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Income Taxation and Marital Decisions*

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Abstract

We develop an equilibrium matching model with search frictions in order to analyze the effects that differential tax treatment of married and single individuals have on marriage formation and dissolution. Our main results are the following: (i) although an increase in the marriage tax reduces the number of marriages, there is a two-sided search effect that can substantially mitigate its impact on marriage formation and dissolution; (ii) an increase in the marriage tax need not make both men and women more reluctant to get married; (iii) the effects of a given change in the differential taxation on marital behavior depend on whether it is implemented via changes in the tax rates that singles face or in the tax rates that married people face; (iv) we compute an example to calculate the size of the two-sided search effect and nd that large changes in the marriage tax penalty can lead to small changes in the number of marriages and divorces. The example also reveals that the number of divorces can actually increase with a reduction in the marriage tax .

KEYWORDS: Marriage Penalty, Marriage Tax, Two-Sided Search, Matching.

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1 Introduction

Nowadays, the income tax treatment of married and single individuals varies markedly across countries and jurisdictions. In several places the prevailing tax laws are signi cantly non-neutral with respect to marital status. The US constitutes a clear example of such lack of neutrality embedded in the tax code: married couples pay federal taxes based on the joint income of the spouses and face a tax schedule that is different from the one applied to single individuals. As a result, the combined tax liabilities of two individuals can dramatically change if they get married. This feature of the tax code generates either a tax penalty (marriage tax) or a tax bonus (marriage subsidy) associated with marriage, as well as variations in marginal tax rates. Other leading examples of countries where the tax code lacks marriage neutrality are Germany and France.[1]

Little modeling efforts have been devoted to the analysis of the effects of differential tax treatment of married and single people on marital behavior,[2] even though the issue is not a new one, it is of economic relevance, and it is also the subject of numerous policy debates.[3] In this paper we take a rst step toward lling this gap by focusing on the equilibrium effects of differential tax treatment on marriage decisions. To this end, we study a simple and tractable equilibrium model of the marriage market with costly search for potential marriage partners based on the two-sided search framework developed by Burdett and Wright (1998), suitably modi ed to account for the differential tax treatment of married and single individuals.

An essential feature of the model is that search is *two-sided*: ex-ante identical single men and women randomly meet pairwise and, after observing an idiosyncratic taste parameter that re ects each agent s preference for the current potential partner, they get married if and only if both nd the current partner acceptable; otherwise they go back to the pool of singles and wait for the next meeting.[4] Agents remain married until one of the spouses dies or decides to dissolve the match.

[1] The German tax system is similar to the one in US. A different scheme exists in France, where the taxable income of all family members is averaged out, and tax liabilities are calculated using the same schedule applied to single individuals. This implies that married couples in France typically experience a tax-induced marriage bonus. In countries such as Canada and Sweden, marriage is neither penalized nor favored by the tax law, as it is the *individual* rather than the couple or the family, the unit subject to taxation.

[2] A number of papers have attempted to estimate empirically the effects that income taxation has on marital decisions in the United States. Alm and Whittington (1995a) and (1995b) report that changes in the marriage tax have a negative impact on the number of marriages; however, the magnitude of the effect in all of their estimations is systematically small. Sjoquist and Walker (1995) conducted a similar exercise, but they found no statistically signi cant effect. Whittington and Alm (1996) found that changes in the marriage tax has small but positive effect on the probability of divorce.

[3] In the United States, the income tax law treats differently married and single people since 1948. It seems that differential taxation of married and single individuals goes back at least to the times of the Roman Emperor Augustus who, to foster family formation, introduced a legislation that set implicit taxes on unmarried adults, including widows and widowers (see Southern (1998)).

[4] Besides being related to Burdett and Wright (1998), this paper is also linked to the literature on equilibrium

When single, agents consume the income they generate, while married people divide the income of the household using a fixed sharing rule (i.e., the model assumes "nontransferable utility"). Income taxation depends on marital status; that is, the tax rates applied to single and married people are different. Obviously, this makes the agents' optimal strategies and the equilibrium number of marriages a function of the extent of the aforementioned differential tax treatment.

The main results of the paper are the following. We find that an increase in the marriage tax has two effects on the number of marriages; on the one hand, each individual becomes more selective in their acceptance decision of potential mates, since the income gains from marriage decrease. This effect has a clear negative impact on the number of marriages. On the other hand, there is an indirect or two-sided search effect that mitigates the initial impact: agents realize that they are accepted less often and, since search is costly, this makes them less selective in their marriage decisions. We prove that this effect, which is due *exclusively* to the existence of search frictions and to the fact that search is two-sided, can dominate the first effect for men or for women, but it cannot prevail for both of them. In other words, it is not true that an increase in the marriage tax makes everybody more reluctant to get married. As a result, although the net effect on the number of marriages is still negative, it is smaller than when the two-sided search effect is ignored, as it would be in partial equilibrium models or in models without search frictions.

We also show that, when utility is nontransferable, the qualitative and quantitative effects that a given change in the differential taxation of married and single individuals have on agents' behavior depend on whether it is implemented via changes in the tax rates that singles face or in the tax rates that applied to married people.

Finally, we compute an example in order to provide an illustration of the model's quantitative implications. When we calibrate it using US data to discipline the choice of the parameters whenever possible, the following striking features emerge: first, we find that large changes in the marriage tax have small effects on the number of marriages. Second, we calculate the size of the two-sided search effect and find that its magnitude can be substantial: changes in the number of married individuals associated with changes in the marriage tax when this effect is considered are only about 60-70% of the corresponding changes for the myopic or one-sided search scenario. Finally, the example reveals that the number of divorces can actually *increase* when the marriage tax decreases.

Both theoretically and using simulations, we emphasize the importance of the two-sided search effect as a key factor operating in an equilibrium search analysis of the marriage tax. This is an important consideration; for example, it might be argued that the potential coexistence of tax penalties and bonuses in the United States may render the effects of the differential tax treatment

matching models with heterogenenous agents that includes Burdett and Coles (1997), Chade (1997), Eeckhout(1999), Morgan (1996), Lu and Mc-Affee (1996), Bloch and Ryder (2000), Shimer and Smith (2000), and Smith (1997).

on the *total* number of married couples small or insignificant. Albeit mainly of academic interest, notice that in our simple model where all married individuals are subject to the same marginal tax rate and thus the tax liabilities of *all* married people are equal, we demonstrate that the two-sided search effect naturally arises, and we illustrate that it can contribute to make the effects of tax penalties and bonuses on marriage formation to be of a small magnitude.

Our analysis is based on a model that lacks some important features such as labor supply decisions, ex-ante heterogeneous individuals in each population, progressive taxes, the possibility of cohabitation, or a more sophisticated household decision problem.[5] In spite of these omissions, we do not feel apologetic; the tractability of the framework is a virtue, and it makes it amenable to an analytic treatment that would be unthinkable in more complicated models. We strongly believe that our results are a useful starting point towards a thorough understanding of the effects of differential tax treatment of married and single individuals.

The paper is organized as follows. Section 2 describes the model. In Section 3 we analyze the equilibrium effects of a change in the differential tax treatment of married and single individuals. Section 4 extends the model by allowing endogenous match dissolutions. A numerical example is discussed in Section 5, and Section 6 concludes. The Appendix contains most of the proofs, the analysis of the model with transferable utility, and some sensitivity analysis of the example.

2 Theoretical Framework

In this section, we describe a marriage market model with search frictions, nontransferable utility, and differential tax treatment of married and single individuals. The model builds on the two-sided search framework developed in Burdett and Wright (1998), which is modified in order to take into account the aforementioned differential tax treatment.

Consider a stationary economy populated by a continuum of agents who live in continuous time and are of two types: m (males) and f (females). The measure of each population is for simplicity normalized to one.

Each agent engages in the time consuming process of looking for a mate. Ex-ante, individuals in each population are identical; however, at each meeting, a man observes a realization of the random variable θ_m, distributed according to $G_m(\theta_m)$, and a woman observes realization of θ_f, distributed according to $G_f(\theta_f)$. For simplicity, it is assumed that θ_m and θ_f are independently distributed on $[0, \overline{\theta}]$, $\overline{\theta}$ □ ∞, and that G_f and G_m are differentiable. The corresponding densities are denoted by $g_f(\theta_f)$ and $g_m(\theta_m)$, respectively, and are assumed to be continuous. These match-specific components are payoff-relevant; that is, although agents are homogeneous ex-ante, they are

[5] See Chade and Ventura (2001) and the discussion therein for a quantitative analysis of a framework that incorporates some of these features.

heterogeneous ex-post in the sense that they are not indifferent about whom to match with.

When single, the instantaneous utility of an agent is just the after tax income $w_i(1-t^S)$, $i = f, m$, where t^S is the tax rate for a single person. If a couple decides to get married after observing θ_m and θ_f, then his instantaneous utility is $k(1-t^M)(w_m+w_f)+\theta_m$ and hers is $(1-k)(1-t^M)(w_m+w_f)+\theta_f$, where t^M is the tax rate for a married couple, and $(k, 1-k)$ are the shares of the total income that each spouse receives.[6] Agents discount the future at the rate r.

De nition 1 *There is differential tax treatment between married and single individuals if $t^M \neq t^S$. If $t^M - t^S > 0$, then there exists a marriage tax or penalty , while there is a marriage subsidy or bonus if $t^M - t^S < 0$.*

Consider the decision problem faced by a man. Marriage proposals arrive randomly according to a Poisson process with parameter α_m. Upon receiving the proposal, a man observes a realization of θ_m and then decides whether to accept or reject the match. Obviously, the woman is facing an analogous problem, and the match is formed if only if both nd it mutually acceptable. A married man does not generate any marriage offer, and he is abandoned by his wife according to a Poisson process with parameter λ_m; even if this event does not occur, a man dies according to another Poisson process with parameter δ_m.

Let U_m be the expected discounted utility of a single man, and let $V_m(\theta_m)$ be the expected discounted utility of a man who is in a marriage characterized by a match speci c component θ_m. Formally, they are recursively de ned as follows:[7]

$$(r + \delta_m)U_m = (1 - t^S)w_m + \alpha_m E[\max\{V_m(\theta_m) - U_m, 0\}], \tag{1}$$

$$(r + \delta_m)V_m(\theta_m) = k(1 - t^M)(w_m + w_f) + \theta_m + \lambda_m(U_m - V_m(\theta_m)). \tag{2}$$

Therefore,

$$V_m(\theta_m) = \frac{k(1 - t^M)(w_m + w_f) + \theta_m + \lambda_m U_m}{r + \delta_m + \lambda_m}. \tag{3}$$

An optimal strategy for a man is to accept a match if and only if the match speci c component is above a threshold θ_m^*, de ned by $V_m(\theta_m^*) = U_m$. Plugging this in (3) yields

$$(r + \delta_m)U_m = \theta_m^* + k(1 - t^M)(w_m + w_f), \tag{4}$$

[6] These shares are taken as given in the model. We can think of them as determined by norms or customs. In the Appendix we show that some of the results also hold when utility is transferable.

[7] These equations are derived using a straightforward discrete approximation argument. See the appendix in Burdett-Wright (1998).

and we can rewrite (1) as

$$\theta_m^* + k(1-t^M)(w_m+w_f) - (1-t^S)w_m = \alpha_m \int_{\theta_m^*}^{\overline{\theta}} (V_m(\theta_m) - V_m(\theta_m^*))dG_m(\theta_m).$$

Integrating the right side by parts, using the derivative of $V_m(\theta_m)$ with respect to θ_m and the Fundamental Theorem of Calculus yields

$$\theta_m^* + k(1-t^M)(w_m+w_f) - (1-t^S)w_m = \frac{\alpha_m}{r+\delta_m+\lambda_m}\mu_m(\theta_m^*),$$

where $\mu_m(\theta_m^*) \equiv \int_{\theta_m^*}^{\overline{\theta}} (1-G_m(\theta_m))d\theta_m$.

Women face an analogous problem, and their (common) threshold θ_f^* is implicitly defined by:

$$\theta_f^* + (1-k)(1-t^M)(w_m+w_f) - (1-t^S)w_f = \frac{\alpha_f}{r+\delta_f+\lambda_f}\mu_f(\theta_f^*),$$

with $\mu_f(\theta_f^*) \equiv \int_{\theta_f^*}^{\overline{\theta}} (1-G_f(\theta_f))d\theta_f$.

When a man or a woman dies, he or she is replaced by a new entrant; if that individual was married, then the widowed agent goes back to the pool of singles. In this way, the size of the two populations remains constant. There is also a matching technology that yields the number of meetings among men and women as a function of the measure of unmatched individuals. This meeting technology is assumed to exhibit constant returns to scale; i.e., the total number of meetings per unit of time is $N = \beta(1-M)$, where β is the contact rate for an individual and $(1-M)$ is the number (measure) of singles in the population (equal to the size of the population, minus the measure M of married agents). A meeting generates a marriage proposal for a man only if $\theta_f \geq \theta_f^*$; hence, the probability that he receives a marriage offer is

$$\alpha_m = \beta(1-G_f(\theta_f^*)). \tag{5}$$

Similarly,

$$\alpha_f = \beta(1-G_m(\theta_m^*)). \tag{6}$$

In this simple setting there are no incentives to terminate a marriage; thus, terminations only occur when one of the spouses dies. This means that, in equilibrium, $\lambda_f = \delta_m$ and $\lambda_m = \delta_f$.

Definition 2 *A matching equilibrium is a pair (θ_m^*, θ_f^*) that satisfies the following equations:*[8]

$$\theta_m^* + k(1-t^M)(w_m+w_f) - (1-t^S)w_m = \frac{\beta(1-G_f(\theta_f^*))}{r+\delta_f+\delta_m}\mu_m(\theta_m^*), \tag{7}$$

$$\theta_f^* + (1-k)(1-t^M)(w_m+w_f) - (1-t^S)w_f = \frac{\beta(1-G_m(\theta_m^*))}{r+\delta_f+\delta_m}\mu_f(\theta_f^*). \tag{8}$$

[8] Implicitly, (7)-(8) assume that the equilibrium is interior, i.e., $\theta_f^* > 0$ and $\theta_f^* > 0$. The proof of Proposition 1 also considers the possibility of corner solutions.

Let $\pi = \frac{\beta}{r+\delta_f+\delta_m}$. Adapting Proposition 1 in Burdett and Wright (1998) to our model yields the following result:

Proposition 1 *Suppose a) μ_m and μ_f are log-concave functions (i.e., $\mu_j''\mu_j - (\mu_j')^2 \leq 0$, $j = m, f$), and b) $E[\theta_m] > \frac{k(1-t^M)(w_f+w_m)-(1-t^S)w_m}{\pi}$ and $E[\theta_f] > \frac{(1-k)(1-t^M)(w_f+w_m)-(1-t^S)w_f}{\pi}$. Then there is a unique matching equilibrium.*

Henceforth, it will be assumed that μ_m and μ_f are log-concave and that the parametric restrictions on $E[\theta_m]$ and $E[\theta_f]$ hold.[9]

In a matching equilibrium, the flow into the pool of married agents in each population, given by $(1-M)\beta(1-G_m(\theta_m^*))(1-G_f(\theta_f^*))$ (number of singles that meets times the probability of marriage), must be equal to the flow out of this pool, given by $M(\delta_f + \delta_m)$ (number of married agents times the sum of the probability of becoming a widow or widower plus the probability of dying).

The equilibrium measure of married agents in each population, M^*, is thus given by

$$\begin{aligned} M^* &= \frac{\beta(1-G_m(\theta_m^*))(1-G_f(\theta_f^*))}{\beta(1-G_m(\theta_m^*))(1-G_f(\theta_f^*)) + (\delta_f+\delta_m)} \\ &= \frac{\beta\mu_m'(\theta_m^*)\mu_f'(\theta_f^*)}{\beta\mu_m'(\theta_m^*)\mu_f'(\theta_f^*) + (\delta_f+\delta_m)} \\ &= \frac{\gamma}{\gamma+(\delta_f+\delta_m)}, \end{aligned} \tag{9}$$

where $\mu_i' = -(1-G_i)$, $i = m, f$, and $\gamma = \beta\mu_m'\mu_f'$ (the arguments of μ_i', $i = m, f$, are omitted to simplify the notation).

3 Changes in $t^M - t^S$: Equilibrium Effects

In this section, we investigate the equilibrium effects that changes in the differential tax treatment of married and single individuals have on the optimal strategies and the fraction of married agents. Although this may be due to a change in t^M or t^S or in both of them, we mainly focus on the case in which only t^M changes. We also compare the results of the model with the ones derived under the assumption that agents ignore the reaction of the other population (we call it the one-sided search case), in order to gauge the contribution of the two-sided search aspect of the environment under consideration.

[9] Log-concavity is a standard assumption in the economics of information and uncertainty, and it is satisfied by many of the standard probability density functions. For a complete characterization of this concept and its implications, see Bagnoli and Bergstrom (1989) and An (1998). Notice also that condition *b)* is satisfied if $E[\theta_i] > \frac{w_m+w_f}{\pi}$, $i = m, f$.

Notice that M^* depends on t^M through the thresholds (θ_f^*, θ_m^*). From (9), it follows that the sign of $\frac{\partial M^*}{\partial t^M}$ is equal to the sign of $\frac{\partial \gamma}{\partial t^M}$, given by

$$\frac{\partial \gamma}{\partial t^M} = \beta(\mu_m'' \mu_f' \frac{\partial \theta_m^*}{\partial t^M} + \mu_f'' \mu_m' \frac{\partial \theta_f^*}{\partial t^M}). \tag{10}$$

The derivatives $\frac{\partial \theta_m^*}{\partial t^M}$ and $\frac{\partial \theta_f^*}{\partial t^M}$ can be found by implicit differentiation of (7) and (8). They are

$$\frac{\partial \theta_m^*}{\partial t^M} = \frac{k(1+\pi\mu_f'\mu_m') - (1-k)\pi\mu_m\mu_f''}{(1+\pi\mu_f'\mu_m')^2 - \pi^2\mu_f''\mu_m\mu_m''\mu_f}(w_m + w_f) \tag{11}$$

$$\frac{\partial \theta_f^*}{\partial t^M} = \frac{(1-k)(1+\pi\mu_f'\mu_m') - k\pi\mu_f\mu_m''}{(1+\pi\mu_f'\mu_m')^2 - \pi^2\mu_f''\mu_m\mu_m''\mu_f}(w_m + w_f). \tag{12}$$

Consider first the symmetric case in which $G_f = G_m = G$, $w_f = w_m = w$, $k = \frac{1}{2}$, and $\lambda_f = \lambda_m$. The matching equilibrium is symmetric with both populations choosing the same threshold θ^*; thus $\mu_f = \mu_m = \mu$. In this case, the sign of $\frac{\partial \theta^*}{\partial t^M}$ depends on the sign of the following expression:

$$\frac{1 + \pi(\mu'^2 - \mu''\mu)}{(1+\pi\mu'^2)^2 - (\pi\mu''\mu)^2}. \tag{13}$$

The log-concavity assumption on μ ensures that the numerator and denominator of (13) are positive. Therefore, θ^* increases when t^M increases and, from (10), M^* decreases. The intuition is rather simple: an increase in t^M implies that the "income gains" from marriage are lower; therefore, agents will not marry unless the match-specific components are high enough to compensate for the decrease in household income.

It is easy to show that the changes in θ^* and in M^* are smaller than in the "one-sided" case.[10] The intuition is the following: when t^M increases, there are two opposite effects on θ^*. First, there is a *direct* effect: the decrease in the income gains from marriage increases the acceptance thresholds of men and women. Second, there is an *indirect* effect that is ignored in the one-sided case: now each agent faces a "tighter" search environment (since they are accepted less often) and this makes them less selective; we call it the *two-sided search* effect. In the symmetric case, we just showed that the first effect dominates for both men and women, and the net result is an increase in the thresholds; nevertheless, the two-sided search effect makes the thresholds and the fraction of married people *less* sensitive to changes in the marriage tax than in the one-sided search case.

Things are a bit more complicated in the the asymmetric case. Given the log-concavity assumption, the sign of the denominator of (11) and (12) is positive; formally,

$$\begin{aligned} (1+\pi\mu_f'\mu_m')^2 - \pi^2\mu_f''\mu_m\mu_m''\mu_f &= 1 + 2\pi\mu_f'\mu_m' + \pi^2((\mu_f'\mu_m')^2 - \mu_f''\mu_m\mu_m''\mu_f) \\ &\geq 1 + 2\pi\mu_f'\mu_m' + \pi^2((\mu_f'\mu_m')^2 - (\mu_f'\mu_m')^2) \\ &= 1 + 2\pi\mu_f'\mu_m' > 0. \end{aligned}$$

[10] The analogue of (13) in the one-sided case is $\frac{1}{1+\pi\mu'^2}$.

However, the numerators can be positive or negative. As the next result shows, an increase in t^M can make one of the populations *more* selective and the other *less* selective in their acceptance decisions.

Proposition 2 *If* t^M *increases, then either (i) both* θ_m^* *and* θ_f^* *increase, or (ii)* θ_m^* *increases and* θ_f^* *decreases, or (iii)* θ_m^* *decreases and* θ_f^* *increases. Case (ii) occurs when* k *is sufficiently close to one, while (iii) arises when* k *is sufficiently close to zero.*

Notice that contrary to what intuition may suggest, Proposition 2 shows that an increase in the marriage tax need not make both men and women less inclined to marry. If the division of the household income is sufficiently asymmetric, then the two-sided search effect dominates for one of the populations, leading to a *decrease* in the acceptance threshold. To grasp the intuition of this result consider case (ii); since the male partner captures most of the household income, an increase in t^M has a substantial direct effect on the acceptance threshold of men, while the opposite happens to the women s threshold. But this implies that the two-sided search effect will be small for men and large for women; case (ii) shows that this indirect effect outweighs the direct one for women.[11]

Proposition 2 also suggests the theoretical possibility that M^* could actually increase with an increase in t^M. The following proposition reveals that this cannot happen:

Proposition 3 M^* *always decreases when* t^M *increases. The decrease in* M^* *is smaller than the corresponding decrease in the one-sided case.*

The proof of the rst part of the proposition is as follows. If we insert (11) and (12) into (10) then, after some manipulation, it is easy to show that a sufficient condition for $\frac{\partial \gamma}{\partial t^M}$ to be non positive is

$$k\mu''_m(\mu'_f)^2\mu'_m - (1-k)\mu_m\mu''_f\mu''_m\mu'_f + (1-k)\mu''_f(\mu'_m)^2\mu'_f - k\mu_f\mu''_f\mu''_m\mu'_m \square 0.$$

But, under log-concavity, this expression is less than or equal to

$$k\mu''_m(\mu'_f)^2\mu'_m - (1-k)(\mu'_m)^2\mu''_f\mu'_f + (1-k)\mu''_f(\mu'_m)^2\mu'_f - k(\mu'_f)^2\mu''_m\mu'_m = 0,$$

and the result follows. The second part of the proposition is due to the two-sided search effect, and the proof is in the Appendix.

It is important to emphasize that the two-sided search effect is due *exclusively* to the existence of search frictions (i.e., search is a time consuming process and time is valuable). To be sure, in a frictionless environment agents would sample marriage proposals until they observe $\overline{\theta}$, rendering the two-sided search effect of a change in t^M irrelevant. In Section 5, we illustrate via simulations

[11] The proof uses a limiting argument as k goes to zero or one to show that the thresholds can move in opposite directions, but this is not the only asymmetry that can lead to this result. For instance, one can show that the same happens if t^S is changed instead and w_m and w_f are sufficiently different. See (14)-(15) below.

that the two-sided search effect can substantially mitigate the direct impact of a large increase in the differential tax treatment of married and single individuals, and the net result is a decrease in M^* of small order of magnitude.

So far we have focused on the case in which the change in the differential tax treatment is brought about by a change in t^M (keeping t^S constant), but analogous results hold if t^S changes instead. Straightforward differentiation of (7)-(8) yields

$$\frac{\partial \theta_m^*}{\partial t^S} = -\frac{w_m(1+\pi\mu_f'\mu_m') - w_f\pi\mu_m\mu_f''}{(1+\pi\mu_f'\mu_m')^2 - \pi^2\mu_f''\mu_m\mu_m''\mu_f} \tag{14}$$

$$\frac{\partial \theta_f^*}{\partial t^S} = -\frac{w_f(1+\pi\mu_f'\mu_m') - w_m\pi\mu_f\mu_m''}{(1+\pi\mu_f'\mu_m')^2 - \pi^2\mu_f''\mu_m\mu_m''\mu_f}. \tag{15}$$

Two noteworthy implications follow from (14)-(15). First, unless $k = \frac{1}{2}$ and $w_m = w_f = w$, the quantitative impact of a given change in $t^M - t^S$ on θ_f^* and θ_m^* depends on whether it is due to a change in t^M or in t^S (compare (10)-(11) with (14)-(15)). Second, the equilibrium effects can be *qualitatively* different in the two cases, as the following example demonstrates.

Example 1: Let $w_m = w_f = w$, and suppose θ_m and θ_f are exponentially distributed with parameter λ. Then it is easy to show that a decrease in t^S increases both θ_m^* and θ_f^*,[12] while an increase in t^M can lead to changes in the threshold of opposite signs depending on the value of k. Thus, a change in $t^M - t^S$ of a given size can affect behavior differently according to how it is implemented.

The main force that drives this example is that utility is nontransferable. In the Appendix we show that with transferable utility cases (ii) and (iii) of Proposition 2 cannot arise, and therefore the qualitative effects of an increase in t^M are the same as those of a decrease in t^S. However, we show that it is still true that the existence of the two-sided search effect makes the optimal strategies and the fraction of married people less responsive to changes in $t^M - t^S$.

4 Endogenous Match Dissolutions

Up to this point, we have studied a model in which marriages are only terminated exogenously by the death of one of the spouses. Since this can be viewed as a serious limitation of our analysis, we introduce endogenous match dissolutions into the model in a simple fashion and analyze the equilibrium effects of changes in t^M. For tractability, we incorporate the possibility of divorce in the same way as Burdett and Wright (1998): according to a Poisson process with parameter ψ

[12] The proof is as follows. Consider the expression $1+\pi(\mu_f'\mu_m' - \mu_m\mu_f')$ in the numerator of (14); it can be rewritten as $1+\pi\frac{\mu_f'}{\mu_m'}(\mu_m'^2 - (\frac{\mu_m'}{\mu_m''}\frac{\mu_f''}{\mu_f'})\mu_m\mu_m'')$. But this expression is positive since $\frac{\mu_m'}{\mu_m''}\frac{\mu_f''}{\mu_f'} = \frac{\lambda}{\lambda} = 1$ and μ_m' is log-concave. Thus, (14) is negative and the result follows.

(we assume for simplicity that it is the same for both populations), a married agent draws a new match-speci c component of his or her current mate which is independent of the previous draw, and then decides whether to continue with the match or get divorced and go back to the pool of singles. The advantage of this procedure is that the optimal strategy for an agent is summarized by a single threshold θ_i^*, $i = m, f$; the agent gets married if the match speci c component is above the threshold and then gets divorced if the new observation falls below it.

We show in the Appendix that a matching equilibrium is a pair of thresholds θ_m^* and θ_f^* that solves the following system of equations:[13]

$$\frac{k(1-t^M)(w_f+w_m)+\theta_m^*-(1-t^S)w_m}{\mu_m(\theta_m^*)} = \frac{-(\beta\mu_f'(\theta_f^*)+\psi)}{\epsilon+\psi\mu_f'(\theta_f^*)} \tag{16}$$

$$\frac{(1-k)(1-t^M)(w_f+w_m)+\theta_f^*-(1-t^S)w_f}{\mu_f(\theta_f^*)} = \frac{-(\beta\mu_m'(\theta_m^*)+\psi)}{\epsilon+\psi\mu_m'(\theta_m^*)}, \tag{17}$$

where $\epsilon = r + \delta_m + \delta_f + 2\psi$.

The equilibrium number of married people is

$$\begin{aligned} M^* &= \frac{\beta(1-G_m(\theta_m^*))(1-G_f(\theta_f^*))}{\beta(1-G_m(\theta_m^*))(1-G_f(\theta_f^*))+\delta_f+\delta_m+\psi(G_m(\theta_m^*)+G_f(\theta_f^*))} \\ &= \frac{\beta\mu_m'\mu_f'}{\beta\mu_m'\mu_f'+\delta_f+\delta_m+2\psi+\psi(\mu_m'+\mu_f')}, \end{aligned} \tag{18}$$

and the divorce ow is given by

$$\begin{aligned} D^* &= \psi(G_m(\theta_m^*)+G_f(\theta_f^*))M^* \\ &= \psi(2+\mu_m'+\mu_f')M^*. \end{aligned} \tag{19}$$

Intuitively, an increase in t^M has the following effects on M^*: on the one hand, it decreases the income gains from marriage and this prompts agents to increase the thresholds θ_i^*, $i = f, m$; this leads to a lower probability of accepting a match and to a higher probability of separation. On the other hand, the two-sided search effect mitigates the initial impact; if it doesn t offset it completely, then the net effect is a *decrease* in the equilibrium number of marriages and their duration. A formal characterization of these results is contained in the following proposition which, for simplicity, focuses on the symmetric case:

Proposition 4 *In the symmetric case, if* $\beta(1-G((t^M-t^S)w)) > \psi$ *then there exists a unique matching equilibrium. An increase in* t^M *increases* θ^* *and decreases* M^**. The magnitude of the changes is smaller than the corresponding changes in the one-sided case.*

[13] This assumes that the equilibrium is interior; in the Appendix we also consider the possibility of corner solutions.

Notice that the impact of an increase in t^M on the divorce flow D^* is ambiguous; although the probability of divorce increases, the number of people married decreases, and this renders the net effect undetermined. In the next section, we compute an example that shows that D^* need not be a monotone function of t^M, and it also illustrates that the two-sided search effect can be strong enough to make one of the populations *less* selective after an increase in t^M. Since the example is asymmetric and no existence proof is available for this case, we prove the following result:

Proposition 5 *Suppose a) $\beta > \psi$, and b) $E[\theta_m] > \frac{\epsilon-\psi}{\beta-\psi}(k(1-t^M)(w_f+w_m)-(1-t^S)w_m)$ and $E[\theta_f] > \frac{\epsilon-\psi}{\beta-\psi}((1-k)(1-t^M)(w_f+w_m)-(1-t^S)w_f)$. Then a matching equilibrium exists.*

5 A Numerical Example

In this section, we compute an example of the model with and without endogenous match dissolutions. Needless to say, the environment we analyze abstracts from potentially important features and therefore one should not make any serious inference about the US from this quantitative exercise. Our goal is to provide an illustration of the quantitative implications of the model as well as of the importance of the two-sided search effect in mitigating the impact of a change in the differential tax treatment of married and single individuals.

We use actual US data to restrict our choice of the model parameters whenever possible. Regarding the match-specific components θ_m and θ_f, we simply assume a particular distribution and then conduct a sensitivity analysis with respect to the parameters that characterize it.

Consider first the benchmark case without endogenous match dissolutions. We set the model period equal to a year and $t^S = 0.20$. Based upon these choices, we choose the rest of the model's parameters as follows. Regarding mortality rates, we assume that males and females enter marriage and labor markets at age 20. Thus, we set mortality rates based on life-expectancy conditional upon being alive at such age. US data indicates a life expectancy of 53.3 years for males and 59.8 for females in 1990 (Statistical Abstract of the United States (1999), Table 128). This yields $\delta_m = 0.0187$ and $\delta_f = 0.0167$. The annual value for the rate of time preference is set equal to 4%, i.e., $r = 0.04$.

The choice of w_f and w_m is based on data on earnings differences between males and females. We set $w_f = 1.0$ and choose w_m so as to match the ratio of mean earnings of males to mean earnings of females. The average of this ratio is about 0.67 for the period 1990-1998 (U.S. Census Bureau, Historical Income Tables, Table P-39. Individuals in the sample are Full-Time, Year-Round Workers). Consequently, we set $w_m = 1.4925$.

We assume that match specific components are exponentially distributed with parameter $\phi_m = \phi_f = \phi$; this assumption implies that μ_f and μ_m are log-concave. The parameter ϕ is chosen so that the mean of match speci c components is in line with the level of income of spouses upon marriage. For the benchmark model (i.e., with no endogenous match dissolutions) with $k = 1/2$, we set ϕ equal to the fraction of income that each spouse obtains, namely $(w_f + w_m)/2$.

The remaining parameter of the model, the contact rate β, is set so that under equal division ($k = 1/2$) and with $t^M = t^S$, the equilibrium fraction of married individuals M^* matches the mean observed value (66.8%) during 1990-1999.[14] The resulting value is $\beta = 0.4766$.

Results We present results in Table 1 for the stock of marriages, threshold values and acceptance rates for males and females ($(1 - G_i(\theta_i^*))$, $i = f, m$). Two features are worth pointing out. First, notice the relative insensitivity of the equilibrium fraction of married individuals for different values of t^M. For example, under equal division a change of eight percentage points in t^M (from $t^M = .16$ to $t^M = .24$), which changes $t^M - t^S$ from $-.04$ to $.04$, generates a reduction of only one percentage point in M^*. If we measure the impact of the marriage tax on marriage behavior using the elasticity of the stock of marriages with respect to $t^M - t^S$, its value is always about -0.01.[15] Second, M^* always decreases with increases in t^M for values of $k \neq 1/2$, and for $k = 0.30$ and $k = 0.70$ one of the thresholds falls when t^M increases. This is in line with the results proved in Proposition 2: for k sufficiently close to one ($k = 0.7$ in our example), the threshold for males increases and the threshold for females decreases, while the opposite happens when k is sufficiently close to zero ($k = 0.30$).

Insert Table 1

Two-Sided vs. One-Sided Search In order to assess the importance of the two-sided search effect, we now compare the results with the one-sided case. We do so by calculating the threshold values for males and females for alternative values of t^M, under the myopic assumption that they consider the threshold of the opposite population xed at the level consistent with no differential tax treatment (i.e., $t^M = t^S = .20$). Then we use equation (9) to derive M^* in this scenario. The results are displayed in Table 2 and Figure 1 for $k = 1/2$.[16] For comparison, we also plot in Figure 1 the relationship between M^* and t^M when agents take into account the two-sided search effect. Qualitatively, the gure clearly depicts that M^* is smaller in the one-sided case if a marriage tax penalty exists ($t^M > .20$), and larger if a marriage subsidy prevails ($t^M < .20$).

[14] Since, in equilibrium, marriages are terminated only by the death of one of the spouses, the fraction of married individuals is calculated from the data (Statistical Abstract of the US, 2000, Table 53) by excluding divorced individuals; that is (*Married* (%))/(*Married* (%) + *Never Married* (%) + *Widowed* (%)).

[15] The elasticities reported in Table 1 are calculated for large changes in the marriage tax: from -0.04 to 0.04. If they were calculated for small changes (for instance, in the neighborhood of $t^M - t^S = 0$), the resulting values would be even smaller in absolute terms.

[16] The results for $k = 0.3$ and $k = 0.7$ are very similar and are therefore omitted.

Insert Figure 1

How important is the role played by the two-sided search effect quantitatively? Table 2 sheds light on this question. It reveals that this effect substantially dampens the changes in M^* associated with changes t^M. The change in the two-sided case is only about 67-68% of the change in the one-sided case. In other words, the explicit consideration of the two-sided search effect reduces the impact of t^M on M^* in approximately *thirty two* percent.

Insert Table 2

Endogenous Match Dissolutions Assuming $k = 0.5$, $t^M = t^S = 0.2$, and exponentially distributed match speci c components, we choose ψ and β simultaneously so as to match two statistics on marriage and divorce in the US: *i)* the average fraction of the population married for 1990-1999, 61.3%, and *ii)* the mean duration of marriages terminated by divorce, 9.8 years (US Monthly Vital Statistic Report, Vol. 43, 9, Supplement, Table 10).[17] We then compute matching equilibria for different values of t^M and k. The results are presented in Table 3.

Insert Table 3

Notice that in every case M^* and the expected duration of marriages terminated in divorce decline with increases in the marriage penalty. We also note that M^* becomes more sensitive to changes in $t^M - t^S$ relative to the benchmark case. Nevertheless, these effects are still relatively small: when $k = 0.5$, an increase of eight percentage points in the marriage tax (from -0.04 to 0.04) reduces the number of marriages in less than two percentage points. We conclude that the relative insensitivity of M^* with respect to changes in the marriage tax that we found previously is still present in the model with divorce.

We also note that the thresholds can move in opposite directions. Interestingly, a noteworthy nding that emerges from Table 3 is that D^* is not a monotone function of t^M; it increases with t^M when $k = .30$ and $k = .70$, but it *falls* as t^M increases for the equal division case. In other words, a decrease in the marriage tax can actually *increase* the number of divorces.

Finally, we evaluate quantitatively the importance of the two-sided search effect. The results are displayed in Table 4, and they reveal that in the model with divorce two-sided search considerations can become even *more* important than in the benchmark case: the change in M^* when the two-sided search effect is present is now only about 60% of the corresponding change in the one-sided case.

[17] Let τ be the number of periods a couple stays married. Taking into account that a marriage can be terminated either by divorce or by death of one of the spouses, it can be shown that the expected duration of a marriage is $E[\tau] = (\delta_m + \delta_f + \psi(G_m(\theta_m^*) + G_f(\theta_f^*)))^{-1}$. Similarly, the expected duration of a marriage terminated by divorce is $E[\tau \mid divorce] = (\psi(G_m(\theta_m^*) + G_f(\theta_f^*)))^{-1}$.

Insert Table 4

6 Concluding Remarks

In this paper, we develop a two-sided search model to analyze the effects on marital decisions of the differential tax treatment of married and single individuals.

Our main ndings are the following. Although an increase in the marriage tax reduces the number of marriages, there is a two-sided search effect that can substantially mitigate its impact on marriage formation and dissolution, and it can be strong enough to make either men or women less selective in their marital decisions. Also, the effects on marital behavior of a given change in the differential taxation depends on whether it is implemented via changes in the tax rates that singles face or in the tax rates that married people face. Finally, in a numerical example we obtain three striking results: (a) large changes in the marriage tax can have small effects on the number of married individuals; (b) the size of the two-sided search effect can be substantial; (c) the number of divorces could actually increase with a decrease in the marriage tax.

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Appendix

A1. Omitted Proofs

Proof of Proposition 1: The equilibrium conditions (5)-(6), $\delta_m = \lambda_f$, and $\delta_f = \lambda_m$, along with the fact that the optimal strategy has the reservation property, allow us to rewrite (1) as follows:

$$(r+\delta_m)U_m = \frac{(1-t^S)w_m + \pi\mu'_f\mu'_m k(1-t^M)(w_m+w_f) - \pi\mu'_f \int_{\theta^*_m}^{\overline{\theta}} \theta_m dG_m(\theta_m)}{1+\pi\mu'_f\mu'_m}.$$

Hence, given θ^*_f men solve

$$\max_{\theta^*_m \geq 0} (r+\delta_m)U_m.$$

Similarly, women solve[18]

$$\max_{\theta^*_f \geq 0} (r+\delta_f)U_f.$$

The Kuhn-Tucker conditions of these problems reveal, after some manipulation, that a matching equilibrium must satisfy the following conditions:

$$k(1-t^M)(w_m+w_f) + \theta^*_m - (1-t^S)w_m + \pi\mu'_f\mu_m \geq 0 \tag{20}$$

$$\theta^*_m \geq 0, \tag{21}$$

with complementary slackness;

$$(1-k)(1-t^M)(w_m+w_f) + \theta^*_f - (1-t^S)w_f + \pi\mu'_m\mu_f \geq 0, \tag{22}$$

$$\theta^*_f \geq 0, \tag{23}$$

with complementary slackness.

Given condition b), there cannot be an equilibrium with $\theta^*_m = \theta^*_f = 0$. For if $\theta^*_f = 0$, then the optimal response is for men to set $\theta^*_m > 0$, and vice versa. Thus, there are only three possible cases: (i) both thresholds are positive; (ii) only θ_m is positive; (iii) only θ_f is positive. Under log-concavity, it easy to show that the absolute value of the inverse of the slope of the reaction function of women $\theta^*_f(\theta^*_m)$ (given by (22)-(23)) is greater than the slope of the reaction function men $\theta^*_m(\theta^*_f)$ (given by (20)-(21)) when they intersect. Hence, the equilibrium is unique. ■

Proof of Proposition 2: We rst show that θ^*_m and θ^*_f cannot both decrease when t^M increases. Since the denominator of (11)-(12) is positive, it is enough to show that the numerators cannot be both negative. They can be written, respectively, as

$$k[a(k)+b(k)] - b(k) \tag{24}$$

[18] The existence of search frictions allows us to ignore the constraint that the thresholds must be smaller than $\overline{\theta}$, for it will never bind.

$$a(k) - k[a(k) + c(k)] \tag{25}$$

where $a(k) \equiv 1 + \pi\mu'_f\mu'_m$, $b(k) \equiv \pi\mu_m\mu''_f$, and $c(k) \equiv \pi\mu_f\mu''_m$.[19] If (24) is negative, then it must be the case that $k < \frac{b(k)}{a(k)+b(k)}$; therefore,

$$\begin{aligned} a(k) - k[a(k) + c(k)] &> a(k) - \frac{b(k)[a(k) + c(k)]}{a(k) + b(k)} \\ &= \frac{(1 + \pi\mu'_f\mu'_m)^2 - \pi^2\mu''_f\mu_m\mu''_m\mu_f}{a(k) + b(k)} > 0 \end{aligned}$$

given the log-concavity of μ_f and μ_m and the fact that $a(k) + b(k) > 0$. Thus, when t^M increases then either (i) both θ^*_m and θ^*_f increase, or (ii) θ^*_m increases and θ^*_f decreases, or (iii) θ^*_m decreases and θ^*_f increases. The analysis of the symmetric case shows that case (i) is nonempty.

Consider case (ii). It is straightforward to show the following results: a) $\frac{\partial\theta^*_m}{\partial k} < 0$, $\frac{\partial\theta^*_f}{\partial k} > 0$, $\lim_{k\to1}\theta^*_f < \overline{\theta}$; b) $\lim_{k\to1} h(k) = h(1) > 0$, where $h(k)$ is the denominator of (11)-(12); c) $\lim_{k\to1} a(k) = a(1) > 0$ and $\lim_{k\to1} a(k) = c(1) > 0$. Therefore,

$$\begin{aligned} \lim_{k\to1}\frac{\partial\theta^*_m}{\partial t^M} &= \frac{a(1)}{h(1)} > 0 \\ \lim_{k\to1}\frac{\partial\theta^*_f}{\partial t^M} &= -\frac{c(1)}{h(1)} > 0. \end{aligned}$$

By continuity, for k sufficiently close to one $\frac{\partial\theta^*_m}{\partial t^M} > 0$ and $\frac{\partial\theta^*_f}{\partial t^M} < 0$, so case (ii) is nonempty. The analysis for case (iii) follows in a similar way by letting k go to zero. ■

Proof of Proposition 3: It remains to prove that the decrease in M^* is smaller than in the one-sided case. Recall that the one-sided case is the one where agents do not take into account the reaction of the other population when t^M increases. From (7)-(8), it follows that in the one-sided case (OS)

$$\frac{\partial\theta^*_m}{\partial t^M}|_{OS} = \frac{k(w_m + w_f)}{1 + \pi\mu'_f\mu'_m} < 0 \tag{26}$$

$$\frac{\partial\theta^*_f}{\partial t^M}|_{OS} = \frac{(1-k)(w_m + w_f)}{1 + \pi\mu'_f\mu'_m} < 0, \tag{27}$$

and therefore,

$$\frac{\partial\gamma}{\partial t^M}|_{OS} = \beta(w_m + w_f)\frac{k\mu'_f\mu''_m + (1-k)\mu''_f\mu'_m}{1 + \pi\mu'_f\mu'_m} < 0. \tag{28}$$

Since $\frac{\partial M^*}{\partial t^M} = \frac{\delta_f + \delta_m}{(\gamma + \delta_f + \delta_m)}\frac{\partial\gamma}{\partial t^M}$, the proof will be complete if we can show that

$$\frac{\partial\gamma}{\partial t^M}|_{OS} - \frac{\partial\gamma}{\partial t^M}|_{TS} < 0, \tag{29}$$

[19] These expressions depend on k through θ^*_f and θ^*_m.

where $\frac{\partial\gamma}{\partial t^M}\mid_{TS}$ includes the two-sided search effect (it is calculated by inserting (11) and (12) into (10)). After some tedious algebra, it can be shown that (29) holds if and only if

$$\pi^2(1-k)\mu'_m\mu_m\mu''_m\mu''_f((\mu'_f)^2-\mu_f\mu''_f)+\pi^2k\mu'_f\mu_f\mu''_f\mu''_m((\mu'_m)^2-\mu_m\mu''_m)$$
$$+\pi(1-k)\mu'_f\mu''_f\mu_m\mu''_m+\pi k\mu_f\mu''_f\mu'_m\mu''_m<0,$$

and it is straightforward to check that this is true if μ_m and μ_f are log-concave. ■

Proof of Proposition 4: We rst prove that if $\beta(1-G((t^M-t^S)w))>\psi$, then there is a unique $\theta^*>(t^M-t^S)w$ that solves

$$\theta^*-(t^M-t^S)w=\frac{-(\beta\mu'-\psi)\mu}{\epsilon+\psi\mu'}. \tag{30}$$

It is easy to show that condition $\beta(1-G((t^M-t^S)w))>\psi$ implies that, if an equilibrium exists, then $\theta^*\in((t^M-t^S)w,\hat{\theta})$, where $\hat{\theta}=G^{-1}(1-\frac{\psi}{\beta})$.

Rewrite (30) as

$$(\theta^*-(t^M-t^S)w)(\epsilon+\psi\mu')=-(\beta\mu'-\psi)\mu,$$

and denote the left side by $r(\theta^*)$ and the right side by $q(\theta^*)$. Notice that $r((t^M-t^S)w)=0$, $r(\hat{\theta})>0$ and $r'(\theta^*)>0$, while $q((t^M-t^S)w)>0$, $q(\hat{\theta})=0$ and $q'(\theta^*)<0$. Hence, there is a unique matching equilibrium characterized by $\theta^*>(t^M-t^S)w$.

The equilibrium fraction of married agents is given by

$$M^*=\frac{\beta(\mu')^2}{\beta(\mu')^2+2\delta+2\psi+2\psi\mu'}. \tag{31}$$

Straightforward differentiation yields

$$\frac{\partial M^*}{\partial t^M}=\frac{2\beta\mu'\mu''(2\delta+2\psi+2\psi\mu')}{(\beta(\mu')^2+2\delta+2\psi+2\psi\mu')^2}\frac{\partial\theta^*}{\partial t^M}<0, \tag{32}$$

where

$$\frac{\partial\theta^*}{\partial t^M}=\frac{\epsilon+\psi\mu'}{\epsilon+2\psi\mu'+\psi\mu''(\theta^*-w(t^M-t^S))+\beta\mu''\mu+\beta(\mu')^2}w>0. \tag{33}$$

In the one-sided case, we have

$$\frac{\partial\theta^*}{\partial t^M}\mid_{OS}=\frac{\epsilon+\psi\mu'}{\epsilon+2\psi\mu'+\beta(\mu')^2}w>0, \tag{34}$$

which is obviously greater than (33). Hence, the decrease in M^* when t^M increases is greater when agents ignore the two-sided search effect. This completes the proof. ■

Proof of Proposition 5: With endogenous match dissolutions, U_m is the same as (1) and $V_m(\theta_m)$ is given by

$$\begin{aligned}(r+\delta_m)V_m(\theta_m) &= k(1-t^M)(w_m+w_f)+\theta_m+(\lambda_m+\psi)(U_m-V_m(\theta_m)) \\ &\quad +\psi E[\max\{V(\theta_m')-U_m,0\}]. \qquad (35)\end{aligned}$$

The optimal strategy is to choose a threshold θ_m^* that determines the match formation and separation decisions.

After tedious algebra, U_m can be rewritten as follows:[20]

$$U_m=\frac{(1-t^s)w_m(r+\delta_m+\lambda_m+G_m\psi)+\alpha_m(1-G_m)k(1-t^M)(w_m+w_f)+\alpha_m\int_{\theta_m^*}^{\overline{\theta}}\theta_m dG_m}{(r+\delta_m)((r+\delta_m+\lambda_m+G_m\psi)+(1-G_m)\alpha_m)} \qquad (36)$$

The problem for men is to nd θ_m^* that solves

$$\max_{\theta_m^*\geq 0}(r+\delta_m)U_m.$$

Similarly, women solve

$$\max_{\theta_f^*\geq 0}(r+\delta_f)U_f.$$

Using the equilibrium conditions $\alpha_i=\beta(1-G_j(\theta_j^*))$, $\lambda_i=\delta_m+\psi G_j(\theta_j^*)$, $i,j=m,f$, it follows that a matching equilibrium is characterized by a pair (θ_m^*,θ_f^*) that satis es

$$\begin{aligned}k(1-t^M)(w_m+w_f)+\theta_m^*-(1-t^S)w_m+\frac{(\psi+\beta\mu_f')\mu_m}{\epsilon+\psi\mu_f'} &\geq 0 \qquad (37)\\ \theta_m^* &\geq 0, \qquad (38)\end{aligned}$$

with complementary slackness;

$$\begin{aligned}(1-k)(1-t^M)(w_m+w_f)+\theta_f^*-(1-t^S)w_f+\frac{(\psi+\beta\mu_m')\mu_f}{\epsilon+\psi\mu_m'} &\geq 0, \qquad (39)\\ \theta_f^* &\geq 0, \qquad (40)\end{aligned}$$

with complementary slackness.

Using these conditions, it is straightforward to show that the following results hold under assumptions a) and b): (i) $\theta_m^*=\theta_f^*=0$ cannot be an equilibrium; (ii) there is a unique best response θ_i^* for each $\theta_j^* \square \overline{\theta}$, $i,j=m,f$; (iii) for every value of θ_j^* such that $\theta_i^*>0$, we have that $\frac{\partial\theta_i^*}{\partial\theta_j^*}<0$; (iv) θ_i^* is either always positive or there is a unique $\hat{\theta_j^*}$ such that $\theta_i^*=0$ for all $\theta_j^*\geq\hat{\theta_j^*}$. It follows from these results that a matching equilibrium exists (i.e., the best response function intersect at least at one point). This completes the proof. ■

[20] To get this expression, a) use (1) to write $E[\max\{V(\theta_m)-U_m,0\}]=\frac{r+\delta_m}{\alpha_m}U_m-\frac{(1-t^S)w_m}{\alpha_m}$; b) plug this into (35) and obtain an expression for $V_m(\theta_m)$; c) insert it into (1) and integrate using the threshold strategy θ_m^*.

A2. The Transferable Utility Case

Let the total instantaneous payoff to a match be

$$z = (1 - t^M)\tilde{w} + \theta, \tag{41}$$

where $\tilde{w} = w_m + w_f$ and $\theta = \theta_m + \theta_f$; notice that $z \in [(1-t^M)\tilde{w} + \underline{\theta}, (1-t^M)\tilde{w} + \overline{\theta}]$. The cumulative distribution of θ, $G(\theta)$, is derived from $G_f(\theta_f)$ and $G_m(\theta_m)$, while the distribution of z, $F(z)$, is given by $F(z) = G(z - (1-t^M)\tilde{w})$.

The payoff z is divided between the spouses according to the Nash Bargaining solution. The shares each of the spouses receives are $S_m(z)$ and $S_f(z)$, respectively; obviously, $z = S_m(z) + S_f(z)$.

Following similar steps as in Burdett and Wright (1998) (pp. 239-241), it is easy to show that a) there exists a unique equilibrium characterized by thresholds S_m^* and S_f^*, such that each agent accepts a match if the share is above the corresponding threshold, b) the Nash Bargaining solution yields $S_m(z) = \frac{1}{2}(z + S_m^* - S_f^*)$ and $S_f(z) = \frac{1}{2}(z + S_f^* - S_m^*)$, c) (S_m^*, S_f^*) is the unique solution to[21]

$$S_m^* - (1-t^S)w_m = \frac{\pi}{2}\int_{S_f^*+S_m^*}^{\overline{z}} (1 - G(z - (1-t^M)\tilde{w}))dz \tag{42}$$

$$S_f^* - (1-t^S)w_f = \frac{\pi}{2}\int_{S_f^*+S_m^*}^{\overline{z}} (1 - G(z - (1-t^M)\tilde{w}))dz. \tag{43}$$

We are now ready to prove the following result:

Proposition 6 *An increase in t^M has the following implications: (i) $\frac{\partial S_m^*}{\partial t^M} = \frac{\partial S_f^*}{\partial t^M} < 0$; (ii) the probability of marriage decreases; (iii) M^* decreases; (iv) the decrease in M^* is smaller than the corresponding decrease in the one-sided case.*

Proof: Differentiating (42) and (43) with respect to t^M yields

$$\frac{\partial S_m^*}{\partial t^M} = -\frac{\frac{\pi}{2}(1 - G(S_f^* + S_m^* - (1-t^M)\tilde{w}))}{(1 + \frac{\pi}{2}(1 - G(S_f^* + S_m^* - (1-t^M)\tilde{w}))^2 - (\frac{\pi}{2}(1 - G(S_f^* + S_m^* - (1-t^M)\tilde{w}))^2}\tilde{w} < 0, \tag{44}$$

and $\frac{\partial S_f^*}{\partial t^M}$ is given by the same expression. This proves (i).

The probability of marriage is given by

$$\beta P(z \geq S_m^* + S_f^*) = \beta(1 - G(S_f^* + S_m^* - (1-t^M)\tilde{w})), \tag{45}$$

and its derivative with respect to t^M is

$$-\beta g(S_f^* + S_m^* - (1-t^M)\tilde{w})(1 - \frac{\pi(1 - G(S_f^* + S_m^* - (1-t^M)\tilde{w}))}{1 + \pi(1 - G(S_f^* + S_m^* - (1-t^M)\tilde{w}))})\tilde{w} < 0. \tag{46}$$

[21] The integral in the right side in both equations follows by integrating $\int_{S_f^*+S_m^*}^{\overline{z}} (z - S_f^* - S_m^*)dF(z)$ by parts.

Hence, (ii) holds.

The equilibrium fraction of married agents is

$$M^* = \frac{\beta(1 - G(S_f^* + S_m^* - (1 - t^M)\tilde{w}))}{\beta(1 - G(S_f^* + S_m^* - (1 - t^M)\tilde{w})) + \delta_f + \delta_m}, \tag{47}$$

and it follows from (ii) that $\frac{\partial M^*}{\partial t^M} < 0$.

Finally, in the one-sided case $\frac{\partial S_m^*}{\partial t^M}$ and $\frac{\partial S_f^*}{\partial t^M}$ are given by

$$-\frac{\frac{\pi}{2}(1 - G(S_f^* + S_m^* - (1 - t^M)\tilde{w}))}{1 + \frac{\pi}{2}(1 - G(S_f^* + S_m^* - (1 - t^M)\tilde{w}))}\tilde{w} < 0, \tag{48}$$

which is smaller than (44). This implies that the decrease in M^* is larger in the one-sided case, completing the proof of the proposition. ■

Notice that, unlike in the nontransferable utility case, it cannot be the case that one population becomes more and the other less selective with an increase in t^M.

A3. Sensitivity Analysis

We present some results regarding the robustness of the example presented in Section 5 with respect to the following variations in the environment: (i) changes in the relative importance of income and match speci c components; (ii) introduction of complementarities between income and match speci c components in the instantaneous utility function. For simplicity, we only report the results for the benchmark case without divorce.

(i) Relative Importance of Income and Match-Speci c Components: It is natural to expect that agents will become more sensitive to changes in the marriage tax if the income aspects associated with marriage become relatively more important; in principle, this could alter the relatively small effect of an increase in t^M on the number of marriages found previously.

We focus only on the case where $k = 1/2$ and compute the equilibrium of the model under the assumption that the mean of the distribution $E[\theta_i]$, $i = m, f$, is equal to a fraction a of the income that each spouse obtains when married, given by $(w_m + w_f)/2$. Table 5 reports the elasticity of M^* with respect to $t^M - t^S$ for $a = \{1/2, 1/4, 1/5\}$. For completeness, the number obtained in Section 5 for $k = 1/2$ is also included ($a = 1.0$).[22]

Insert Table 5

[22] The contact rate implicit in the calculations in Table 5 is the one used in Tables 1 and 2. The elasticities do not change signi cantly if the contact rate is adjusted to match, for each level of a, the target number of marriages under $k = 1/2$ and $t^S = t^M = 0.20$.

Intuitively, as a decreases and income considerations become relatively more important, the elasticity increases in absolute value. In other words, the behavior of individuals towards marriage becomes more sensitive to changes in the marriage tax when the match-speci c component is less important. We note that, although the elasticities increase in absolute value, the number of marriages is still relatively insensitive to increases in the marriage tax.

(ii) Complementarities in the Utility Function: Up to this point, it has been assumed that the instantaneous utility an agent gets when married is of the form $u_i = y_i + \theta_i$, $i = m, f$, $y_m = k(1 - t^M)(w_m + w_f)$ and $y_f = (1 - k)(1 - t^M)(w_m + w_f)$. A feature of this functional form is the lack of complementarities between y_i and θ_i, i.e., $\frac{\partial^2 u_i}{\partial y_i \partial \theta_i} = 0$.

We now introduce a small amount of complementarities of the form $u_i = y_i + \xi y_i \theta_i + \theta_i$, $\xi > 0$. In other words, the marginal utility of income (the match speci c component) is an increasing function of the match speci c component (income). An increase in t^M also affects negatively the new term $\xi y_i \theta_i$; therefore, one would expect agents to become more selective than before due to this additional effect. However, the two-sided search effect becomes more pronounced, too; therefore, it seems that, at least qualitatively, the results derived in Section 3 should not change.

The quantitative effects are summarized in Table 6, where the contact rate β and the distribution of match-speci c components are the same as in the benchmark case.[23] To illustrate the phenomenon that the thresholds can move in opposite directions, we also report the results for the case with $k = .20$.

Insert Table 6

Table 6 reveals that as ξ increases, the equilibrium number of marriages becomes *less* sensitive to changes in the marriage tax than in the benchmark case, suggesting that the mitigating impact of the two-sided search effect *increases* with the introduction of complementarities.

[23] Nothing changes if the contact rate is adjusted to match a target number of marriages for $k = 1/2$ and $t^S = t^M = .20$.

Table 1: Stock of Marriages, Individual Thresholds and Acceptance Rates ($t^S = .20$).

Tax on Married Couples (t^M)	$k = .30$	$k = .50$	$k = .70$
16%			
Fraction Married	.6740	.6740	.6740
θ_f^*	.5478	.9666	1.3859
θ_m^*	1.7800	1.3611	.9418
Acceptance Rate (Fem.)	.6443	.4604	.3289
Acceptance Rate (Male)	.2397	.3355	.4697
18%			
Fraction Married	.6710	.6710	.6710
θ_f^*	.5663	.9751	1.3844
θ_m^*	1.7785	1.3696	0.9603
Acceptance Rate (Fem.)	.6748	.4573	.3293
Acceptance Rate (Male)	.2400	.3332	.4627
20%			
Fraction Married	.6680	.6680	.6680
θ_f^*	.5848	.9837	1.3830
θ_m^*	1.7771	1.3782	0.9789
Acceptance Rate (Fem.)	.6255	.4542	.3297
Acceptance Rate (Male)	.2403	.3309	.4559
22%			
Fraction Married	.6649	.6649	.6649
θ_f^*	.6035	.9923	1.3820
θ_m^*	1.7757	1.3868	0.9975
Acceptance Rate (Fem.)	.6162	.4510	.3300
Acceptance Rate (Male)	.2405	.3286	.4491
24%			
Fraction Married	.6618	.6618	.6618
θ_f^*	.6222	1.0010	1.3804
θ_m^*	1.7745	1.3956	1.0162
Acceptance Rate (Fem.)	.6070	.3263	.3303
Acceptance Rate (Male)	.2408	.4480	.4425
Elasticity ($M^*, t^M - t^S$)	-.00918	-.00918	-.00918

Table 2: Absolute Changes in the Stock of Marriages: One-Sided vs. Two-Sided Case ($t^S = .20$)

Marriage Tax-Subsidy ($t^M - t^S$)	One Sided (1)	Two Sided (2)	(2)/(1)
$k = 0.5$			
-.20	.0428	.0286	.6684
-.10	.0221	.0148	.6702
.10	-.0234	-.0159	.6761
.20	-.0482	-.0328	.6807

Table 3: Number of Marriages and Divorces, Individual Thresholds and Marriage Duration ($t^S = .20$).

Tax on Married Couples (t^M)	$k = 0.3$	$k = .50$	$k = .70$
16%			
Fraction Married	.6581	.6215	.6227
Divorce Flow	.0507	.0626	.0622
$E[\tau \vert\ divorce]$	13.0	9.9	1.0
θ_f^*	0	.6173	1.2900
θ_m^*	1.9053	1.2489	.5771
18%			
Fraction Married	.6539	.6171	.6177
Divorce Flow	.0517	.0625	.0623
$E[\tau \vert\ divorce]$	12.8	9.9	9.9
θ_f^*	.0174	.6287	1.2785
θ_m^*	1.8977	1.2543	.6050
20%			
Fraction Married	.6466	.6126	.6128
Divorce Flow	.0522	.0625	.0625
$E[\tau \vert\ divorce]$	12.4	9.8	9.8
θ_f^*	.0910	.6401	1.2677
θ_m^*	1.8509	1.2600	.6325
22%			
Fraction Married	.6396	.6081	.6079
Divorce Flow	.0531	.0625	.0626
$E[\tau \vert\ divorce]$	12.0	9.7	9.7
θ_f^*	.0910	.6515	1.2575
θ_m^*	1.8509	1.2658	.6596
24%			
Fraction Married	.6328	.6036	.6030
Divorce Flow	.0539	.0624	.0626
$E[\tau \vert\ divorce]$	11.7	9.7	9.6
θ_f^*	.1258	.6630	1.2479
θ_m^*	1.8306	1.2118	.6865
Elasticity ($M^*, t^M - t^S$)	-.01961	-.01461	-.0249

Table 4: Absolute Changes in the Stock of Marriages:
One-Sided vs. Two-Sided Case
(Model w/ Divorce, $t^S = .20$)

Marriage Tax-Subsidy $(t^M - t^S)$	One Sided (1)	Two Sided (2)	(2)/(1)
-.20	.0701	.0423	.6034
-.10	.0356	.0217	.6096
.10	-.0370	-.0230	.6216
.20	-.0748	-.0474	.6337

Table 5: Monetary vs. Match-Speci c Components ($k = 1/2$)

	$a = 1/5$	$a = 1/4$	$a = 1/2$	$a = 1.0$
Elasticity $(M^*, t^M - t^S)$	-.04616	-.03684	-.01864	-.00918

Table 6: Stock of Marriages and Individual Thresholds
with Complementarities in Payoffs ($t^S = .20$).

Tax on Married Couples (t^M)	$k = .5$		$k = .2$	
	$\xi = .1$	$\xi = .2$	$\xi = .1$	$\xi = .2$
16%				
Fraction Married	.6735	.6730	.6683	.6643
θ_f^*	.9869	1.0036	.4329	.5057
θ_m^*	1.3440	1.3299	1.9271	1.8771
18%				
Fraction Married	.6708	.6705	.6657	.6620
θ_f^*	.9941	1.0099	.4509	.5199
θ_m^*	1.3521	1.3376	1.9237	1.8757
20%				
Fraction Married	.6680	.6680	.6631	.6596
θ_f^*	1.0015	1.0164	.4691	.5344
θ_m^*	1.3603	1.3454	1.9203	1.8743
22%				
Fraction Married	.6652	.6654	.6604	.6572
θ_f^*	1.0090	1.0230	.4875	.5490
θ_m^*	1.3686	1.3533	1.9168	1.8729
24%				
Fraction Married	.6623	.6628	.6577	0.6548
θ_f^*	1.0166	1.0296	.5061	.5640
θ_m^*	1.3770	1.3614	1.9134	1.8714
Elasticity $(M^*, t^M - t^S)$	-.00835	-.00765	-0.08027	-.00719
Elasticity $(M^*, t^M - t^S)$ ($\xi = 0$)	-.00918	-.00918	-.00918	-.00918