\underline{x_l^*}, \overline{x_l^*}\}$ with adaptation conditions for low skilled experts holding. With $V - p - 2\,\frac{s+d}{z} > 0$, consumers will opt for $f = f_l^*$ leading to a partial non-degenerate equilibrium with low skilled experts choosing $x_l \in \{\underline{x_l^*}, \overline{x_l^*}\}$ and high skilled experts choosing $x_h = 0$.

(iv) *Scenario (iv)*

$$2c < p = 2c/(1-y) \rightarrow \begin{cases} x_h \in [\underline{x_h}, \overline{x_h}], x_l = 1 & \text{if } f = f_h^* = 0 < f_l^* \\ x_l \in \{\underline{x_l}, \overline{x_l}\}, x_h = 0 & \text{if } f = f_l^* > f_h^* \\ x_h, x_l = 0 & \text{if } f > f_h^*, f_l^* \end{cases}$$

In scenario (iv), the difference in qualification between high and low skilled experts in comparison to relative price $p/2c$ is less extreme than in scenario (iii). Depending on adaptation conditions, consumers will choose either $f = f_h^* = 0$ or $f = f_l^* \in]0, 1[$. In the former case, consumers search for matching opinions all the time, making high skilled experts indifferent between high and low effort and low skilled experts strictly preferring high effort. In the latter case, consumers play heir mixed strategy which makes high skilled experts to always choose low effort. In contrast, low skilled experts become indifferent between high and low effort, which would result in the same outcome as in scenario (iii). With $V - p - 2\,\frac{s+d}{z} > 0$, consumers strictly prefer any kind of non-degenerate equilibrium to a degenerate one. Notice that in the case that all adaptation conditions hold, consumers can choose freely between a partial and a perfect non-degenerate equilibrium. We show in the welfare section, that consumers prefer equilibria with $f = f(q)^* = 0$, since their welfare decreases in f. Consequently, consumers will opt for the perfect non-degenerate equilibrium in this scenario, if they can choose freely.

(v) *Scenario (v)*

$$p > 2c/(1-y) \rightarrow \begin{cases} x_h, x_l = 1 & \text{if } f < f_h^*, f_l^* \\ x_h \in \{\underline{x_h}, \overline{x_h}\}, x_l = 1 & \text{if } f = f_h^* < f_l^* \\ x_l \in \{\underline{x_l}, \overline{x_l}\}, x_h = 0 & \text{if } f = f_l^* > f_h^* \\ x_h, x_l = 0 & \text{if } f > f_h^*, f_l^* \end{cases}$$

In scenario (v), consumers are confronted with the same choices as in scenario (iv). However, note that in this scenario there is no possibility for an equilibrium with $f = f(q)^* = 0$. Again, consumers will adapt their behavior according to adaptation conditions. If all holds, they will opt for the equilibrium with the lower f, which will be a perfect non-degenerate equilibrium.

Appendix B - Further Calculations

Proof of conditions for non-degenerate equilibrium:

(i) Solving (11) reveals the possible values for $z \in \{\underline{z}, \overline{z}\}$

$$V - p - 2\frac{s+d}{z} = zV - p - (s+d)$$
$$z^2 - \frac{z(V+d+s)}{V} = -\frac{2(s+d)}{V}$$
$$z_1, z_2 = \pm\sqrt{(\frac{V+d+s}{2V})^2 - \frac{2(s+d)}{V}} + \frac{V+d+s}{2V}.$$

(ii) Building the f.o.c. for (11) determines the maximum value for s according to z

$$\frac{\partial \overline{s}}{\partial z} = \frac{(V - 2Vz)(2-z) + Vz(1-z)}{(2-z)^2} \stackrel{!}{=} 0$$
$$= (z-2)^2 - 2$$
$$z_1, z_2 = \pm\sqrt{2} + 2.$$

Since $z \in [0, 1]$, the only feasible solution is $z^* = 2 - \sqrt{2}$.

By inserting this into (11), we get the maximum value for $\overline{s}$

$$
\begin{aligned}
\overline{s}(z^*) &= \frac{V(2-\sqrt{2})(1-(2-\sqrt{2}))}{2-(2-\sqrt{2})} \\
&= V(3-2\sqrt{2}).
\end{aligned}
$$

Appendix C - Proof of Proposition 1

For any situation (d, p, z, f) being an equilibrium, all formerly defined market conditions need to be fulfilled. For an equilibrium to be a SBE, it needs to maximize overall welfare, given the market conditions, i.e. V, c and s, as well as given the market composition, i.e. a, y and k. It has been outlined that in any SBE $z \in \{\underline{z}, \overline{z}\}$ which requires $d = 0$. Moreover, $f = f_q^* \in \{\underline{f_q^*}, \overline{f_q^*}\}$ which requires that $p \in \{\underline{p}, \overline{p}\}$.
With adaptation conditions holding for low a low skilled equilibrium, given $p = \overline{p}$ and $f_l^* = \overline{f_l^*}$, the necessary value for z to make the situation a SBE, is determined by whether $\overline{p} > p^*$. If $p = \overline{p}$, it follows that $\overline{c} \leq \overline{p}/2c = (zV - s)/2$. From (37) follows that for $\overline{p} < p^*$, it is necessary that $\overline{c} > s/ay$. Using the second adaptation condition with $ay < z$, it follows that

$$
\frac{zV - s}{2} > \frac{s}{z}
$$

Solving for z gives

$$
z_{1,2} = \frac{s}{2V} \pm \sqrt{\frac{s^2 - 8sV}{4V^2}}.
$$

Since in any equilibrium, $\overline{s} = \frac{zV(1-z)}{2-z}$, there is no z which fulfills the condition. Consequently, $\overline{p} < p^*$ cannot be a low skilled equilibrium. However, with $p > p^*$ there is a potential low skilled SBE given by $(0, \overline{p}, \overline{z}(0), \overline{f_l^*})$

By a switch to a high skilled equilibrium, p^* increases. This enables an equilibrium with $\overline{p} < p^*$ while $f = f_h^*$ which requires $a(1-y) \geq 1 - z$. Consequently, $(0, \underline{p}, \underline{z}(0), \underline{f_h^*})$ with $p < p^*$, $ay > z/(1 - x_h^*)$ and $a(1 - y) \geq 1 - z$ is a possible high skilled SBE.

Assume a potential high skilled equilibrium with $p > p^*$, $ay > z/(1 - x_h^*)$ and $a(1 - y) \geq 1 - z$. If this SBE is possible, it would result in $(0, \underline{p}, \overline{z}(0), \underline{f_h^*})$. However, if $a(1 - y) \geq 1 - z$ and $ay > z/(1 - x_h^*)$, this requires that there exist an $y = y^*$ with

$$
y^* = \frac{\overline{z}}{(1-\overline{z})(1-x_h^*) - \overline{z}}.
$$

Notice that by assuming $a = (1-z)/(1-y)$, this implies $x_h^* = 0$ according to (16). With $x_h^* = 0$ it follows that $y^* = z$. Therefore, in order to be an equilibrium, this requires $y > z$. However, as simultaneously $a \geq (1 - z)/(1 - y)$ this leads to a contradiction, since $a \leq 1$. Consequently, $(0, \underline{p}, \overline{z}(0), \underline{f_h^*})$ cannot be an equilibrium.

Next, assume the potential high skilled SBE $(0, \overline{p}, \underline{z}(0), \overline{f_h^*})$. If this is possible, it follows from (37) that

$$z < z^* = \frac{2c(c(1-x_h)ay - s)}{(V-c)(p(1-y)-2c)}.$$

Since $p = \overline{p} > 2c/(1-y)$, for $z < z^*$ it is necessary that $c(1-x_h)ay - s \geq 0$. Moreover, it requires that $\underline{p} \leq p \leq \overline{p}$. With $\partial\overline{p}/\partial s > 0$, it requires that $\underline{p} \leq \overline{p}$ at least if $s = \overline{s} = V(3-2\sqrt{2})$, which is the maximum amount for s in any equilibrium.[8] With $s = \overline{s}$, the former condition for $z < z^*$ becomes $c \geq \overline{s}/(ay(1-x_h)$. Inserting this into $\underline{p} \leq \overline{p}$ gives

$$\frac{2V(3-2\sqrt{2})}{(1-y)ay(1-x_h)} \leq \underline{z}V - V(3-2\sqrt{2}),$$
$$\frac{2(3-2\sqrt{2})}{\underline{z}-(3-2\sqrt{2})} \leq (1-y)ay(1-x_h).$$

Notice that by assuming that $s = \overline{s}$, $\underline{z}$ becomes independent of the actual value of V. Following this, $\frac{2(3-2\sqrt{2})}{\underline{z}-(3-2\sqrt{2})} > 1$ which results in a contradiction, as $(1-y)ay(1-x_h) \leq 1$. Consequently, $(0, \overline{p}, \underline{z}(0), \overline{f_h^*})$ cannot be an equilibrium.

[8]Notice that in order to be a flexible price equilibrium, $s \leq \frac{V(2\sqrt{5}-2)}{8+4\sqrt{5}}$ which is more restrictive than in the fixed case. However, our argumentation does not change by it.