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Where did it go wrong? Marriage and divorce in Malawi

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Do individuals marry and divorce for economic reasons? Can we measure the economic attractiveness of a person's marriage market? We answer these questions using a structural model of consumer-producer households that is applied to rich data from Malawi. Using revealed preference conditions for a stable marriage market, we define the economic attractiveness of a potential match as the difference between the potential value of consumption and leisure with the new partner and the value of consumption and leisure in the current marriage. We estimate this marital instability measure for every possible pair in geographically defined marriage markets in 2010. We find that the marital instability measure is predictive of future divorces, particularly for women. We further show that this estimated effect on divorce is mitigated by the woman's age, and by a lack of men, relative to women, in the marriage market, showing that these factors interact with the economic attractiveness of the remarriage market. These findings provide out-of-sample validation of our model and evidence that the economic value of the marriage market matters for divorce decisions.

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1. Introduction

Becker (1973, 1974) convincingly argued that the institution of marriage can be analyzed by means of modern microeconomic theory. In his ground-breaking work, as well as in subsequent work by Becker, Landes, and Michael (1977), the concept of the marriage market is introduced, which rests on the simple but powerful assumption that individuals are rational utility maximizers who compete as they seek mates. This framework implies that each individual looks for the best mate subject to the restrictions imposed by the marriage market. An important concept in this theory is gains to marriage, which depend on a given union as well as the opportunities provided by the marriage market as a whole. While companionship and the production of children are important components of marital gains, there are also considerable economic gains to marriage, such as the sharing of public goods and the division of labor within unions (see Browning, Chiappori, and Weiss (2014) for an extensive discussion).

In this paper, we focus on the relationship between the economic gains of marriage with respect to household production and consumption decisions, and divorce and remarriage. More specifically, individuals seek to find the best match in the marriage market, and better outside options in terms of one's marriage market will affect intrahousehold sharing in the current match, and subsequent divorce, if opportunities on the marriage market dominate the allocation of consumption and time in the current marriage. We provide a structural measure of the value of an individual's remarriage market, based on a robust revealed preference approach, and show that it predicts future divorce, in an out-of-sample test of the model. This suggests that our quantification of marriage (in)stability can be an attractive tool to further guide the extensive literature on the drivers and consequences of divorce (see, e.g., Amato (2010) for a review).

In estimating our model, we fix our attention on households in Malawi, a context where divorce is common and remarriage is socially acceptable. Lifetime divorce probabilities are between 40% and 65%, and remarriage is almost universal: within 2 years of divorce, over 40% of women remarry, with this figure reaching almost 90% after 10 years (Reniers (2003); see also the discussion in Section 2). Marriages also tend to happen within neighboring villages, which allows the accurate definition of marriage markets. This is essential for obtaining reliable estimates of the value of individuals' marriage markets. Finally, our focus on Malawi allows us to specifically investigate drivers of divorce in a developing country, whereas existing empirical work has mostly focused on developed countries.

Model Our model combines three spheres of household decision-making. A first element is the income generated by household production, which is directly related to economies of scale and risk sharing opportunities provided by a marriage. Next, we introduce individual preferences over private and public goods (inside the household), which capture both unequal sharing of private goods and economic gains of jointly consuming public goods. Heterogeneity between husband and wife in these preferences correlates with unequally distributed gains of marriage and/or divorce. Finally, we focus on rational partner choice on the marriage market, meaning that the value of a given marriage is compared to the value of being single or marrying someone else.

In recent work, Cherchye, Demuynck, De Rock, and Vermeulen (2017a) focused on the last two elements. That is, they analyze the impact of gains from public goods and the marriage market on the intrahousehold distribution of resources. These authors combine the static collective model of household consumption (Chiappori (1988, 1992)) with the assumption of a stable marriage market, the latter relating directly to the ideas in Becker (1973, 1974) and Becker, Landes, and Michael (1977). Based on the potential income in the counterfactual situation and the value of the consumption bundle in the current marriage, the model quantifies the outside options of a myopic spouse and subsequently relates this to that spouse's share of household resources (in the current marriage). These outside options improve with one's productivity, which implies that the marriage market can explain the widely observed positive relationship between wages and the share of household resources consumed (see, e.g., Blundell, Chiappori, Magnac, and Meghir (2007), Cherchye, De Rock, and Vermeulen (2012), and Cherchye, De Rock, Lewbel, and Vermeulen (2015)).

Dunbar, Lewbel, and Pendakur (2013) did not reject the implications of the static collective model among Malawi households, which allows them to identify the intrahousehold sharing of resources. However, they do not explicitly model the marriage market nor do they model a household's agricultural production, which is essential in the context of Malawi (see Section 2 for more details), and more generally in a developing context. Therefore, we extend the framework of Cherchye et al. (2017a) by presenting a structural model of consumer-producer households that integrates economic gains to marriage, both in terms of public goods and the division of labor in household production, and that accounts for the intrahousehold allocation of resources in the context of a marriage market (see also Apps and Rees (1996) and Chiappori (1997)).

To obtain a tractable model that combines all these features of household decision making, we adopt a static perspective (ignoring intertemporal aspects of household decisions) and we assume stability on the marriage market. Importantly, however, this is not necessarily in contradiction with the widespread observation that households divorce. It simply implies that myopic individuals do not take into account future shocks (e.g., related to individual preferences, labor productivity, remarriage opportunities, etc.) that may change their current (and future) choices. Static models are popular in the literature (see, e.g., Browning, Chiappori, and Weiss (2014)) and can be considered as a building block for more advanced models that focus on the intertemporal aspects of household decisions (see, e.g., Chiappori and Mazzocco (2017) for a recent review). Also, it is important to note that our model performs remarkably well empirically: there is no a priori mechanical reason to expect the predictive power on future divorces that we document.

Empirical findings Our model yields two structural measures of the value of an individual's outside options, which we term *marital instability indices*: the first index captures how much better off (in consumption terms) the individual would be if single (the Individual Rationality (*IR)* index), while the second index measures how much better off the individual would be if he/she remarried another individual in the same marriage market (the Blocking Pair (*BP)* index). After computing the *BP* index for each possible pair within each marriage market, we then take the maximum of an individual's set of *BP* indices to obtain an estimate of the economic value of the (re)marriage market that reflects the individual's most attractive remarriage option.[1] We estimate these instability indices for each married individual in the first wave of our data (2010).

Using the 2013 wave of the dataset, we are able to observe if the individual has subsequently divorced. If individuals have divorced by 2013, this indicates that they experienced an important shock between 2010 and 2013; for example, a change in the economic opportunities on the marriage market, or a deterioration of match quality in the marriage. We link our measures of instability to these observed subsequent divorces, which sheds light on the relationship between economic gains to marriage (as defined in our model) and divorce. This also implies an out-of-sample test of the validity of our structural model. Note that this does not imply that there is no room for renegotiation between spouses after a negative shock occurs (see also Voena (2015), Bronson (2015), and Reynoso (2018)). Rather, our interpretation is that if the couple is highly unstable according to our measures, then there is less room for renegotiation. A big negative shock then results in divorce if the negative shock cannot be internalized through a substantial change of the intrahousehold bargaining positions. This interpretation is also in line with the structural analysis of Lise and Yamada (2018).

We find that the wife's *BP* index significantly predicts subsequent divorce. In particular, a 1 percentage point increase in the wife's *BP* index, as a proportion of her household income, raises the probability of divorce by 1.4 percentage points on average. This is an economically significant effect, as the per-year divorce probability is 8.5%.[2] Interestingly, this significant association cannot be explained by spouses' wages, land income or nonlabor income which, alongside intrahousehold sharing, are the key determinants of the *BP* index in the structural model. This suggests that intrahousehold sharing plays an important role in the gains to marriage and divorce. As an extension to these results, we also estimate a model that allows the instability indices to have a different effect on divorcing and remaining single, and divorcing and remarrying. Crucially, we find that the wife's *BP* index is significantly associated with the wife divorcing and remarrying, but not divorcing and remaining single. This is consistent with the intuition that the *BP* index captures the attractiveness of options on the remarriage market. Therefore, we find that a model-based measure of individuals' outside options on the marriage market correlates with out-of-sample realizations of divorce.

[1] We also consider the average of an individual's *BP* indices, and the 95th percentile of an individual's *BP* indices, with very similar results; see Section 6.

[2] Modeling divorce as a simple Markov process, and using the proportions of individuals currently married and divorced in the dataset and the remarriage probabilities in Reniers (2003), implies an annual divorce probability of 8.5%.

Relation to the literature Our paper makes two key contributions to the literature. First, from a methodological point of view, it significantly extends the theoretical model in Cherchye et al. (2017a) by also accounting for the economic gains of production decisions in modeling households' behavior. This is particularly relevant for consumer-producer households in developing countries, for which agricultural production activities are prevalent (see, e.g., Udry (1996), Apps and Rees (1996), Chiappori (1997), and Karlan, Osei, Osei-Akoto, and Udry (2014), and Walther (2018)). A distinguishing feature of our approach is that it belongs to a revealed preference tradition that is free of any parametric assumptions, and optimally allows for heterogeneity in preferences and production technologies. See Samuelson (1938), Afriat (1967), Diewert (1973), and Varian (1982) for early contributions on the revealed preference analysis of household consumption behavior, and Afriat (1972) and Varian (1984) for the analysis of production behavior. More recently, Cherchye, De Rock, and Vermeulen (2007, 2009, 2011) have extended this seminal work toward the analysis of households in the framework of a collective model. Finally, and importantly from a methodological point of view, our revealed preference methods allow us to estimate shadow wages and land prices, which are often missing or suffer from measurement error in empirical applications. As such, we obtain an empirically tractable model that can be applied to a context with consumer–producer households to study household choices and the role of the marriage market.

Second, our empirical application contributes a unique perspective to the active literature on the economic drivers of divorce. Many studies focus on the role of shocks in a reduced form approach. For example, unemployment (Charles and Stephens (2004), Dorion and Mendolia (2011), and Eliason (2012)), shocks to earnings capacity (Weiss and Willis (1997)), television access (Chong and La Ferrara (2009)), changes in house prices (Farnham, Schmidt, and Sevak (2011)), and lottery winnings (Hankins and Hoekstra (2011)), to name a few, have all been shown to correlate significantly with subsequent divorce. Structural (parametric) models also make more precise the mechanisms behind divorce decisions, but have rather tended to focus on learning about match quality, or the role of policy changes (Brien, Lillard, and Stern (2006), Bruze, Svarer, and Weiss (2015), Voena (2015), Bronson (2015), Goussé, Jacquemet, and Robin (2017), Reynoso (2018)).

Our paper breaks new ground in the literature on divorce in three important ways. First, we combine a structural and reduced form approach, using a structural model to provide a theoretical underpinning to the value of an individual's outside option on the marriage market, and a reduced form approach to correlate this measure with subsequent divorces. The latter step provides an out-of-sample validity test of our structural model, which is rather unique. Second, we provide empirical evidence of the well-known intuition that outside options, and in particular the value of one's remarriage market, matter for divorce decisions, while accounting for full heterogeneity in individual preferences, individuals' bargaining power and households' technologies. This is a crucial difference between our work and studies such as Voena (2015), Bronson (2015), and Reynoso (2018), which are based on strong parametric assumptions with respect to individuals' preferences, bargaining power and economies of scale. Of course, the latter analyses are richer in some other aspects (most notably, dynamic aspects), which makes our study complementary to these other studies.

Third, our findings on the role of outside opportunities in triggering divorce complement models where match quality plays an important role in marriage and divorce decisions: individuals can be thought of as matching primarily for economic reasons, but high match quality can compensate for economic "mismatch." However, when match quality erodes, individuals search for a better economic match, and so divorce when there are more economically attractive individuals available in their marriage market (see, e.g., Chiappori, Radchenko, and Salanié (2018) who use economic and noneconomic measures of match quality to predict divorce). In fact, we find that match quality matters in addition to our measures of economic gains on the marriage market. For example, we find that the estimated effect of the value of the remarriage market on divorce is mitigated when spouses are older, and is reduced when spouses are assortatively matched on age. The latter result relates to findings on the importance of assortative matching in marriage (see, e.g., Hitsch, Hortacsu, and Ariely (2010), Greenwood, Guner, Kocharkov, and Santos (2014), and Chiappori, Oreffice, and Quintana-Domeque (2017)). Finally, and consistent with the literature, the sex ratio is an important determinant of outside options: the relative attractiveness of women's remarriage opportunities turns out to be less predictive of divorce when there are fewer men relative to women in her marriage market (Chiappori, Fortin, and Lacroix (2002)).

Structure The rest of this paper unfolds as follows. Section 2 describes the context of Malawi, which motivates the structure of our model and the empirical analysis. Section 3 introduces our revealed preference methodology for analyzing the stability of marriage. Here, we also define our *IR* and *BP* indices for marriage stability. In Section 4, we discuss the dataset and explain how we construct marriage markets. Section 5 presents summary statistics of the main outcomes of our structural model. These results motivate our key empirical analysis in Section 6, in which we focus on the empirical relationship between the economic gains to matches (captured by our structural *IR* and *BP* indices) and divorce and remarriage probabilities. Section 7 concludes. The Appendix presents the proofs of our results and the Appendices in the Online Supplementary Material (Cherchye, De Rock, Vermeulen, and Walther (2021)) provide additional information and empirical results.

2. Malawian context

Malawi is a poor country in Sub-Saharan Africa, with a GDP per capita of $226 in 2013 (World Bank (2015)). It ranks 174th out of 187 countries on the 2014 Human Development Index, with an average life expectancy of 55.3 years. The proportion of females with secondary school education is low, at 10.4%. Households in Malawi primarily engage in subsistence agricultural production, with smallholder plots in the region of 0.2–3 hectares (Bignami-Van Assche, Van Assche, Anglewicz, Fleming, and van de Ruit (2011), Ellis, Kutengule, and Nyasulu (2003)). Land is largely passed on through inheritance, often at the time of marriage, and determined by descent, which can be matrilineal or patrilineal (Walther (2018)). The predominant crop grown is maize, and agricultural production involves the joint labor supply of husbands and wives (see Walther (2017) for more information on labor supply). Individuals' primary assets, and thus determinants of outside options, are their landholdings and capacity for labor supply. These features make it important to take account of households' agricultural production when considering their decision-making.

There are two key reasons why we choose this context to examine the role of economic factors in divorce. First, Malawi is characterized by high divorce rates. Marriage is almost universal (Reniers (2003)), with over 99% of women and 97% of men having married at least once by the age of 30 (Demographic Health Survey Report, 2004). Early marriage is common, with the median age of first marriage at 18 for women and 23 for men (DHS Report, 2004). However, marriage is also unstable, with almost half of all marriages ending within 20 years, a figure much higher than in other African countries, and similar to present-day figures for the U.S. (Reniers (2003)). In this sense, Malawi is characterized by a high turnover of marriages and divorces. One driver of the high divorce rate is that divorce is easy to obtain: spouses seeking divorce need only state that there is no love remaining in the marriage (Mwambene (2005)), so that divorce is unilateral. Although data on who triggers divorce is lacking, there do not appear to be gender asymmetries in divorce rates; see also Table 1 below. An important observation when applying our model is that remarriage is also common, with 40% of women remarrying within 2 years. Thus, Malawi is characterized by an ease of moving between marriage and divorce, which is consistent with the assumptions of our model presented in Section 3, with no frictions on the marriage market and where outside options are determined by utility on divorce.

Second, marriage is local. Approximately 45% of married individuals are from the village they live in, while a further 25% are from another village within the same district (Malawi IHS 2010). This allows us to be precise about defining the marriage markets within which divorced individuals can look for potential remarriage partners. In particular, we use geographic information about households to construct marriage markets—we discuss this in detail in Section 4.

To get a sense of the reasons for divorce given by individuals in Malawi, Table 1 shows responses given by men and women in the 2008 wave of the Malawi Longitudinal Study

Table 1. Reasons for divorce, responses in 2008 Malawi longitudinal survey of families and health.

	Men	Women
Lack of love	28.7%	31.5%
Spouse unfaithful	35.8%	21.9%
Spouse did not provide	4.8%	9.6%
Spouse married someone else	7.5%	20.2%
Respondent unfaithful	5.9%	3.6%
Suspected spouse of having HIV	0%	0.2%
Other	17.3%	13.0%
# Recorded divorces	734	977
# Recorded marriages	2566	3186
% Marriages ending in divorce	28.6	30.7

Note: This table shows the reported reasons for divorce for all observed divorces as of the 2008 wave of the Malawi longitudinal survey of families and health.

of Families and Health (University of Pennsylvania) to the question: What was the main reason your marriage ended? Respondents gave a complete history of their marriages and divorces. The modal response across both men and women is "lack of love." However, unfaithfulness of the spouse is the next most common reason, and is also closely related to the answer "Spouse married someone else," as both involve the presence of an alternative partner. Combining these two categories implies that among men, approximately 43% of divorces occurred due to the presence of another partner, while among women, this figure is 42%. It is interesting to note that while HIV prevalence is high in Malawi and argued to be an important parameter for partner choice (Greenwood, Kircher, Santos, and Tertilt (2019)), the percentage of individuals reporting this as a reason for divorce is close to zero.

3. Consumption, production and marriage stability

Our method for measuring the instability of marriage takes as a starting point the model of Cherchye et al. (2017a). These authors define a revealed preference characterization of household consumption under stable marriage to analyze the intrahousehold allocation of resources and the gains to marriage in terms of public goods. A novel feature of our analysis is that we integrate household production in this revealed preference framework, thus explicitly linking productivity to marriage decisions.

As explained in Section 2, agricultural production is an important dimension of household decisions in developing countries, and Malawi in particular. It is the primary source of livelihood and a crucial determinant of outside options. Moreover, our structural modeling of household production allows us to use shadow wages and land prices in our analysis of marriage stability. This is particularly important in view of our aim to accurately estimate the value of an individual's marriage market. The majority of households in Malawi do not perform market work, which means that observed market wages are likely to be upward biased relative to the distribution of wage offers, and will upward bias the estimated productivity of individuals and their value on the marriage market. Our method circumvents this issue by estimating each individuals' productivity on the land, which is a more accurate measure of economic attractiveness for farming households. This also indicates the usefulness of our model for other settings where individual's productivity on the land is an important factor.

One limitation of our model is that consumption and production decisions are separable from each other. This assumption has been rejected in some developing countries (see, e.g., Duflo and Udry (2004) for the case of Côte d'Ivoire), although recent work on intrahousehold allocation in Malawi finds behavior consistent with separability (Walther (2018) and Rangel and Thomas (2019)). Nonseparable consumption and production decisions make the nonparametric identification of models like ours notoriously difficult (see, e.g., Pollak and Wachter (1975)). At this point, the benefits of a relatively easily implementable nonparametrically identified structural model seem to outweigh the potential advantages of nonseparable consumption and production decisions that require strong parametric assumptions to obtain identification.

3.1 *Notation and components of the structural model*

We focus on the marriage stability of couples that consist of a female a and a male b. In what follows, we will often refer to individual $i = a, b$. Let A be a finite set of females and B a finite set of males. The marriage market is defined by a matching function $\sigma : A \cup B \rightarrow A \cup B$. This function satisfies, for all $a \in A$ and $b \in B$,

$$\sigma(a) \in B, \sigma(b) \in A,$$

$$\sigma(a) = b \in B \quad \text{if and only if} \quad \sigma(b) = a \in A.$$

In words, the function σ assigns to every female or male a partner of the other gender (i.e., $\sigma(a) = b$ and $\sigma(b) = a$). For simplicity, we will assume in this methodological section that $|A| = |B|$, which means that all individuals are matched. Actually, it is relatively straightforward to formally include singles in the models below.[3] However, unless there is a shortage on one side of the marriage market, rationalizing the behavior of singles requires an explicit model for frictions on the marriage market or marriage costs. To focus our discussion, we abstract from these extensions in the theoretical framework, but we allow potential matches to be formed between married individuals and singles in the marriage market in the empirical analysis, so that empirically we allow for the possibility that $|A| \neq |B|$.

Each individual i is assumed to spend his or her total time endowment (denoted by $T \in \mathbb{R}_+$) on leisure ($l^i \in \mathbb{R}_+$), market work ($m^i \in \mathbb{R}_+$) and agricultural work on the household's land (denoted by $h^i \in \mathbb{R}_+$). The individual's budget constraint for time is

$$T = m^i + h^i + l^i.$$

The price of time is individual i's wage, which we represent by $w^i \in \mathbb{R}_{++}$.

To model agricultural production, we assume that there are three types of inputs: the individuals' time spent on agricultural labor (h^a and h^b), land ($L \in \mathbb{R}_+$) and other inputs ($x \in \mathbb{R}_+$; e.g., fertilizer). To take our Malawian context into account, we distinguish between land belonging to the female ($L^a \in \mathbb{R}_+$), land belonging to the male ($L^b \in \mathbb{R}_+$) and joint "household" land ($L^{(a,b)} \in \mathbb{R}_+$):

$$L = L^a + L^b + L^{(a,b)}.$$

The first two types of land are assignable in the post-divorce allocation, while this typically is not the case for jointly owned land. For a given match (a, b), we assume a common price for the three land types, so that the price of L^a, L^b and $L^{(a,b)}$ is given by $z^{(a,b)} \in \mathbb{R}_{++}$. The price is pair-specific to allow for different values of land, reflecting for instance different qualities of land, scarcity, etc. The other input x is assumed to be a Hicksian aggregate with a price that is normalized to unity. The inputs are transformed into an output $y \in \mathbb{R}_+$ by means of an agricultural production function $F(h^a, h^b, L, x)$.

[3]Specifically, some of the variables in Propositions 1 and 2 (individual quantities, share of nonlabor income and shadow wages) must be set equal to zero in the case of singles. But the basic structure of the rationalizability conditions in the propositions remains intact.

We assume that this function is increasing in its arguments and characterized by constant returns to scale (in line with Pollak and Wachter (1975)). The output associated with agricultural production is again a Hicksian aggregate, with a price that is normalized to unity. Note that we make the assumption that agricultural production is marketable. As such, it is associated with an exogenous normalized price (see also Chiappori (1997)). The household is further associated with nonlabor income $n^{(a,b)} \in \mathbb{R}_+$.

The total income of a household consists of income from market work, agricultural production, and nonlabor income. It is allocated to a Hicksian aggregate good with a price that is normalized to unity. This Hicksian aggregate is used for the private consumption of both spouses (denoted by $q_a, q_b \in \mathbb{R}_+$) and the household's consumption of a public good (denoted by $Q \in \mathbb{R}_+$). Examples of private goods are food and clothing, while an example of a public good is expenditure on children. Importantly, the household's consumption of the private good, for example food, equals the sum of the food bought at the market and food produced at home when the household produces less than it consumes, and equals a share of the home produced food when the household produces more than it consumes. Further, by including public consumption, our model effectively captures economies of scale in consumption, which form a prime economic motivation for marriage (in addition to household (agricultural) production).

Finally, each individual i is assumed to derive utility from leisure, private consumption as well as public consumption. The preferences of individual i are represented by a utility function $U^i(l^i, q_i, Q)$ that is assumed to be continuous, concave, and strictly increasing in leisure l^i and private consumption q_i, and increasing in public consumption Q. Note that the individual heterogeneity in these preferences, for instance with respect to public goods, are directly related to the unequal distribution of the gains of marriage or divorce.

3.2 *Marriage stability: Theoretical characterization*

We now define a stable marriage allocation. We say that an allocation is stable if it satisfies three equilibrium conditions.

Our first two equilibrium conditions relate to the households' production and consumption behavior. At the production level, we closely follow the set-up of Chiappori (1997) and assume that each household $(a, \sigma(a))$ is a profit maximizer. This implies that the chosen output–input combination solves

$$\begin{aligned} &\max_{h^a, h^{\sigma(a)}, L, x} y - w^a h^a - w^{\sigma(a)} h^{\sigma(a)} - z^{(a,\sigma(a))} L - x \\ &\text{s.t.} \\ &y = F\big(h^a, h^{\sigma(a)}, L, x\big). \end{aligned} \tag{1}$$

This formulation of the household's optimization problem makes clear that it is not relevant who owns the land for the production decisions (as L $(= L^a + L^{\sigma(a)} + L^{a,\sigma(a)})$ is used as the argument of the household's production function). The household jointly decides on the optimal level of all inputs, including the total amount of land that is used.

At this point, we note that profit maximization is arguably a strong assumption, particularly for agricultural household production in developing countries (see, e.g., Udry (1996)). Therefore, in our following analysis we will allow for possible deviations from exact profit maximizing behavior. These deviations may be interpreted as reflecting cross-household variation in production technologies or productive efficiencies.

At the consumption level, we adopt the collective approach of Chiappori (1988, 1992, 1997) and assume that within-household allocations are Pareto efficient. Formally, this means that every matched couple $(a, \sigma(a))$ is using a two-step procedure. In the first step, the households select a profit maximizing input-output combination (denoted by the subindex $*$) and, in the second step, they choose a consumption allocation that solves

$$\begin{aligned}
&\max_{l^a, l^{\sigma(a)}, q_a, q_{\sigma(a)}, Q} U^a\big(l^a, q_a, Q\big) + \mu U^{\sigma(a)}\big(l^{\sigma(a)}, q_{\sigma(a)}, Q\big) \\
&\text{s.t.} \\
&w^a l^a + w^{\sigma(a)} l^{\sigma(a)} + q_a + q_{\sigma(a)} + Q \\
&\quad \leq w^a T + w^{\sigma(a)} T + n^{(a,\sigma(a))} + y_* - w^a h_*^a - w^{\sigma(a)} h_*^{\sigma(a)} - z^{(a,\sigma(a))} L_* - x_*,
\end{aligned} \tag{2}$$

where μ represents the Pareto weight of male $\sigma(a)$ relative to female a.

At this point, it is worth highlighting a few important aspects of our representation of the households' production and consumption behavior. Most notably, problem (2) makes explicit how the two decision steps are connected. The optimal decision taken in the first (production) step transforms part of the household's resources into the marketable good y_*, which in turn can be used to consume the quantities q_a, $q_{\sigma(a)}$ and Q in the second (consumption) step. Next, our structural model assumes interior solutions for both the production problem (1) and the consumption problem (2). In case couples spend their time on both market work and agricultural work, this implies that prices line up exactly (for these couples). In our empirical application, reliable data for input prices and wages will be missing. As we will explain in Section 3.4, we remedy this problem by making use of shadow prices and wages which guarantee that our assumptions of optimizing behavior hold. Finally, the Pareto weights in (2) are in general not constant. For instance, they will typically vary with wages or marriage market characteristics (such as sex ratios). Attractively, these Pareto weights capture the intrahousehold sharing of resources: a higher value for μ implies that the household decisions reflect to a greater degree male $\sigma(a)$'s preferences.

Our third and final equilibrium condition assumes that the marriage market is stable. Using the definition of Gale and Shapley (1962), marriage stability imposes that marriage matches satisfy the conditions of Individual Rationality and No Blocking Pairs. To formalize the notion of Individual Rationality, let U_H^a and U_H^b represent female a's and male b's utility in their marriage. These utilities follow from the above optimization program. Let us further denote the female's and male's maximum attainable utilities as singles by U_S^a and U_S^b, respectively. In this respect, we assume that singles are also consumer-producer households that follow the same two-step procedure as couples. Their production technologies, however, depend only on their own time spent on agricultural labor (combined with land L and the other input x), and they do not face an intrahousehold bargaining process (reflected by the household maximizing a weighted sum of individual utilities) in the consumption step.

Individual Rationality requires

$$U_H^a \geq U_S^a \quad \text{and} \quad U_H^b \geq U_S^b. \tag{3}$$

Intuitively, Individual Rationality imposes that no female or male wants to exit their marriage and become a single.

Next, to formalize the condition of No Blocking Pairs, we let $U^a_{P_{(a,b)}}$ and $U^b_{P_{(a,b)}}$ represent any possible realization of utilities for female a and male b if they formed a pair. Then the No Blocking Pair requirement imposes that

$$U^i_{P_{(a,b)}} > U^i_H \quad \text{implies} \quad U^{i'}_H > U^{i'}_{P_{(a,b)}} \quad \text{for } i, i' \in \{a, b\}, i \neq i'. \tag{4}$$

In words, a marriage market allocation has No Blocking Pairs if no female a and male b are both better off, with at least one of the two strictly better off, by remarrying each other instead of staying with their current partners.

In what follows, we will quantify deviations from the Individual Rationality and No Blocking Pair conditions by Individual Rationality (*IR*) and Blocking Pair (*BP*) indices, which measure the degree of marriage instability. We will compute these indices under the maintained assumptions that intrahousehold consumption allocations are Pareto efficient and production allocations are profit maximizing. As indicated above, we will also show how we can allow for deviations from exact profit maximizing behavior (due to technological heterogeneity or productive inefficiency) in our empirical analysis.

3.3 *Marriage stability: Empirical conditions*

To define our empirical conditions for a stable marriage allocation, we assume a data set $\mathcal{D}$ that contains the following information for a given marriage market:

- matching function σ,
- time uses l^i, m^i, and h^i of each individual i,
- wage w^i of each individual i,
- consumption quantities $(q^{(a,\sigma(a))}, Q^{(a,\sigma(a))})$ of every matched couple $(a, \sigma(a))$,
- land quantities L^a, $L^{\sigma(a)}$, and $L^{(a,\sigma(a))}$ of every matched couple $(a, \sigma(a))$,
- land price $z^{(a,\sigma(a))}$ of every matched couple $(a, \sigma(a))$,
- input quantity $x^{(a,\sigma(a))}$ of every matched couple $(a, \sigma(a))$,
- output quantity $y^{(a,\sigma(a))}$ of every matched couple $(a, \sigma(a))$,
- nonlabor income $n^{(a,\sigma(a))}$ of every matched couple $(a, \sigma(a))$.

We remark that the set $\mathcal{D}$ does not include information on individuals' private consumption; only the aggregate household quantities $q^{(a,\sigma(a))}$ are observed, which is usually the case for household data. The individuals' private quantities will be treated as unknowns in our empirical conditions for marriage stability.[4] Next, in what follows we will assume that wages and land prices remain the same when individuals exit marriage (and become single or remarry), so that divorce has no productivity effects. The assumption that land prices and wages are perfectly observed is relaxed below (see Section 3.4). Finally, given that the data set that we use below allows for identifying both individual and joint land holdings, we use this information to reconstruct a lower bound on the individual incomes used in our restrictions. We assume that individuals keep their own land after divorce, whereas the joint land (together with all other nonassigned nonlabor income) is shared endogenously. We remark that our conditions for stable marriage would be readily adapted if information on individual land holdings were not available.

Characterizing stable marriage As explained in Section 3.2, we say that the data set $\mathcal{D}$ is consistent with a stable matching if it allows the specification of individual utility functions U^a and U^b that represent the observed consumption behavior as Pareto efficient and the observed marriages as stable. We use revealed preference conditions that are intrinsically nonparametric, in the sense that they do not require an explicit (parametric) specification of the functions U^a and U^b. In particular, we obtain the following testable implications for a stable marriage matching.[5]

PROPOSITION 1. *A* necessary condition *for the data set $\mathcal{D}$ to be consistent with a* ***stable matching*** *σ is that there exist for each matched pair $(a, \sigma(a))$, $a \in A$:*

a. *individual quantities $q_a^{(a,\sigma(a))}, q_{\sigma(a)}^{(a,\sigma(a))} \in \mathbb{R}_+$ for which $q_a^{(a,\sigma(a))} + q_{\sigma(a)}^{(a,\sigma(a))} = q^{(a,\sigma(a))}$,*

b. *and nonlabor incomes $N^a, N^{\sigma(a)} \in \mathbb{R}_+$ for which $N^a + N^{\sigma(a)} = n^{(a,\sigma(a))} + x^{(a,\sigma(a))} + z^{(a,\sigma(a))} L^{(a,\sigma(a))}$,*

such that the following constraints are met for all females $a \in A$ and males $b \in B$:

i. *the individual rationality restrictions*

$$\begin{aligned} N^a + z^{(a,\sigma(a))} L^a + w^a T &\leq w^a l^a + q_a^{(a,\sigma(a))} + Q^{(a,\sigma(a))}, \\ N^b + z^{(\sigma(b),b)} L^b + w^b T &\leq w^b l^b + q_b^{(\sigma(b),b)} + Q^{(\sigma(b),b)}, \end{aligned} \tag{5}$$

ii. *and the no blocking pair restrictions*

$$\begin{aligned} &\big(N^a + z^{(a,\sigma(a))} L^a + w^a T\big) + \big(N^b + z^{(\sigma(b),b)} L^b + w^b T\big) \\ &\quad \leq \big(w^a l^a + w^b l^b\big) + \big(q_a^{(a,\sigma(a))} + q_b^{(\sigma(b),b)}\big) + \max\big\{Q^{(a,\sigma(a))}, Q^{(\sigma(b),b)}\big\}. \end{aligned} \tag{6}$$

[4] In our empirical application, part of the private consumption will be assignable to men and women (i.e., individual expenditures on health, education, and clothing; see Online Appendix OA1). Such information is easy to include in the linear conditions in Proposition 1. It implies lower bound restrictions on the unknowns $q_a^{(a,\sigma(a))}$ and $q_{\sigma(a)}^{(a,\sigma(a))}$. For ease of notation, we do not explicitly consider this refinement here.

[5] See the Appendix for the proofs of our results.

Moreover, a sufficient condition *for the data set $\mathcal{D}$ to be consistent with a stable matching σ is that, in addition, the inequalities* (6) *are strict for $b \neq \sigma(a)$.*

Restrictions (a) and (b) of Proposition 1 specify feasibility constraints that apply to the unknown individual quantities and nonlabor incomes for the matched pairs. These restrictions are associated with the assumption that households choose Pareto efficient intrahousehold allocations. Restrictions (i) and (ii) can be given a "revealed preference" interpretation in terms of a stable marriage allocation. The inequalities (5) in requirement (i) impose, for each individual male and female, that the budget constraints under single status (with potential income $N^a + z^{(a,\sigma(a))}L^a + w^a T$ for female a and $N^b + z^{(\sigma(b),b)}L^b + w^b T$ for male b) do not allow buying a bundle that is strictly more expensive than the one consumed under the current marriage (i.e., $(l^a, q_a^{(a,\sigma(a))}, Q^{(a,\sigma(a))})$ for female a and $(l^b, q_b^{(\sigma(b),b)}, Q^{(\sigma(b),b)})$ for male b). Indeed, if this requirement were not met, then at least one man or woman would be better off (i.e., could attain a strictly better bundle) as a single, which would mean that the marriage allocation is not stable. A similar intuition holds for the no blocking pair restrictions (6) in requirement (ii). When evaluating the potentially blocking pair (a, b), we define its available budget as the sum of the counterfactual (post-divorce) budgets of female a and male b. This budget is compared to the cost of a bundle guaranteeing for both individuals the same private consumption (i.e., $(l^a, q_a^{(a,\sigma(a))})$ for female a and $(l^b, q_b^{(\sigma(b),b)})$ for male b) and at least the same public consumption (i.e., $\max\{Q^{(a,\sigma(a))}, Q^{(\sigma(b),b)}\}$) as in their current marriages.[6] If (6) were not met, then both female a and male b would be better off (with at least one strictly better off) by remarrying each other, and thus, the current marriage allocation would not be stable. See also the Appendix for more details.

Some remarks are in order. First, we treat the individuals' post-divorce shares of nonlabor income (N^a and N^b in Proposition 1) as unknowns that are defined endogenously. Our method basically considers the post-divorce sharing that makes the observed marriages as attractive as possible, or, in other words, minimizes instability which is important to avoid an upward bias of our empirical results in our reduced form exercise later on. A similar remark holds for the unobserved allocation of the private goods (q_a and q_b). Next, and related to this, for each solution of the unknown variables that satisfies the empirical constraints in the proposition, we can construct utility functions U^a, U^b and a Pareto weight μ that represents the data in terms of a stable marriage allocation. In general, however, the solution to the constraints in Proposition 1 will not be unique, which means that this revealed preference approach typically obtains set identification of the structural components U^a, U^b, and μ. We refer to Cherchye, De Rock, and Vermeulen (2011) for a detailed discussion on set identification in the context of the collective model of household consumption, which directly extends to the current setting. These authors also explain the main differences between set identification on the basis of revealed preference characterizations such as ours and point identification that is

[6]We assume that children are captured by the public good, so that these are sufficient conditions for both spouses to be able to afford child custody on divorce. Allowing child custody (and its associated cost) to be spouse-specific would increase the attractiveness of divorce for the spouse who does not receive child custody.

typically pursued in the so-called differential approach to characterizing collective consumption behavior (see, e.g., Chiappori and Ekeland (2009)).

Three further remarks are of a practical nature and pertain to bringing the characterization in Proposition 1 to observational data. First, consistency of $\mathcal{D}$ with a stable matching requires that it is possible to specify individual quantities $q_a^{(a,\sigma(a))}$, $q_{\sigma(a)}^{(a,\sigma(a))}$, and nonlabor incomes N^a, $N^{\sigma(a)}$ that satisfy a set of constraints that are linear in these unknowns. Therefore, a convenient feature of the conditions in Proposition 1 is that they can be checked through linear programming, which makes them straightforward to apply in practice. Next, as discussed in Cherchye et al. (2017a), by considering all possible solutions to the rationalizability constraints in Proposition 1, we could set identify the *sharing rule*, which captures how total household consumption is shared between the spouses. Specifically, we could compute upper and lower bounds on the household's resources shares going to the individual spouses. Finally, as argued in Cherchye, Demuynck, De Rock, and Vermeulen (2017b), the empirical requirement defining the sufficient condition for data consistency with a stable marriage allocation is a very mild one that is easy to verify in practice. Therefore, we will not explicitly discuss this empirical requirement in what follows.

Quantifying marriage instability An important focus of our empirical analysis is on marriage instability. As explained before, we quantify marital instability in terms of individuals' consumption gains from divorcing and remaining single or remarrying. More specifically, when an observed household is not satisfying our testable implications, we use our model to define two structural measures of instability: the Individual Rationality (*IR*) indices capture how much better off (in consumption terms) individuals would be as a single person, and the Blocking Pair (*BP*) indices measure how much better off individuals would be when remarrying other partners in the same marriage market.

To operationalize these ideas, for each exit option from marriage (i.e., becoming single or remarrying another potential partner) we quantify the minimal within-marriage consumption increase that is needed to represent the observed marriage as stable with respect to the given exit option (as characterized by the conditions (i) and (ii) in Proposition 1). If a household satisfies the original stability constraints, then there is no need for such a consumption increase, and our stability indices that we introduce below will equal zero. In the other case, there will be a need for a strictly positive increase, which indicates how far the observed behavior (with the original income levels) is from stable behavior. To put it differently, the consumption increase measures the potential economic gain from divorce when choosing a particular exit option and, therefore, we interpret it as revealing the degree of marriage instability.

Formally, starting from our characterization in Proposition 1, we include an instability index in each restriction of individual rationality ($s^{\mathrm{IR}}_{a,\emptyset}$ for the female a and $s^{\mathrm{IR}}_{\emptyset,b}$ for the male b) and no blocking pair ($s^{\mathrm{BP}}_{a,b}$ for the pair (a,b)). We replace the inequalities (5) by

$$\begin{aligned}
\big(N^a + z^{(a,\sigma(a))}L^a + w^a T\big) - s^{\mathrm{IR}}_{a,\emptyset} &\le w^a l^a + q_a^{(a,\sigma(a))} + Q^{(a,\sigma(a))}, \\
\big(N^b + z^{(\sigma(b),b)}L^b + w^b T\big) - s^{\mathrm{IR}}_{\emptyset,b} &\le w^b l^b + q_b^{(\sigma(b),b)} + Q^{(\sigma(b),b)},
\end{aligned} \tag{7}$$

and the inequalities (6) by

$$\begin{aligned}&\left(N^a + z^{(a,\sigma(a))}L^a + w^a T\right) + \left(N^b + z^{(\sigma(b),b)}L^b + w^b T\right) - s^{\mathrm{BP}}_{a,b}\\&\quad\leq \left(w^a l^a + w^b l^b\right) + \left(q_a^{(a,\sigma(a))} + q_b^{(\sigma(b),b)}\right) + \max\left\{Q^{(a,\sigma(a))}, Q^{(\sigma(b),b)}\right\},\end{aligned} \tag{8}$$

and we add the restriction $0 \leq s^{\mathrm{IR}}_{a,\emptyset}, s^{\mathrm{IR}}_{\emptyset,b}, s^{\mathrm{BP}}_{a,b}$. The indices $s^{\mathrm{IR}}_{a,\emptyset}, s^{\mathrm{IR}}_{\emptyset,b}$ and $s^{\mathrm{BP}}_{a,b}$ represent individuals' consumption gains when choosing particular exit options from marriage: $s^{\mathrm{IR}}_{a,\emptyset}$ when female a becomes single, $s^{\mathrm{IR}}_{\emptyset,b}$ when male b becomes single, and $s^{\mathrm{BP}}_{a,b}$ when a and b remarry with each other. Clearly, imposing $s^{\mathrm{IR}}_{a,\emptyset}, s^{\mathrm{IR}}_{\emptyset,b}, s^{\mathrm{BP}}_{a,b} = 0$ obtains the original (sharp) conditions in Proposition 1, while higher values for $s^{\mathrm{IR}}_{a,\emptyset}, s^{\mathrm{IR}}_{\emptyset,b}$ and $s^{\mathrm{BP}}_{a,b}$ correspond to larger deviations from stable marriage behavior. We measure the degree of instability by computing

$$\min_{s^{\mathrm{IR}}_{a,\emptyset}, s^{\mathrm{IR}}_{\emptyset,b}, s^{\mathrm{NBP}}_{a,b}} \sum_a s^{\mathrm{IR}}_{a,\emptyset} + \sum_b s^{\mathrm{IR}}_{\emptyset,b} + \sum_a \sum_b s^{\mathrm{BP}}_{a,b}, \tag{9}$$

subject to the feasibility constraints (a) and (b) in Proposition 1 and the linear constraints (7) and (8). This implies that we try to minimize the total economic gains related to divorce in order to verify how close the observed data set is to a stable marriage market. By solving (9), we compute *IR* indices for the Individual Rationality constraints ($s^{\mathrm{IR}}_{a,\emptyset}$ and $s^{\mathrm{IR}}_{\emptyset,b}$ in (7)) and *BP* indices for the No Blocking Pairs constraints ($s^{\mathrm{BP}}_{m,w}$ in (8)). Correspondingly, for each exit option, we can define an associated gain from divorce. In our application, we will define "relative" divorce gains by setting out these gains as proportions of current household income. In the next section, we will define a modified version of the objective (9) to address empirical concerns related to unobserved input prices and cross-household heterogeneity in technologies and productive (in)efficiencies.

3.4 *Unobserved input prices and production inefficiency*

Above we have assumed that prices of the inputs of the household production are observed. In a setting where most households are farmers and only few work off-farm, observed wages are missing or upward biased, while agricultural productivity is more important for economic attractiveness but is not measured in the data. When prices and wages are not observed, shadow prices can be used instead. To obtain shadow prices, we use the structural model that we defined in Section 3.2. In particular, as in Chiappori (1997), we assume profit maximizing behavior under constant returns to scale. In the spirit of Proposition 1, we present a revealed preference characterization, which here means that it does not require an explicit specification of the production technology (represented by the function F).[7] In what follows, we will also show how we can account for deviations from exact profit maximization (because of technological heterogeneity or profit inefficiencies) in our empirical analysis.

[7]See, for example, Afriat (1972) and Varian (1984) for seminal contributions on this nonparametric approach to analyzing efficient production behavior.

Let the true wages (w^i for each individual $i = a, b$) and land prices ($z^{(a,\sigma(a))}$) for each matched pair $(a, \sigma(a))$ be unobserved. Then we can define shadow wages and prices under the identifying assumption of profit maximizing behavior. Specifically, we say that the data set $\mathcal{D}$ is consistent with shadow profit maximization if we can specify a production function F that represents the observed production behavior as profit maximizing under these shadow wages and land prices. In other words, this identifying assumption allows us to obtain individual-specific measures of labor productivity and a household-specific measure of land productivity. The following result is an adaptation of Theorem 6 in Varian (1984) to our particular setting.

Proposition 2. *The data set $\mathcal{D}$ is consistent with **shadow profit maximization** if and only if, for each matched pair $(a, \sigma(a))$ $(a \in A)$, there exist shadow wages $w^a, w^{\sigma(a)} \in \mathbb{R}_+$ and a land price $z^{(a,\sigma(a))} \in \mathbb{R}_+$ that satisfy*

$$0 = y^{(a,\sigma(a))} - \left[w^a h^a + w^{\sigma(a)} h^{\sigma(a)} + z^{(a,\sigma(a))}\left(L^a + L^{\sigma(a)} + L^{(a,\sigma(a))}\right) + x^{(a,\sigma(a))}\right] \tag{10}$$

such that, for all $a' \in A$,

$$0 \geq y^{(a',\sigma(a'))} - \left[w^a h^{a'} + w^{\sigma(a)} h^{\sigma(a')} + z^{(a,\sigma(a))}\left(L^{a'} + L^{\sigma(a')} + L^{(a',\sigma(a'))}\right) + x^{(a',\sigma(a'))}\right]. \tag{11}$$

The restrictions (10) and (11) require that there exist shadow prices such that the observed input-output combination of each matched pair $(a, \sigma(a))$ achieves a profit of zero (see (10)), which must exceed the profit for any household $(a', \sigma(a'))$ (with $a' \in A$) under the same prices (see (11)). Note that this condition of zero maximum profit directly follows from our constant returns to scale assumption. We can append these profit efficiency restrictions to the stability conditions above. As a result, our marriage stability analysis will use shadow wages and land prices that are identified under the assumption of profit maximizing household production. See also the linear program that we present below in (14).

Our empirical analysis will make use of two extensions of the characterization in Proposition 2. The first extension pertains to the fact that our characterization in Proposition 2 only imposes that shadow prices should be nonnegative. Obviously, this still admits shadow prices that are unrealistic proxies of the true (unobserved) prices (e.g., prices that are infinitely high). To exclude such unrealistic scenarios, we impose lower and upper bounds on possible prices. Specifically, we append the restrictions

$$\underline{w}^a \leq w^a \leq \overline{w}^a, \qquad \underline{w}^b \leq w^b \leq \overline{w}^b \quad \text{and} \quad \underline{z}^{(a,\sigma(a))} \leq z^{(a,\sigma(a))} \leq \overline{z}^{(a,\sigma(a))},$$

where $\underline{w}^a, \underline{w}^b, \underline{z}^{(a,\sigma(a))} \in \mathbb{R}_{++}$, and $\overline{w}^a, \overline{w}^b, \overline{z}^{(a,\sigma(a))} \in \mathbb{R}_{++}$ are predefined lower and upper bounds. Specifically, from our data we computed a median observed wage per hour of hired workers in the district. Based on plot characteristics and reported potential rent, we also calculated a median rental income per acre for each village. In our empirical application, the lower bounds are then set to zero and the upper bounds to two times the respective median. We refer to online Appendix OA1 for more details on our procedure to define lower and upper bounds on shadow wages and land prices.

Our second extension pertains to the fact that the characterization in Proposition 2 implicitly assumes that different households are exactly profit efficient and characterized by a homogeneous production technology (defined at the marriage market level). Clearly, in practice we need to account for unobserved heterogeneity in technologies and productive (in)efficiencies across households (see, e.g., Udry (1996)). To do so, we introduce deviational variables $\pi^{a+}, \pi^{a-}, \pi^{a,a'} \in \mathbb{R}_+$ for each matched pair $(a, \sigma(a))$. These variables capture possible deviations from the original (sharp) conditions in Proposition 2, which can thus be explained as deviations from exact profit maximization under a homogeneous production technology.[8]

Formally, in our profit characterization in Proposition 2, we replace the equality restriction (10) by

$$\begin{aligned}\pi^{a+} - \pi^{a-} &= y^{(a,\sigma(a))} \\ &\quad - \left[w^a h^a + w^{\sigma(a)} h^{\sigma(a)} + z^{(a,\sigma(a))}\left(L^a + L^{\sigma(a)} + L^{(a,\sigma(a))}\right) + x^{(a,\sigma(a))}\right], \end{aligned} \quad (12)$$

and the inequality restriction (11) by

$$\begin{aligned}\pi^{a,a'} &\geq y^{(a',\sigma(a'))} \\ &\quad - \left[w^a h^{a'} + w^{\sigma(a)} h^{\sigma(a')} + z^{(a,\sigma(a))}\left(L^{a'} + L^{\sigma(a')} + L^{(a',\sigma(a'))}\right) + x^{(a',\sigma(a'))}\right]. \end{aligned} \quad (13)$$

The variables $\pi^{a+}, \pi^{a-}, \pi^{a,a'}$ account for deviations from the zero maximum profit that appears on the left-hand side in the original conditions (10) and (11). That is, they capture deviations from the assumption of profit maximizing behavior under constant returns to scale with a homogeneous household technology.

In our application, we use shadow prices that minimize the aggregate value of the deviational variables, $\sum_a (\pi^{a+} + \pi^{a-} + \sum_{a'} \pi^{a,a'})$. This implies that we replace the objective (9) defined above by (with $0 \leq \alpha \leq 1$),

$$\begin{aligned}\min_{s^{\mathrm{IR}}_{a,\emptyset}, s^{\mathrm{IR}}_{\emptyset,b}, s^{\mathrm{NBP}}_{a,b}, \pi^{a+}, \pi^{a-}, \pi^{a,a'}} \; & \alpha\left(\sum_a s^{\mathrm{IR}}_{a,\emptyset} + \sum_b s^{\mathrm{IR}}_{\emptyset,b} + \sum_a \sum_b s^{\mathrm{BP}}_{a,b}\right) \\ & + \left(\sum_a \left(\pi^{a+} + \pi^{a-} + \sum_{a'} \pi^{a,a'}\right)\right), \end{aligned} \quad (14)$$

subject to the constraints (a) and (b) in Proposition 1, the stability constraints (7) and (8) and the profit maximization constraints (12) and (13). Because all constraints are linear in unknowns, we can compute the solution values of $s^{\mathrm{IR}}_{a,\emptyset}$, $s^{\mathrm{IR}}_{\emptyset,b}$, $s^{\mathrm{BP}}_{a,b}$, π^{a+}, π^{a-}, and $\pi^{a,a'}$ by straightforward linear programming. Summarizing, the above minimization program looks for optimal feasible values of unobserved individual quantities, shadow prices (including wages) and nonlabor incomes in such a way that deviations from stability and profit maximization are minimized.

[8]Deviational variables are also used in the "goal programming" approach to deal with infeasible linear programs.

In the minimization program (14), the parameter α is a tuning parameter that represents the "penalization" weight of the marriage instability indices relative to the technological heterogeneity variables. By setting $\alpha = 10^{-6}$ in our empirical application, we essentially implement a two-stage optimization process. In the first stage, we identify shadow prices as the prices that correspond to minimal deviations from our profit maximization conditions (measured by $\sum_a (\pi^{a+} + \pi^{a-} + \sum_{a'} \pi^{a,a'})$), which allows us to grasp productivity differences across individuals and land holdings. In the second stage, we compute the instability indices to capture the value of the marriage (by minimizing $\sum_a s^{\mathrm{IR}}_{a,\emptyset} + \sum_b s^{\mathrm{IR}}_{\emptyset,b} + \sum_a \sum_b s^{\mathrm{BP}}_{a,b}$). Thus, because we use profit maximizing behavior as our identifying assumption to obtain shadow wages and land prices (which are used to calculate our instability indices), we give it a substantially higher weight in the specification of our objective function in (14) by setting α to be very small.[9]

4. Data

Our data are drawn from the third Malawi Integrated Household Survey (IHS). We use the baseline survey conducted in 2010 and the second wave in 2013, where approximately one quarter of households were reinterviewed. Households were chosen randomly in both waves, and both the baseline sample and the panel subsample were designed to be nationally representative of the population of Malawi.[10] We restrict our sample to rural, monogamous households that engage in agriculture.[11] This yields a sample of 8624 households in 2010, of which 5943 were married. Of the married households, approximately one-third ($N = 1406$) are observed 3 years later. We allow singles to form potential blocking pairs with married individuals, but our instability indices are only estimated for married individuals. Online Appendix OA1 discusses the construction of the dataset in more detail.

A crucial component of our analysis is the specification of marriage markets, within which individuals can potentially form blocking pairs. As stated earlier, marriages tend to be local in Malawi. In the IHS dataset, approximately 45% of married individuals are from the village they live in, while a further 25% are from another village within the same district. We use this fact to guide our definition of marriage markets. In particular, we use the GPS coordinates of villages to construct clusters of two to three geographically close villages, which form a marriage market. We use the k-means unsupervised machine learning algorithm, which partitions the data into k clusters using the squared Euclidean distance. We set the number of clusters to 300, so that the number of households per cluster ranges from 5 to 58, with the average number of households per cluster at 33.5. The fact that we construct small marriage markets based on geographically proximate villages increases the likelihood of encounters between individuals in these

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[9]As a robustness check, we explored the impact of alternative values for α. This resulted in qualitatively similar results for the shadow prices and the stability indices (see online Appendix OA3).

[10]In the baseline survey, 768 communities were selected based on probability proportional to size, within which 16 households were randomly sampled.

[11]We use survey weights in all our descriptive statistics and also take into account the fact that the primary sampling units are villages by clustering at the village level.

Table 2. Summary statistics of rural, monogamously married households in 2010 IHS.

Variable	Mean	Standard Error
Age of head	40.407	(0.222)
Head has no education (0–1)	0.763	
Head has primary education (0–1)	0.104	
Head has secondary education (0–1)	0.124	
Head has tertiary education (0–1)	0.009	
Number of children	2.952	(0.029)
Land (acres)	1.945	(0.040)
Total consumption ('000s)	210.672	(3.535)
Public share of consumption	0.2293	(0.0020)
Private share of consumption, woman	0.0133	(0.0004)
Private share of consumption, man	0.0113	(0.0005)
Nonassignable share of consumption	0.7461	(0.0020)
Number of observations (N)	5943	
Number of marriage markets	300	

Note: This table shows the average characteristics of the households in the 2010 estimating sample.

marriage markets. As households are randomly sampled at the village level, the sample will be representative of the *types* of individuals in a person's marriage market. In this sense, although we do not observe the complete population of each marriage market, we observe a representative subset of types. We are implicitly assuming that the remarriage market is captured by these geographical clusters; thus, it cannot be the case that individuals only remarry people in faraway villages, for example, due to social stigma. Indeed, the social stigma of divorce is likely to be fairly low in this setting, given the high divorce rate. Finally, the more individuals there are in the marriage market, the more likely that there is a profitable new match. Thus, the size of the marriage market can affect the values of marital instability and we address this by controlling for marriage market fixed effects in our empirical analysis of divorce decisions (see Section 6).

Table 2 describes the characteristics of our sample. On average, the household head is middle-aged and 76% of household heads have no education. The average household has approximately three children and almost two acres of land. Most consumption is non-assignable, with 23% of consumption devoted to public goods and 2% devoted to the man's and woman's assignable goods, on average. The primary component of nonassignable consumption is food, which forms 64% of total consumption, on average. Clothing forms 3% of annual consumption, while public consumption includes utilities and house-related expenses, which form 14% of annual consumption, on average. All spending on children (education, health, clothing) is subsumed in public consumption. Thus, the majority of our households' budget is spent on food, with a further large share spent on housing and utilities.

5. Estimation results of the structural model

In this section, we discuss the estimation results from the structural model. We estimate our model using the first wave of the survey (2010), and reserve the second wave of the panel (2013) for our out-of-sample prediction of divorces. In particular, the optimization program in equation (14) in Section 3.3 yields several outputs: instability indices for each possible pair in each marriage market; instability indices for each individual for the outside option of being single, individual resource shares, deviational variables, and the budget components (shadow wages, shadow land prices, and individual nonlabor income). We present descriptive statistics in Table 3.[12]

We find that, on average, men have a significantly higher share of the household's resources than women. This is in line with the results obtained by Dunbar, Lewbel, and Pendakur (2013), albeit with a very different estimation strategy. Further, we find that women have a significantly lower shadow wage than men, which is consistent with reported nonagricultural wages in the survey. Women also have significantly lower land income than men, on average, which is partly driven by the fact that the average woman owns less land than the average man. Nonlabor income is overall high for both men and women, and is defined as the shortfall between income and consumption and leisure, so that high nonlabor income is driven by high leisure, low agricultural productivity, low land price, and small landholdings. In particular, reported leisure is very high in the survey, suggestive of overreporting, and is the most important contributor to the large average nonlabor income. These observations are useful to bear in mind when we discuss our estimates of the relationship between the outputs of our structural model and divorce in Section 6.2.1.

Next, the deviational variables capture deviations from our assumption of profit maximizing behavior under constant returns to scale with a homogeneous household technology. To make them more easily interpretable, we express them relative to the observed average output at the village level. The fraction of nonzeroes and the reported average values are relatively high. This reflects substantial unobserved technological heterogeneity across households. Given the focus of our current empirical exercise, we do not investigate this heterogeneity in more detail. We leave this as a potentially interesting avenue for follow-up research.

Finally, for each individual, we define two Blocking Pair (*BP*) indices: the *BPmax* index represents the individual's gain associated with the most attractive remarriage option, and the *BPavg* index gives the individual's average gain from remarriage, across all possible new pairs that this individual could form in their marriage market. The Individual Rationality (*IR*) index measures the gain from divorcing and being single. All indices are expressed relative to the household's total income. For the ease of interpretation of our empirical results, we multiply the BP indices with 100.

Some interesting observations emerge. First, we estimate that 61% of women have a profitable match in their marriage market, while fewer than 17% of men have a profitable match. From the *BPmax* estimates we learn that, on average, women gain more by choosing the most attractive remarriage option than men. However, our *BPavg* results reveal that women's gains from selecting the "average" remarriage possibility are

[12] As we indicated above, our nonparametric characterization of household behavior under marital stability obtains set identification (i.e., upper and lower bounds) of the unknowns in our structural model. The descriptive statistics in Table 3 summarize the estimates that we obtain as outcomes of the optimization problem in equation (14) when using the Tomlab solver for linear programming in Matlab.

TABLE 3. Summary statistics of estimates from the structural model.

Shares, Wages, Land and Income

	Men		Women	
Variable	Mean	Standard Error	Mean	Standard Error
Share of household resources (in %)	51.99	0.30	48.01	0.30
Wage	118.92	1.026	115.24	0.805
Land income ('000s)	8.830	0.351	3.985	0.157
Nonlabor income ('000s)	138.47	3.165	206.27	2.744
Number of observations		5943		

Deviational Variables

Variable	Mean	Standard Error	% Non-Zero
π^{a+}	0.266	0.011	32.69
π^{a-}	0.681	0.028	65.17
$\pi^{a,a'}$	0.802	0.044	99.98
Number of observations		5943	

Instability Indices

	Men			Women		
Variable	Mean	Standard Error	% Non-Zero	Mean	Standard Error	% Non-Zero
BPmax	0.698	0.072	16.12	3.371	0.172	60.98
BPavg	0.247	0.022	16.12	0.123	0.007	60.98
IR	0.018	0.001	44.76	0	*N/A*	0
Number of observations			5943			

Note: This table shows the variables estimated in the structural model based on the 2010 estimation sample.

generally lower than men's. This implies that women have many unattractive potential matches and some very attractive potential matches, while men have mostly mediocre, somewhat attractive matches.

This asymmetry in gains from remarriage may be caused by unequal distribution of gains to switching (i.e., unequal sharing of resources), heterogeneity in preferences (e.g., related to expenditures on public goods) or productivity differences (i.e., different shadow prices). These household-specific variables are all partly captured by our *BP* index. Importantly, however, since the *BP* index is intrinsically an equilibrium concept, it also accounts for the attractiveness of the individual marriage market as a whole. Reniers (2003) discussed the features of higher order marriages, and how they differ between men and women. He finds that in higher order marriages, women are less likely to reside patrilocally/virilocally (with the in-laws, which is considered disempowering), and are more likely to reside matrilocally/uxorilocally (near their own families, which is considered beneficial). This suggests that at least on this one facet of marriage, women may benefit more, relative to men, in higher order marriages. Another plausible reason for this pattern is that there is asymmetry in the distribution of productivity across individuals. In particular, there may be more women who have high productivities, but only a few men who are particularly productive. In fact, Online Appendix OA2 shows an example of one marriage market in the data, where this exact pattern is evident. If this is the case, then there will be many women that are potentially attractive to other men, but only a few men that are attractive to (many) women. Recall that the BP index requires identification of a pair where remarriage is beneficial for both, therefore a low proportion of men with profitable BP matches can also indicate that they themselves are not attractive to other females. This asymmetry in attractiveness (as captured by productivities) by gender can also explain why women have more profitable matches than men in the data.

In contrast, no women in our sample would prefer to be single over staying married, while over 44% of men would prefer the single option. In the context of a frictionless marriage market, this implies that the model omits unobserved costs of being single for men and remarriage for women. At this point, we note that the absence of domestic nonagricultural labor, which is currently subsumed in leisure both in the model and the data, may explain these findings. Walther (2017) showed that virtually all domestic labor in Malawi is carried out by women.[13] This implies that, to a first approximation, we overestimate women's leisure and underestimate their domestic labor in the data, but measure men's labor and leisure fairly accurately. The impact of women's domestic labor on their spouses is unambiguous: they benefit. This implies that we will tend to underestimate the value of current marriages for men, which may be the reason why we predict that a relatively large number of men would prefer to be single over their current marriage. For women, the point is more nuanced: it is not clear whether incorporating domestic labor would increase or decrease the value of current marriages for women. This depends on their trade-off between leisure and the public good produced by their

[13] Table 2 in Walther (2017) contains detailed information on time use from a different survey: on average, women spend around 4 hours per day on domestic labor, while men spend around 0.2 hours per day.

TABLE 4. Changes in marital status between 2010 and 2013, Malawi IHS.

		N (%)		
	Married	Divorced–Remarried	Divorced–Single	Total
Couples	1242	164 (11.7%)		1406
Women	1242	74 (5.4%)	64 (4.6%)	1380
Men	1242	84 (6.2%)	21 (1.6%)	1347

Note: This table shows summary statistics of marital status changes between the 2010 and 2013 waves of the Malawi IHS. Only households observed in both waves are included.

domestic time (see Donni (2008) for more discussion). We return to this point in our discussion of our baseline results in Section 6.2.

Turning next to summary statistics of divorce between 2010 and 2013, Table 4 shows that 11.7% of households divorce between the two waves of the survey.[14] Of those women with known marital status in 2013, there is a similar number of single women and remarried women, while most men remarry. Finally, Table 5 compares the characteristics of couples who divorce with those who do not. We find that both men and women who divorce have higher values of all instability indices in 2010, and we present a rigorous analysis of this relationship in Section 6.2. The table also shows that households who divorce have significantly lower total consumption, fewer children and less land. Among couples who are still married, the household head is older on average, which falls in line with standard intuition that poor matches are dissolved early on.

TABLE 5. Summary statistics of characteristics of couples who divorce and do not divorce between 2010–2013.

	Divorce		Do not divorce		
	Mean	Standard Error	Mean	Standard Error	P-Value
BPmax, woman	3.70	(0.49)	3.25	(0.33)	0.19
BPmax, man	0.72	(0.29)	0.59	(0.13)	0.66
BPavg, woman	0.14	(0.02)	0.12	(0.01)	0.19
BPavg, man	0.32	(0.20)	0.21	(0.04)	0.58
IR, man	0.019	(0.004)	0.017	(0.002)	0.50
Age of head	35.35	(1.07)	40.97	(0.55)	0.00
Number of children	2.49	(0.16)	3.13	(0.06)	0.00
Land (acres)	1.72	(0.16)	2.06	(0.07)	0.03
Total consumption ('000s)	203.29	(12.51)	237.04	(9.44)	0.01
Number of observations	164		1242		
Number of marriage markets		117			

Note: P-values indicate whether the two means are statistically significantly different from each other.

[14]There are some divorced households in 2013 where one of the spouses could not be reinterviewed; this is why the total number of divorced men or women with known marital status is fewer than the total number of divorced households.

6. Divorce and the marriage market

In this section, we demonstrate the empirical relevance of our model by showing that our structurally defined instability indices are correlated with individual and household characteristics that are plausible measures of individuals' outside options in the data, and that they predict future divorce and remarriage.

6.1 *What drives instability?*

From our discussion above, we know that the *BP* index is increasing in the potential income on divorce, which itself is driven by the sum of the individual's nonlabor income and potential labor income. Potential labor income depends on an individual's productivity, which we estimate from our model of agricultural production. On the other hand, the *BP* index is decreasing in the value of the current marriage, which depends on (the share of) private and public goods consumption and on leisure, also valued at an individual's productivity. All these aspects are influenced by individual and marriage market characteristics that are not explicitly used in the estimation of our model through the linear program in equation (14). Therefore, it is a valuable exercise to provide correlational evidence that our *BP* indices are associated with these characteristics in the way that we would expect. For example, distance to road or urban center is likely to be correlated with some measure of productivity of the individual. It is likely that age of the spouse captures a similar effect: younger spouses may be more productive than older spouses on the land, or older spouses may provide agricultural expertise and, therefore, higher productivity with age.

In particular, we estimate the correlation between the instability indices and the age and education of the spouses, the number of children they have, as well as dummy variables for whether they have the same age and the same education (intended to capture the value of assortative mating). For characteristics of the marriage market, we include the number of churches (to capture religiousness), the distance to the nearest road, the distance to the nearest urban center, the fraction of females with at least primary education, the fraction of school-age children currently in school, the fraction of adults who say they can read the local language, as well as the number of households in the marriage market.

The equation we estimate is

$$s^j_{i,m} = \alpha_0 + \boldsymbol{\alpha}_1 \mathbf{H}_{i,m} + \boldsymbol{\alpha}_2 \mathbf{X}_m + \varepsilon_{i,m}, \tag{15}$$

where $s^j_{i,m}$ is the instability index j ($j = BPmax, BPavg, IR$) of individual i living in marriage market m, $\mathbf{H}_{i,m}$ are characteristics of individual i's household, and $\mathbf{X}_m$ are characteristics of individual i's marriage market. We report our estimates in Table II in Online Appendix OA3.

We find that the more educated the household head (which is the husband in virtually all cases), the lower are the wife's *BP* indices (i.e., her remarriage possibilities are less attractive). This estimated effect is monotonically increasing in the education level of the household head. For example, a woman living in a household where the head has primary school education has an average *BPmax* index that is 47 percentage points lower than a comparable woman where the head has no education. Recall that the *BP* indices are defined relative to household income, so that this coefficient captures a decline in the ratio of 0.47. On the other hand, the education of the household head is not correlated with the *BP* indices of the husband. Instead, we find that he has stronger outside options when he is older (likely because this is correlated with accumulated wealth). Children in marriage significantly reduce the value of all outside options, with a larger effect on women than men.

For the marriage market characteristics, we observe a relationship between connectedness and stability: marriage markets that are far away from roads and urban centers are more stable. A one kilometer increase in the marriage market's distance to the nearest road reduces the wife's average *BPmax* by 5.1 percentage points, while the same increase to the nearest urban centre reduces this index by 0.3 percentage points on average. Next, the rate of child schooling is negatively (though insignificantly) correlated with both men's and women's blocking pair indices. This indicates that high rates of child schooling are potentially stabilizing for marriage markets. Finally, as expected, larger marriage markets are associated with larger values of the *BPmax* indices and the husband's *IR* index.

To further improve our understanding of what drives our stability indices, we conduct a related exercise to assess the proportion of variation accounted for by each explanatory variable. In particular, we estimate the partial R^2 obtained by dropping each explanatory variable from the full model in Table II. These estimates in Table III, Online Appendix OA3, show that up to 2.2% of the variation in the wife's instability indices is explained by the household's proximity to infrastructure (roads and urban centers). The size of the marriage market cluster is also important for both the wife's and husband's instability indices, which is consistent with the fact that a bigger marriage market increases the likelihood that a profitable new match can be found.

Next, we also estimate the partial R^2 obtained when we include the budget components in the estimation of equation (15): individuals' estimated individual nonlabor incomes and the shadow wages, shadow land income, and shadow fertiliser investment. Table IV, Online Appendix OA3, shows that nonlabor income trumps most other variables in terms of explanatory power, accounting for up to 12.9% of the variation in men's instability indices and 3.7% of the variation in women's instability indices. Wages are also important, explaining 7.6% of men's outside options when single. Only the size of the marriage market cluster and distance to road remain important explanatory variables after including the budget components. These estimates show that the value of individuals' blocking pairs hinges on their nonlabor income and potential labor income on divorce, which is what the structural model would lead us to expect.

6.2 *Divorce*

6.2.1 *Main results* We now present the empirical analysis of divorce. In particular, we estimate whether our structural measures of the value of the remarriage market, and of being single, can predict future divorces. Note that there is no a priori reason to expect an empirical association between our measures of instability and future divorces, as no information from the 2013 wave was used in the estimation of the structural model. Hence, this provides an out-of-sample test of our model. We estimate a linear model of divorce between 2010 and 2013, with the *BP* indices of the spouses and the *IR* index of the husband as covariates (recall that the *IR* index is zero for all wives). We include marriage market fixed effects, and also control for all household-level variables reported in Table II, as they covary with the instability indices and potentially also with divorce probability. Marriage market fixed effects will capture characteristics that matter for overall divorce propensity such as the size of the marriage market, as well as the geographical heterogeneity in descent practices that is known to exist in Malawi (Walther (2018)). The equation we estimate is

$$d_{h,m} = \beta_0 + \beta_1 s^j_{i,h,m} + \beta_2 s^j_{i',h,m} + \boldsymbol{\beta}_3 \mathbf{H}_{h,m} + \boldsymbol{\beta}_4 \boldsymbol{\mu}_m + \epsilon_{i,m}, \tag{16}$$

where $d_{h,m}$ is a dummy variable that equals one if household h in marriage market m divorces between 2010–2013, and zero if they remain married, $s^j_{i,h,m}$ is the instability index j of spouse i in household h in marriage market m, $s^j_{i',h,m}$ is the instability index j of spouse i', $\mathbf{H}_{h,m}$ are household characteristics and $\boldsymbol{\mu}_m$ are marriage market fixed effects. We estimate these equations separately for $j = BPmax$ and $j = BPavg$, but include $j = IR$ in both of these equations. Standard errors are clustered at the marriage market level. The estimates are reported in Table 6.

We find that the instability indices have significant predictive power for future divorce, particularly for measures of the value of the wife's remarriage market. In regression (1), a one percentage point increase in the wife's maximum gain from remarriage

TABLE 6. OLS regressions of divorce between 2010–2013 on instability indices in 2010 and other control variables.

	Divorced in 2013			
	(1)	(2)	(3)	(4)
BPmax (woman)	0.014	0.014		
	(0.006)	(0.006)		
BPmax (man)	0.001	0.001		
	(0.030)	(0.030)		
IR (man)	0.846	0.864	−0.006	0.005
	(2.504)	(2.491)	(1.644)	(1.639)
BPavg (woman)			0.519	0.521
			(0.143)	(0.146)
BPavg (man)			0.019	0.019
			(0.026)	(0.025)
N	1406			
R^2	0.126	0.126	0.129	0.130

Note: Standard errors in parentheses. This table reports OLS regressions. All regressions include marriage market fixed effects, the age of the husband and wife in 2010, fixed effects for the education of the household head, and the number of children the household had in 2010. Columns (2) and (4) also control for dummy variables indicating whether the couple are within 2 years of age of each other, and whether they have the same level of education.

raises the probability of divorce by 1.4 percentage points on average. This is a sizeable effect, as the annual divorce probability is approximately 8.5%. In regression (2), we control for measures of assortative mating: dummy variables that equal one if the spouses have the same education level and the same age (±2 years). The coefficient on *BPmax* is unchanged. In regression (3), we repeat the first specification (without assortative mating variables) but replace *BPmax* with *BPavg*, and we find that a one unit increase in the average remarriage gain for the wife, as a proportion of her household's income, raises divorce probability by 51.9 percentage points. Note that the impacts of a unit change in the maximum and average gains from remarriage on divorce probability are not directly comparable to each other, as the levels of *BPmax* and *BPavg* are different (see Table 3). In particular, a one-unit increase in *BPavg*, the average value of an individual's outside options, would represent a substantial improvement in that individual's marriage market. In terms of standard deviations, the effect sizes are as follows: a one standard deviation increase in the wife's *BPmax* index increases divorce probability by 0.15 standard deviations, while a similar increase in the wife's *BPavg* index increases divorce probability by 0.79 standard deviations. Overall, we thus find that our measures of the value of the woman's remarriage market are predictive of divorce.

We also examine how sensitive our estimates are to the inclusion of the explanatory variables. Table V in Online Appendix OA4 reports the successive inclusion of the explanatory variables in the estimates in Table 6. For the sake of brevity, we focus on the estimates for *BPmax*. Column (1) only includes the instability indices, and consistent with Table 5, these are not statistically significantly different between households who divorce and do not. Column (2) introduces marriage market fixed effects, which yield a statistically significant and larger positive coefficient on the wife's *BPmax*, indicating that there is significant unobserved variation in divorce probability across marriage markets that is captured by the instability indices in Column (1) and affects the estimation of the coefficients. In fact, once we successively include all other, household level, control variables in Columns (3)–(6), the coefficients on the instability indices do not change in a noticeable way from those in Column (2). This exercise demonstrates that the instability indices pick up crucial household-level variation in divorce probabilities, once marriage market variation is accounted for by the cluster fixed effects.

We find no significant associations between the measures of husbands' outside options, and divorce. Thus, economic gains to divorce and remarriage matter for the women in our sample, but not the men. In Malawi, women marry young and divorce often. In the demographic literature, it has been argued that women in Malawi use marriage and divorce to improve their economic situation; for example, women are less likely to live in their husband's village in higher order marriages, which is considered empowering (Reniers (2003)). Men, on the other hand, are more likely to remarry younger women, and hence plausibly are motivated by the fecundity, rather than economic circumstance, of their potential spouse. This intuition can explain why we observe that the economic value of a woman's marriage market matters, while that of the man's does not.

It is important to note that Tables 4 and 6 show different relationships. Table 4 is a *level effect*, in the sense that it shows that the average man is more likely to be remarried following a divorce than the average woman; Table 6 is a *slope effect*, in the sense that it shows that the average woman is more likely to respond to an economically attractive outside option with a divorce than the average man. These two findings are not inconsistent with each other: when a man decides to divorce, he finds a new spouse relatively easily, while a woman faces more difficulty. However, this does not illuminate on what drives men to divorce in Malawi, which according to our results are not economic considerations. Instead, women, though less likely to remarry overall, are much more likely to divorce for an economically attractive new partner. This is further confirmed by our results in Table 8 below.

We consider alternative mechanisms that could explain our empirical results. First, we explore whether the absence of data on domestic labor could be a potential source of omitted variable bias. In particular, as domestic labor is currently subsumed in leisure, higher unobserved values of domestic labor will tend to reduce the value of an individual's *BP* index. This is likely to only be the case for women, as men in Malawi contribute very little to domestic labor (see the discussion in Section 5). Whether the omission of domestic labor (and hence its appearance in the error term) can explain the estimated positive coefficients on *BPmax* and *BPavg* in the regression of divorce probability depends on the correlation between domestic labor and divorce probability. We estimated this correlation using a different dataset that contains information on domestic labor, the Malawi Longitudinal Study of Families and Health, and find a statistically insignificantly estimated coefficient of about zero. This suggests that domestic labor is unlikely to explain the positive coefficient that we estimate.[15]

Second, we consider that the measure *BPmax* is likely to be sensitive to who is sampled from the marriage market, more so than *BPavg*. An alternative measure that captures the top end of the remarriage distribution, but that is less sensitive to sampling, is the 95th percentile of an individual's *BP* indices (*BP95*). These results are displayed in Table VII in Online Appendix OA4 and the coefficients on *BP95* are consistent with those on *BPmax* in Table 6; a one unit increase in *BP95* increases divorce propensity by 4.6 percentage points, which predictably lies between the coefficients on *BPavg* and *BPmax*.

In Table VI in Online Appendix OA4, we estimate the specifications in Table 6 using a logit regression model, where we report marginal effects at means. The marginal effect of *BPavg* is similar in magnitude to the average affect in Table 6, while the estimated effect of *BPmax* is virtually unchanged. The inclusion of a dummy for the existence of polygamy in the village does not affect the significant estimated effect of the wife's instability index on divorce, but we do find that the existence of polygamy increases the overall probability of divorce (results not reported for compactness).

[15]The Malawi Longitudinal Study of Families and Health (MLSFH) is run by the University of Pennsylvania and contains detailed information on time use and marital status over time. Using the waves of data available for 2004 and 2006, we estimate the correlation between divorce in wave $t + 1$ (2006) and a wife's domestic labor in wave t (2004). Domestic labor includes reported time spent on cooking, washing clothes, and cleaning on a typical day, and we condition on total hours accounted for in the time diary, total number of children, and region fixed effects. We estimate a coefficient of 0.001 (s.e. 0.005) on domestic labor, suggesting that our estimates in Table 6 are unlikely to be biased by the omission of domestic labor.

TABLE 7. OLS regressions of divorce between 2010–2013 on instability indices in 2010, control variables, share public consumption, and male's resource share from the structural model.

	Divorced in 2013			
	(1)	(2)	(3)	(4)
BPmax (woman)	0.014	0.014		
	(0.006)	(0.006)		
BPmax (man)	0.001	0.001		
	(0.030)	(0.030)		
IR (man)	0.901	0.868	0.040	0.038
	(2.501)	(2.528)	(1.646)	(1.657)
BPavg (woman)			0.518	0.518
			(0.146)	(0.157)
BPavg (man)			0.019	0.019
			(0.026)	(0.025)
Male share	0.054	0.046	0.058	0.057
	(0.150)	(0.167)	(0.149)	(0.167)
Share public consumption		−0.014		−0.001
		(0.114)		(0.114)
N	1406			
R^2	0.126	0.126	0.129	0.130

Note: Standard errors in parentheses. This table reports OLS regressions. All regressions include marriage market fixed effects, the age of the husband and wife in 2010, fixed effects for the education of the household head, the number of children the household had in 2010, and dummy variables indicating whether the couple are within 2 years of age of each other, and whether they have the same level of education.

Next, we show that the estimated effect of the *BP* indices cannot be washed away by controlling for the husband's share of household resources and the share of public consumption in the household. Within our specific model, the latter two variables provide the main incentives to marry. To investigate their effect, we sequentially add both variables to our specifications in columns 2 and 4 of Table 6, yielding the results in Table 7. As we explained in our discussion of Proposition 1, our revealed preference approach only allows us to set identify the intrahousehold sharing of consumption. Therefore, in our regressions we used our estimates that are summarized in Table 3 for the husband's resource share. Note that the newly added variables in Table 7 are "bad controls," in the sense that they themselves are determined by choices (Angrist and Pischke (2009)). However, we do not interpret this exercise in a causal way. Rather, our goal is to investigate how the relationship between our instability indices and divorce propensity is affected by these variables. Interestingly, we find that our estimated effect of the *BP* indices is not sensitive to the inclusion of the variables. This is not surprising: although an individual's share of household resources and the level of public consumption affect the economic gains of remarriage, they are only part of the story. Since the *BP* indices are intrinsically an equilibrium concept, they incorporate not only these household-specific variables, but also the particular structure of the attractiveness of individuals' marriage markets.

Table 8. OLS regressions of marital status in 2013 on instability indices in 2010 and other control variables.

	Marital Status of Woman		Marital Status of Man	
	Remarried (1)	Single (2)	Remarried (3)	Single (4)
BPmax (woman)	0.011	0.006	0.010	0.003
	(0.003)	(0.004)	(0.005)	(0.003)
BPmax (man)	0.004	0.005	0.010	−0.005
	(0.012)	(0.019)	(0.022)	(0.007)
IR (man)	0.021	0.479	0.013	0.649
	(1.105)	(1.524)	(1.685)	(0.473)
N	1380	1380	1347	1347
R^2	0.113	0.105	0.119	0.094

Note: Standard errors in parentheses. This table reports OLS regressions. The dependent variable Remarried takes a value of one if the person has divorced and remarried by 2013, and zero otherwise. The variable Single takes a value of one if a person has divorced but has not remarried by 2013, and zero otherwise. All regressions include marriage market fixed effects, the age of the husband and wife in 2010, fixed effects for the education of the household head and the number of children the household had in 2010, and dummy variables for whether the couple are within 2 years of age of each other, and whether they have the same level of education.

6.2.2 *Divorce: Remarriage or remaining single?* An important implication of the way that the instability indices are defined is that the *BP* index measures the attractiveness of a potential new match in the marriage market, while the *IR* index measures the attractiveness of being single. Therefore, we should observe these associations in the data. In order to show that this is the case, we estimate the relationship between the *BP* indices and two separate outcomes: divorce and remarriage, and divorce and remaining single. In particular, we define two indicator variables: the variable Remarried takes the value one if an individual divorced and remarried between 2010 and 2013, and zero otherwise (including if they remained married), while Single takes the value one if the individual divorced but was not remarried in 2013, and zero otherwise. We observe this information for most but not all individuals in the survey, and are able to construct these variables separately for men and women. As in the main estimates in Table 6, we control for marriage market fixed effects and household characteristics. The results are in Table 8. For compactness, we report the estimated effect of *BPmax* here; the same regressions with *BPavg* are in Table VIII in Online Appendix OA4.

The results are consistent with the premise that the *BP* indices measure the attractiveness of the remarriage market. In particular, a higher value of the wife's *BP* index is associated with a significantly higher probability that the wife divorces and remarries in the next 3 years, instead of remaining married (regression (1)). The index also predicts divorcing and being single (regression (2)); however, the coefficient is around one half of the size of the coefficient in regression (1). Indeed, not everyone who divorces with the intention of remarrying will manage to do so. Interestingly, the wife's *BP* index is also predictive of the husband divorcing and remarrying, consistent with men preferring to remarry rather than remain single, even if they did not trigger the divorce. The husband's *IR* index does not affect the probability of either divorce status, which is consistent with its weak significance in Table 6, suggesting that the *IR* index does not fully capture the gains to being single. In terms of magnitudes, we find that a one unit increase in the wife's best gain from remarriage, as a proportion of household income, raises the probability that the wife has divorced and remarried, relative to all other marital states, by 1.1 percentage points. It also increases the probability of being divorced and single by 0.6 percentage points, and raises the probability of the husband having remarried by 1 percentage point. These magnitudes are similar to those in Table 6.

In Online Appendix OA4, we present the estimates of a multinomial logit model of marital status in 2013 (see Tables IX and X). Consistent with the OLS results, we find that an increase in the wife's *BP* index is associated with increased odds of divorcing and remarrying by 2013 for both the husband and wife. In particular, a one unit increase in *BPmax* is associated with a 6.2% higher risk of the woman and 11.8% higher risk of the man being divorced and remarried, compared to the base category of remaining married. Additionally, an increase in the husband's *BP* index is associated with higher odds of the husband divorcing and remarrying. Neither *BP* index is associated with significantly changed odds of divorcing and being single, compared to remaining married.

6.2.3 *Interactions between the remarriage market and other drivers of match quality* As a further exercise, we explore the role of other drivers of marital surplus in divorce, and how they interact with the estimated effects of our economic measures of the remarriage market. We focus on other drivers of match quality and attractiveness that have been well-documented in the literature: age, education, and assortative mating in these factors (see, for instance, Browning, Chiappori, and Weiss (2014) for a recent overview). We have already controlled for these measures in the main results; here, we explore heterogeneity of our main effects with respect to these variables. In this sense, we go some way toward characterizing match quality as consisting of both an economic value, as captured by our *BP* indices, and value from noneconomic characteristics. We expect that characteristics that improve the value of the current marriage, such as the number of children, will reduce the predictive impact of *BP* indices on divorce, as these characteristics can compensate spouses for lower "economic attractiveness." We also explore heterogeneity of the main effects with respect to the local sex ratio (defined as the ratio of males over females in a given village, hence exploiting variation between villages within a marriage market). The results for *BPmax* are in Table 9; similar estimates for *BPavg* can be found in Table XI of Online Appendix OA4.

We find precisely estimated differences in the gradient of *BPmax* with respect to age, having the same age as the spouse, and the sex ratio. In particular, the estimated effect of the wife's *BP* index is decreasing with her age, suggesting that being older makes it more difficult to find an alternative partner. Interestingly, we find a significant estimated negative interaction between the husband's *BPmax* and being of the same age, suggesting that husbands value assortative mating on age. This does not contradict the estimates in Table II, as those regressions focus on absolute values, while here we look at age gaps: it can be that husbands value both young wives (in absolute terms) and also wives of a similar age to them.

Next, in regression (3), we examine the interaction between the sex ratio and the estimated effect of remarriage options on divorce. For a sex ratio equal to one, an increase

Table 9. OLS regressions of divorce between 2010–2013 on instability indices in 2010 and their interactions with other variables.

	Divorced in 2013 (1)		*Divorced in 2013* (2)		*Divorced in 2013* (3)
BPmax (w)	0.037	*BPmax* (w)	0.013	*BPmax* (w)	−0.047
	(0.010)		(0.006)		(0.036)
Age**BPmax* (w)	−0.001	Same age**BPmax* (w)	0.007	Sex ratio**BPmax* (w)	0.073
	(0.000)		(0.010)		(0.042)
BPmax (m)	0.015	*BPmax* (m)	0.001	*BPmax* (m)	0.011
	(0.037)		(0.031)		(0.046)
Age**BPmax* (m)	−0.000	Same age**BPmax* (m)	−0.020	Sex ratio**BPmax* (m)	−0.011
	(0.000)		(0.010)		(0.037)
N	1406		1406		1406

	(4)		(5)
BPmax (w)	0.015	*BPmax* (w)	0.019
	(0.009)		(0.007)
Same educ**BPmax* (w)	−0.001	# Children**BPmax* (w)	−0.002
	(0.008)		(0.002)
BPmax (m)	−0.010	*BPmax* (m)	0.013
	(0.031)		(0.032)
Same educ**BPmax* (m)	0.012	# Children**BPmax* (m)	−0.004
	(0.011)		(0.002)
N	1406		1406

Note: Standard errors in parentheses. This table reports OLS regressions. All regressions include marriage market fixed effects, the age of the husband and wife in 2010, fixed effects for the education of the household head and the number of children the household had in 2010, and dummy variables for whether the couple are within two years of age of each other, and whether they have the same level of education. They also include the variable that is being interacted with the indices (e.g., sex ratio in regression (3)).

in the wife's *BPmax* index of one unit increases the probability of divorce by approximately 7.3 percentage points. The more men there are, relative to women, the stronger the estimated effect of the wife's potential gains from remarriage on divorce probability. This is a rational response: if there are more men relative to women in the population, the likelihood of a profitable remarriage is greater. The asymmetry between men and women in this response may be due to a situation where women look for economically better matches, while men look for more attractive wives. This would mean that the same variable measuring the availability of men versus women (the sex ratio) would not have the same heterogeneous effect on their response to a high *BP* index. Further analyzing different consideration sets is an interesting avenue for further research.

Finally, we summarize the other, less precisely estimated effects. The interaction term between the number of children and the spouses' *BP* indices is negative, suggesting that having more children reduces the effect of the attractiveness of other outside options. This is consistent with the observation that divorce occurs less among couples who have children. Similarly, the coefficient on the interaction between having the same education level, and the *BP* indices, is negative, which suggests that assortative mating on education can compensate for a lack of economic attractiveness.

7. Conclusion

Divorce is a widespread phenomenon with potentially large welfare effects on all parties that are involved. The study of divorce in the economic literature has been largely dominated by the role of economic shocks (with the exception of studies that link intrahousehold choices to divorce decisions, such as Voena (2015), Bronson (2015), and Reynoso (2018)). We argue that the marriage market has a crucial role to play in the decision to divorce. We have defined structural measures of individuals' outside options on the marriage market and shown that they are significant (out-of-sample) predictors of future divorces. These measures are based on a collective model with consumption and agricultural production embedded in a marriage market. We quantify marital instability in terms of Individual Rationality (*IR*) and Blocking Pair (*BP*) indices, which capture spouses' consumption gains to remarrying another individual in the same marriage market (*BP* index) and to being single (*IR* index).

We estimate this model on data drawn from a household survey in Malawi, which has rich information on consumption and production, as well as information on marital status changes over 3 years. Our key results are as follows. We find that a 1 percentage point increase in the wife's most attractive outside option, relative to her household income, is associated with a 1.4 percentage point higher probability of divorce over the following 3 years, and increases the probability that she has divorced and remarried by 1.1 percentage points. We find no significant associations between the value of the husband's remarriage market and subsequent divorce, which is consistent with men and women valuing economic characteristics in their partners to different extents (Reniers (2003)). The estimated relationship between the wife's remarriage market and divorce cannot be explained by a linear combination of wages, nonlabor income, and land income, indicating that intrahousehold sharing of consumption is the key driver of this relationship. Finally, we find that this estimated effect interacts with other characteristics that affect match quality. In particular, it is dampened by the age of the spouses, and by a shortage of men, relative to women, in the marriage market.

Our findings show that divorce in Malawi is driven, at least partly, by the economic considerations of spouses. In addition, our empirical results validate the set-up of our theoretical model, akin to an out-of-sample test. More generally, they show the value-added of adopting a Beckerian approach that analyses marriage decisions through the lens of a structural model of household decision making. Further, as agricultural productivity is a key determinant of outside options for households reliant on production, our model is applicable to other contexts as well.

Notwithstanding the good performance of our model when applied to the consumer-producer economy of rural Malawi, its static framework will likely be restrictive in other contexts. Indeed, introducing uncertainty about future marriage prospects and nonmyopic individual preferences would make the model richer. Examples of parametric dynamic models of matching and divorce can be found in Voena (2015), Bronson (2015), and Reynoso (2018). Adams, Cherchye, De Rock, and Verriest (2014) provide a revealed preference analysis of dynamic collective household behavior, but without explicitly modeling the individuals' outside options on the marriage market. This study may constitute a useful starting point for developing a dynamic extension of our analysis. We leave this exercise to future work.

Appendix: Proofs

Proof of Proposition 1. *Necessity.* To prove that the empirical conditions stated in Proposition 1 are necessary for the data set $\mathcal{D}$ to be consistent with a stable matching σ we apply the revealed preference argument that underlies Proposition 1 of Cherchye et al. (2017a), but now adapted to our particular setting. Particularly, our conditions use information on (i) the bundles of goods consumed by individuals in their current match, (ii) the cost of these bundles in two alternative scenarios outside the observed match (i.e. as single (for the individual rationality requirement) and with some other potential partner (for the no blocking pair requirement)) and (iii) the available budget in these two counterfactual scenarios.

As explained in the main text, we assume that individuals are endowed with utility functions $U^a(l^a, q_a, Q)$ and $U^b(l^b, q_b, Q)$. For each matched couple $(a, \sigma(a))$, our data set $\mathcal{D}$ contains l^a, $l^{\sigma(a)}$ and $Q^{(a,\sigma(a))}$ and the aggregate private consumption $q^{(a,\sigma(a))}$. To reconstruct the individual consumption bundles, we have to consider all feasible specifications of $q_a^{(a,\sigma(a))}$ and $q_{\sigma(a)}^{(a,\sigma(a))}$ that satisfy $q_a^{(a,\sigma(a))} + q_{\sigma(a)}^{(a,\sigma(a))} = q^{(a,\sigma(a))}$ (i.e. condition (a)). For every observed match, this results in the individual consumption bundle $(l^a, q_a^{(a,\sigma(a))}, Q^{(a,\sigma(a))})$ for individual a and $(l^a, q_{\sigma(a)}^{(a,\sigma(a))}, Q^{(a,\sigma(a))})$ for individual $\sigma(a)$.

Next, in our labor supply model the price of an individual's leisure is the individual's wage, and the prices of the Hicksian private quantity $q^{(a,\sigma(a))}$ and the Hicksian public quantity $Q^{(a,\sigma(a))}$ are equal to one. We use this price information to compute the consumption cost of the within-marriage bundles in the two out-of-marriage scenarios. For the first scenario, if female a and male b would become single, they would have to bear the full cost of the public good to consume exactly the same quantity. When adding the cost of leisure and the private Hicksian quantities, this gives a total cost of $w^a l^a + q_a^{(a,\sigma(a))} + Q^{(a,\sigma(a))}$ for female a and $w^b l^b + q_b^{(\sigma(b),b)} + Q^{(\sigma(b),b)}$ for male b.

For the second scenario, if the potentially blocking pair consisting of a and b would be matched, they would need the quantity $\max\{Q^{(a,\sigma(a))}, Q^{(\sigma(b),b)}\}$ of the public good to guarantee that both a and b consume at least the same amount as in their current match. Similarly to the first scenario, when adding the cost of leisure and the private Hicksian quantities, this yields a total cost of $(w^a l^a + w^b l^b) + (q_a^{(a,\sigma(a))} + q_b^{(\sigma(b),b)}) + \max\{Q^{(a,\sigma(a))}, Q^{(\sigma(b),b)}\}$ for the potentially blocking pair (a, b).

Restrictions (i) and (ii) in Proposition 1 compare these consumption costs with the available budget in the two counterfactual situations.[16] For each scenario, this available budget has three components. The first component is the potential labor income of each individual, i.e. $w^a T$ for female a and $w^b T$ for male b. The second component is the nonlabor income associated with the individuals' private land holdings. These private land holdings L^a and L^b are evaluated at the land prices $z^{(a,\sigma(a))}$ and $z^{(\sigma(b),b)}$, which generates the private land values $z^{(a,\sigma(a))}L^a$ for female a and $z^{(\sigma(b),b)}L^b$ for male b. These two first budget components are observed at the individual level, which means that we can assign these incomes to respectively a and b in the counterfactual scenarios. This assignability does not hold for the third budget component, which captures the remaining (nonassignable) nonlabor income, i.e. the sum of (1) nonlabor income $n^{(a,\sigma(a))}$, (2) the value $z^{(a,\sigma(a))}L^{(a,\sigma(a))}$ of the household's joint (non-assignable) land holdings and (3) the value $x^{(a,\sigma(a))}$ of other input used for agricultural production. To reconstruct the individual incomes of a and $\sigma(a)$, we have to consider all possible decompositions N^a and $N^{\sigma(a)}$ that satisfy the adding-up restriction $N^a + N^{\sigma(a)} = n^{(a,\sigma(a))} + x^{(a,\sigma(a))} + z^{(a,\sigma(a))}L^{(a,\sigma(a))}$ (similar to our treatment of the individual quantities $q_a^{(a,\sigma(a))}$ and $q_{\sigma(a)}^{(a,\sigma(a))}$).

As a final step, the individual rationality restrictions (i) in Proposition 1 state that a necessary condition for marital stability is that these individual budgets cannot strictly exceed the cost of the bundles consumed by the individuals in their current matches, which gives

$$N^a + z^{(a,\sigma(a))}L^a + w^a T \leq w^a l^a + q_a^{(a,\sigma(a))} + Q^{(a,\sigma(a))},$$

$$N^b + z^{(\sigma(b),b)}L^b + w^b T \leq w^b l^b + q_b^{(\sigma(b),b)} + Q^{(\sigma(b),b)}.$$

If these conditions were not met for some individual, then this individual would be better off by living alone for any possible specification of the individual (continuous, concave and monotonically increasing) utility functions. For example, the individual as a single could compose a consumption bundle with strictly more of each consumed good.

A directly analogous argument holds for the no blocking pair restrictions (ii) in Proposition 1. When evaluating the potentially blocking pair (a, b), we now compare the

[16]We remark that our production assumption of profit maximization under constant returns to scale yields zero (maximum) profit. This implies that (1) total input value (used in our budget calculations) equals the value of the generated production output, and (2) there is no additional production profit (or loss) term to be included in the available consumption budgets.

sum of the counterfactual budgets for female a and male b to the cost for a bundle guaranteeing at least the within-marriage consumption quantities for these two individuals. In this case, marital stability requires the inequality

$$\begin{aligned}&\big(N^a + z^{(a,\sigma(a))}L^a + w^a T\big) + \big(N^b + z^{(\sigma(b),b)}L^b + w^b T\big)\\ &\quad\le \big(w^a l^a + w^b l^b\big) + \big(q_a^{(a,\sigma(a))} + q_b^{(\sigma(b),b)}\big) + \max\big\{Q^{(a,\sigma(a))}, Q^{(\sigma(b),b)}\big\}.\end{aligned}$$

Sufficiency. Cherchye et al. (2017b) introduced the Weak Axiom of Revealed Stable Matchings (WARSM) to define sufficient empirical conditions for a stable marriage allocation. Reformulating this WARSM for our setting gives exactly the conditions stated in Proposition 1. This shows that the data set $\mathcal{D}$ satisfies the empirical conditions in Proposition 1 if and only if it satisfies WARSM. Finally, Corollary 1 in Cherchye et al. (2017b) states that the WARSM defines a sufficient condition for the data set $\mathcal{D}$ to be consistent with a stable matching σ as soon as all the inequalities in our condition (ii) are strict for the unmatched pairs (i.e. the pairs (a, b) with $b \neq \sigma(a)$). □

Proof of Proposition 2. The result is an adaptation of Theorem 6 of Varian (1984) to our specific setting. In particular, we follow Chiappori (1997) by assuming profit maximization under constant returns to scale and exogenously given input and output prices. Let us start by assuming that the input prices of land (i.e. $z^{(a,\sigma(a))}$) and labor (i.e. w^a and $w^{\sigma(a)}$) are observed. Given that we assume a production technology with constant returns to scale, maximum attainable profit must equal zero. This defines the equality restriction (10) for each observed match $(a, \sigma(a)))$ in Proposition 2.

Next, profit maximizing behavior requires for every observed match $(a, \sigma(a))$ that, for the prices faced by $(a, \sigma(a))$, there does not exist a different input-output combination that yields higher profit. For a homogeneous production technology associated with a given marriage market, this yields the inequality restriction (11) in Proposition 2 for each combination of observed matches $(a, \sigma(a))$ and $(a', \sigma(a'))$. Intuitively, it says that $(a, \sigma(a))$ cannot attain a higher profit by adopting the input-output combination of $(a', \sigma(a'))$. Varian (1984, Theorem 6) has shown that consistency with these two requirements is a necessary and sufficient condition for the data to be consistent with profit maximizing behavior under a constant returns to scale production technology.

Finally, since we do not observe the input prices of land and labor, we simply need that there exists at least one possible specification of shadow land prices and wages that makes the data consistent with the profit maximization restrictions (10) and (11). □

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