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A THEORY OF THE COMPETITIVE SAVING MOTIVE

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Abstract

Motivated by recent empirical work, this paper formalizes a theory of competitive savings - an arms race in household savings for mating competition that is made more fierce by an increase in the male-to-female ratio in the pre-marital cohort. Relative to the empirical work, the theory can clarify a number of important questions: What determines the strength of the savings response by males (or households with a son)? Can women (or households with a daughter) dis-save? What are the conditions under which aggregate savings would go up in response to a higher sex ratio? This theory can potentially help to understand the savings patterns in China, India, Vietnam, Singapore, Hong Kong, and other economies that have experienced a dramatic increase in the pre-marital sex ratio.

Keywords: Surplus Men, Savings Race, Trade Surplus, Global Imbalances
JEL Classification: F3, F4, J1, J7

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1. Introduction

Recent empirical work suggests that one explanation for the rapid rise in the household savings rate in China, India, Singapore, Vietnam and several other economies is an arms race in savings for competition for marriage partners triggered by a rise in the pre-marital sex ratio, a phenomenon that has erupted vigorously since the beginning of the 21st century (Wei and Zhang, 2011). This source of incremental savings - dubbed as the competitive saving motive - is distinct from the precautionary saving motive or savings for life-cycle reasons, the relatively more standard explanations for household savings. The competitive saving motive can be quantitatively important. It is estimated by Wei and Zhang (2011) to account for half of the observed increase in the Chinese household savings rate in recent years. Without taking this into account, one would not have a complete picture of the underlying causes for the global current account imbalances, and might be prone to write incorrect prescriptions for the problem.

Because the existing empirical work is not accompanied by a formal theory, it leaves many important questions unanswered. For example, what determines the strength of the competitive savings motive by males (when there is a relative surplus of males)? What is the effect of a higher sex ratio on the aggregate savings given the potential that females may under-save? The goal of this paper is to develop a formal theory of the competitive saving motive that can clarify these questions. With the theory, we can also assess welfare implications of the competitive saving motive.

We construct a simple overlapping generations (OLG) model with two sexes and a desire to marry. To focus on the macroeconomic implications of sex ratio imbalances, we intentionally shut down channels such as the usual precautionary savings motive, habit formation, culture, and financial development. Because it is an OLG model, there are still life-cycle considerations, which, however, do not lead to current account imbalances on their own.

Under reasonable conditions, we show that men respond to a rise in the sex ratio by raising their savings rates. Moreover, the increment in their savings is always enough to offset any decrease in women's savings. As a result, the aggregate savings rises with the sex ratio. We also discuss a number of extensions that aim to allow for additional realism: (a) incorporate parental savings for children, (c) introduce intra-household bargaining, (c) consider an OLG structure in which each generation lives for 50 periods and makes savings decisions in multiple periods, and (d) allow for income inequality. In each case, under reasonably general conditions, both the aggregate savings rate and the current account rise in response to a rise in the sex ratio. (Some of the extensions are reported in online appendices.)

To check if the model can deliver an effect that is economically significant, we employ quantitative calibrations. In the benchmark case, for a small open economy, as the sex ratio rises from 1 to 1.15, the economy-wide savings rate and the current account will both rise by more than 6% of GDP. We also consider a case of two large economies, whose relative sizes and income levels are calibrated to

mimic China and the United States. The synthetic United States is assumed to always have a balanced sex ratio, while the synthetic China experiences a significant rise in the sex ratio. The rise in China's sex ratio produces a rise in its current account surplus, and a corresponding rise in the current account deficit for the United States. The magnitudes of the current account imbalances in the simulations (about 4.4% of GDP for China and -1.5% of GDP for the United States when China's sex ratio rises from 1 to 1.15) are around one-half of the actual current account imbalances observed in the data. While the sex ratio imbalance is not the only factor affecting the global current account imbalances in recent years, it could be one of the significant, and yet thus far unrecognized, factors. (This extension is also reported in an online appendix.)

A desire to enhance one's prospects in the marriage market through a higher level of wealth could be a motive for savings even in countries with a balanced sex ratio. But such a motive is not as easy to detect when the competition is modest. When the sex ratio gets out of balance, obtaining a marriage partner becomes much less assured. A host of behaviors that are motivated by a desire to succeed in the marriage market may become magnified. But sex ratio imbalances so far have not been investigated by macroeconomists. This may be a serious omission. A sex ratio imbalance at birth and in the marriage age cohort is a common demographic feature in many economies, especially in Asia, such as Korea, India, Vietnam, Singapore, Taiwan and Hong Kong, in addition to China. In many economies, parents have a preference for a son over a daughter. This used to lead to large families, not necessarily an unbalanced sex ratio. However, in the last three decades, as the technology to detect the gender of a fetus (Ultrasound B) has become less expensive and more widely available, many more parents engage in selective abortions in favor of a son, resulting in an increasing relative surplus of men. The spread of technology started in the early 1980s and accelerated quickly afterwards. 1985 was the first year in which half of the hospitals in China had acquired at least one Ultrasound B machine. By the early 1990s, all county-level hospitals had at least one such machine (Ebenstein, Li, and Meng, 2010). The strict family planning policy in China, introduced in the early 1980s, has induced Chinese parents to engage in sex-selective abortions more aggressively than their counterparts in other countries. The sex ratio at birth in China rose from 106 boys per hundred girls in 1980 to 122 boys per hundred girls in 1997 (see Wei and Zhang, 2011, for more detail). It may not be a coincidence that the Chinese current account surplus started to garner international attention around 2002 just when the first cohort born after the implementation of the strict family planning policy was entering the marriage market.

In the benchmark model and numerical examples, we assume an exogenous sex ratio. While the sex ratio is endogenous in the long-run as parental preference evolves, the assumption of an exogeous sex ratio can be defended on two grounds. First, the technology that enables the rapid rise in the sex ratio has only become inexpensive and widely accessible in developing countries within the last 25 years or so. As a result, it is reasonable to think that the rising sex ratio affects only the relatively young cohorts' savings decisions, but not those who have passed half of their working careers. Second, data suggests that if the preference for a son has a mean-reverting property, it must be a very slow-moving process. Almost all countries that have a skewed sex ratio today have exhibited a gradual climb over the last decade or two. This suggests that a systematic reversal of the sex ratio is

unlikely to happen in most economies in the short run. In any case, we also consider endogenous sex ratios in an extension and find that all qualitative results still hold.

To see if the theoretical predicion has any support in the data, we check if a country's savings rate is systematically linked to its sex ratio. After controlling for the effects on the savings rate from income, the share of working age people in the population (i.e., a proxy for the life cycle theory), the ratio of private bank credit to GDP (a proxy for financial development), and social security expenditure as a share of GDP (a proxy for the precautionary savings motive), we find that the sex ratio, the savings rate, and the current account as a share of GDP are strongly positively correlated.

There are three bodies of work that are related to the current paper. First, the literature on status goods, positional goods, and social norms (e.g., Cole, Mailath and Postlewaite, 1992, Corneo and Jeanne, 1999, Hopkins and Kornienko, 2004 and 2009) has offered many useful insights. One key point is that when wealth can improve one's social status (including improving one's standing in the marriage market), in addition to affording a greater amount of consumption goods, there is an extra incentive to save. This element is in our model as well. However, all existing theories on status goods feature a balanced sex ratio. Yet, an unbalanced sex ratio presents some non-trivial challenges. In particular, while a rise in the sex ratio is an unfavorable shock to men (or parents with sons), it is a favorable shock to women (or parents with daughters). Could the latter group strategically reduce their savings so as to completely offset whatever increments in savings men or parents with sons may have? In other words, the impact on aggregate savings appears ambiguous. Our model will address this question. In any case, the literature on status goods has no discernible impact in policy circles. For example, while there are voluminous documents produced by the International Monetary Fund or speeches by U.S. officials on China's high savings rate and large current account surplus, no single paper or speech thus far has pointed to a possible connection with its high sex ratio imbalance.

A second related literature is the economics of family, which is too vast to be summarized here comprehensively. One interesting insight of this literature is that a married couple's consumption has a partial public goods feature (Browning, Bourguignon and Chiappori, 1994; Donni, 2006). We make use of this feature in our model as well. None of the papers in this literature explores the general equilibrium implications for aggregate savings from a change in the sex ratio.

The third literature examines empirically the causes of a rise in the sex ratio. The key insight is that the proximate cause responsible for a majority of the recent rise in the sex ratio imbalance is sex-selective abortions, which have been made increasingly possible by the spread of Ultrasound B machines. There are two deeper causes for parental willingness to disproportionately abort female fetuses. The first is the parental preference for sons, which in part has to do with the relatively inferior economic status of women. When the economic status of women improves, sex-selective abortions appear to decline (Qian, 2008). The second is either something that leads parents to voluntarily choose to have fewer children than earlier generations, or a government policy that limits the number of children a couple can have. In regions of China where the family planning policy is less strictly

enforced, there is also less sex ratio imbalance (Wei and Zhang, 2009). Bhaskar (2011) examines parental sex selections and their welfare consequences.

The rest of the paper is organized as follows: in Section 2, we provide some suggestive data patterns that motivate the theory. In Section 3, we present a benchmark model that delivers the main mechanism. In Section 4, we consider an extension that allows for parental savings and endogenous sex ratios. In section 5, we also calibrate the model to see if the sex ratio imbalance can produce changes in the aggregate savings rate and current account whose magnitudes are economically significant. Finally, in section 6, we offer concluding remarks and discuss possible future research.

2.   Some Data Patterns

To motivate the theory, we discuss two types of empirical approaches that allow us to check for plausibility and empirical importance of the theory. First, we provide some cross-country evidence on the relationships between a country's sex ratio and its savings rate, and between the sex ratio and its current account. Second, we review household-level evidence from China on the association between sex ratios and savings rates.

2.1   Cross Country Data Patterns

We run a panel regression of the savings rate on the sex ratio and other control variables including country and year fixed effects. To be precise, the specification equation is the following:

$$savings.rate_{it} = \beta_0 + \beta_1 \cdot |\text{sex ratio}_{it} - 1| + \beta_2 \cdot |\text{sex ratio}_{it} - 1| \cdot LowSR_{it} + \beta_3 Z_{it} + \varepsilon_{it}$$

where $savings.rate_{it}$ is the ratio of country i's national savings to its GDP in year t. The sex ratio is defined as the male to female ratio for the age group of 10-24 (from the United Nations Population Division). In our theory, men and women are symmetric. The savings rate is predicted to be higher with either a surplus of men or a surplus of women. For this reason, our key regressor is $|\text{sex ratio}_{it} - 1|$. Our key coefficient is β_1. If our story is right, this coefficient should be positive.

In reality, the ability to tolerate singlehood could be different between men and women, and the desire to compete in the marriage market by raising savings could also be different. That is, for a given rise in the gender imbalance, the savings response could be different, depending on whether an economy has too many men or too many women. For this reason, we create a dummy LowSR to indicate cases in which there is a surplus of young women in the marriage market, or when $\text{sex ratio}_{it} < 1$. We add as a second regressor an interaction term between this dummy and the extent of gender ratio imbalance, $|\text{sex ratio}_{it} - 1| \cdot LowSR_{it}$. The coefficient before this regressor, β_2, tells us if the aggregate savings response to a higher sex ratio depends on whether the gender ratio imbalance is in the direction of excess men or excess women.

Since our theory is about savings in the private sector, we control for the government deficit in the regression. Our choice of other control variables is guided by the life-cycle theory, precautionary saving theory, and financial development theory. We therefore include in Z_i log per capita GDP, dependency ratio (a proxy for life-cycle theory), private credit to GDP ratio (a proxy for financial development), and both country and year fixed effects. Unfortunately, we are not able to obtain a panel data on social security enrollment or social security coverage; we therefore assume that the country fixed effects capture the absence or presence of a social security system and the generosity of the system across countries.

Government deficit data are obtained from the IMF's World Economic Outlook (WEO) database. Current account, GDP, the share of working age in the population and private credit to GDP ratio are obtained from the World Bank's WDI database. The intertemporal theory predicts that a country's current account should be sensitive to temporary shocks. The sex ratio data is from the United Nations' Population Division.

The first four columns of Table 1 report a set of savings regressions with a progressively expanding set of control variables. In each regression, we have a positive and statistically significant coefficient on the sex ratio: as the sex ratio becomes more unbalanced, the savings rate tends to go up. Using column (4) of Table 1, we can illustrate the magnitude of the estimates: a rise in the sex ratio from 1.00 to 1.10 is associated with a rise in the savings rate by 5.8 percent of GDP (=58.5% x 0.10).

Because β_2 is not statistically significant, we cannot reject the null that the aggregate savings response to a higher sex ratio is the same regardless of whether the surplus gender is male or female. However, because there are relatively few observations with the sex ratio less than one. This coefficient is not precisely estimated, and we need to exercise caution in interpreting it. Interestingly, the coefficient on the dummy for excess females itself is positive and significant. This suggests that the savings rate for such countries tend to be higher than sample average. We do not have a good explanation for this phenomenon, but it could reflect other differences between surplus female and surplus male countries that are not related to the sex ratio per se.

We comment briefly on other control variables. We find that a higher income is associated with a higher savings rate, which is a quite typical finding in the literature. A higher government deficit is associated with a lower savings rate. The financial development index (private credit as % of GDP) sometimes has a negative and significant sign; the negative sign is consistent with Caballero, Farhi, and Gourinchas (2008) and Ju and Wei (2010 and 2011). The dependence ratio is statistically insignificant, which suggests that life cycle considerations may not play a strong role in explaining cross country variations in the savings rate.

Some countries report savings rates in excess of 80% of GDP and are likely outliers. To ensure such observations do not drive the data pattern, we exclude these observations and re-do the regressions and report them in Columns 5-8 of Table 1. This turns out to make little difference for the basic results.

We also examine the relationship between a country's current account (as % of GDP) and its sex ratio, and report the results in Table 2. The coefficients on the sex ratio in all the regressions are positive and statistically significant. This means that the current account tends to be higher in countries with a higher sex ratio. To illustrate the economic magnitude of the estimates, we use the last column in Table 2: A rise in the sex ratio from 1.00 to 1.10 is projected to be associated with a rise in the current account by 2.2% of GDP (=22.27% x 0.10).

There are important caveats with the empirical patterns. First, in spite of our best efforts, there may still be potential control variables that are missing from our list. Second, the sex ratio can be endogenous and/or measured with errors. This would normally call for an instrumental variable approach. At this point, we are not able to come up with convincing instrumental variables in a cross-country context. For these reasons, it is important to review some micro-evidence from within China.

2.2   Cross-Household and Cross-Region Evidence from China

The sex ratio for the Chinese pre-marital cohort increased from being basically balanced in 1990 to about 115 young men per 100 young women in 2007. Its household savings rate (out of disposable income) almost doubled from 16% to 30% during the same period. While China is not the only economy with a high sex ratio (and a high savings rate), it is the one with the most extreme sex ratio imbalance at the moment, and, because of its size, its savings rate and current account attract the most international attention. For this reason, it is useful to highlight a few empirical patterns documented in Wei and Zhang (2011) that are most relevant for the current paper.

First, let us start with Chinese households' self-reported reasons for savings. A survey of rural households (Chinese household income project in 2002) asked households why they save. There were seven possible categories for saving rationale in the questionnaire: (1) children's wedding, (2) children's education, (3) bequest to children, (4) building a house, (5) (own) retirement, (6) medical expenses, and (7) others. The first three reasons could be grouped under the heading of "savings directly for children." If we just focus on families with an unmarried child, one sees a stunning difference between families with a son versus those with a daughter. 29.8% of families with a son list savings for their child's wedding as either the most or the second most important reason for savings, versus 18.3% of families with a daughter who do the same. Overall, 92.2% of son-families list one of the top three reasons as their primary reasons for savings, which is 5.8 percentage points higher than the percent of the daughter families who say the same. In comparison, 45.5% of daugher-families and 37.3% of son-families say their most or the second most important reason for savings is their own retirement. (Note that the sum of the percentage of households that list various reasons as the most or the second most important reason for savings can be more than 100% since a given household could list one category as the most important reason for savings, and another category as the second most important reason for savings.)

Second, we now summarize the relationship between household savings rates (out of disposable

income) and local sex ratios (at the county or city level), holding constant other determinants of savings rate (household income, household head's age, gender, ethnicity, and educational level, and children's age, and whether there is a family member that has a major illness). What is most revealing for our theory is not just a direct comparison in the savings rates between son-families and daughter-families, but the effect of an interaction term between having an unmarried son and living in a region with a high local sex ratio. This exercise is interesting in China because the migration rate for the purpose of marriage is low (about 92% of marriages take place between a man and a woman from the same county). When focusing on families with a son in rural areas, Wei and Zhang report that these families' savings rate tends to be higher in regions with a more skewed sex ratio. In comparison, the savings rate by families with a daughter appears to be uncorrelated with the local sex ratio. Across Chinese cities, the savings rates by both son-families and daughter families tend to rise with the local sex ratio. These patterns are consistent with our model that allows for intra-family bargaining. When women (or their parents) are concerned with erosion of bargaining power within a family, they may not reduce their savings rate in response to a higher sex ratio. When the effect of intra-family bargaining dominates, the savings rate by daughter-families could rise in response to a rise in the sex ratio.

Third, across Chinese provinces, Wei and Zhang report a strong positive correlation between local savings rates and local sex ratios, controlling for the age structure of local population, per capita income, the share of employment in state-owned firms in the local labor force, and the share of local labor force enrolled in social security. To go from correlation to causality, Wei and Zhang employ variations in the local enforcement of family planning policy (including monetary penalties for violating birth quotas) as instruments for the sex ratio. The 2SLS estimation confirms the basic finding: regions with a higher sex ratio are also likely to have a higher household savings rate. Based on the 2SLS estimates, 40-60% of the rise in the household savings rate from 1990 to 2007 can be attributed to the observed rise in the sex ratio for the pre-marital age cohort during the period.

Overall, the evidence from within China is consistent with the theoretical predictions.

3.   The Benchmark Model

We construct an overlapping generations model with two sexes. Both men and women live two periods: young and old. An individual (of either sex) receives an exogenous endowment in the first period and nothing in the second period. She or he consumes a part of the endowment in the first period and saves the rest for the second period.

A marriage can only take place between a man and a women in the same generation and at the beginning of their second period. Once married, the husband and the wife pool their first-period savings together and consume an identical amount in the second period. The second period consumption within a marriage has a partial public good feature. In other words, the husband and the wife can each consume more than half of their combined second period income - the exact proportion is an exogenous parameter to be explained below. Everyone is endowed with an ability to give his/her

spouse some emotional utility (or "love" or "happiness"). This emotional utility is a random variable in the first period with a common and known distribution across all members of the same sex, and its value is realized and becomes public information when the individual enters the marriage market.

Each generation is characterized by an exogenous ratio of men to women $\phi (\geq 1)$. All men are identical *ex ante*, and all women are identical *ex ante*. Men and women are symmetric in all aspects except that the sex ratio may be unbalanced.

We describe the equilibrium in this economy in six steps. First, we start with a representative woman's optimization, followed by a representative man's optimization problem. Second, we describe how the marriage market works. Third, we perform comparative statics, in particular, on how the savings rates change in response to a rise in the sex ratio. Fourth, we consider a small open economy with production and discuss the current account response to a change in the sex ratio. Fifth, we solve for a two-country model in which the global interest rate is endogenous. Sixth, we use numerical calibrations to see if the model can deliver current account responses that are economically significant.

3.1   A Representative Woman's Optimization Problem

A representative woman makes her consumption/saving decisions in her first period, taking as given the choices made by men and all other women. If she is not married, her second-period consumption is

$$c_{2w,n} = Rs^w y^w$$

where R, y^w and s^w are the gross interest rate, her endowment, and savings rate, respectively.

If she is married (at the beginning of the second period), her second-period consumption is

$$c_{2w} = \kappa(Rs^w y^w + Rs^m y^m)$$

where y^m and s^m are her husband's endowment and savings rate, respectively. κ $(\frac{1}{2} \leq \kappa \leq 1)$ represents the notion that consumption within a marriage is a public good with congestion. As an example, if a couple buys a car, both spouses can use it. When $\kappa = \frac{1}{2}$, the husband and the wife only consume private goods. In contrast, when $\kappa = 1$, all the consumption is a public good with no congestion[1].

She chooses her savings rate to maximize the following objective function:

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[1]   By assuming the same κ for the wife and the husband, we abstract from a discussion of bargaining within a household. In an extension later in the paper, we allow κ to be gender specifc, and to be a function of the sex ratio and the relative wealth levels of the two spouses, along the lines of Chiappori (1988 and 1992) and Browning and Chiappori (1998). This tends to make the response of the aggregate savings stronger to a given rise in the sex ratio.

$$V^w = \max_{s^w} u(c_{1w}) + \beta E[u(c_{2w}) + \eta^m]$$

subject to the budget constraints that

$$c_{1w} = (1 - s^w)y^w \tag{1}$$

$$c_{2w} = \begin{cases} \kappa(Rs^w y^w + Rs^m y^m) & \text{if married} \\ Rs^w y^w & \text{otherwise} \end{cases} \tag{2}$$

where V^w is her value function, and E is the expectation operator. η^m is the emotional utility (or "love") she obtains from her husband, which is a random variable with a distribution function F^m. Utility function $u(\cdot)$ satisfies the standard properties that $u' > 0$, and $u'' < 0$. The exact value of emotional utility is revealed at the beginning of the second period and becomes common knowledge at that time. Bhaskar (2011) also introduces a similar "love" variable.

3.2 A Representative Man's Optimization Problem

A representative man has a similar optimization problem as the representative woman. In particular, if he is not married, his second-period consumption is

$$c_{2m,n} = Rs^m y^m$$

If he is married, his second-period consumption is

$$c_{2m} = \kappa(Rs^w y^w + Rs^m y^m)$$

He chooses his savings rate to maximize the following value function:

$$V^m = \max_{s^m} u(c_{1m}) + \beta E[u(c_{2m}) + \eta^w]$$

subject to the budget constraints that

$$c_{1m} = (1 - s^m)y^m \tag{3}$$

$$c_{2m} = \begin{cases} \kappa(Rs^w y^w + Rs^m y^m) & \text{if married} \\ Rs^m y^m & \text{otherwise} \end{cases} \tag{4}$$

where V^m is his value function. η^w is the emotional utility he obtains from his wife, which is drawn from a distribution function F^w. We assume η^w and η^m are independent.

3.3   The Marriage Market[2]

In the marriage market, every woman (or man) ranks all members of the opposite sex by a combination of two criteria: (1) the level of wealth (which is determined solely by the first-period savings), and (2) the size of "love" he/she can obtain from his/her spouse. The weights on the two criteria are implied by the utility functions specified earlier. More precisely, woman i prefers a higher ranked man to a lower ranked one, where the rank on man j is given by $u(c_{2w,i,j}) + \eta_j^m$. Symmetrically, man j assigns a rank to woman i based on the utility he can obtain from her $u(c_{2m,j,i}) + \eta_i^w$. (To ensure that the preference is strict for men and women, when there is a tie in terms of the above criteria, we break the tie by assuming that a woman prefers j if $j < j'$ and a man does the same.) Note that "love" is not in the eyes of the beholder in the sense that every woman (man) has the same ranking over men (women).

The marriage market is assumed to follow the Gale-Shapley algorithm, which produces a unique and stable equilibrium of matching (Gale and Shapley, 1962; and Roth and Sotomayor, 1990). The algorithm specifies the following: (1) Each man proposes in the first round to his most preferred choice of woman. Each woman holds the proposal from her most preferred suitor and rejects the rest. (2) Any man who is rejected in round k-1 makes a new proposal in round k to his most preferred woman among those who have not yet rejected him. Each available women in round k "holds" the proposal from her most preferred man and rejects the rest. (3) The procedure repeats itself until no further proposals are made.[3]

With many women and men in the marriage market, all women (and all men) approximately form a continuum and each individual has a measure close to zero. Let I^w and I^m denote the continuum formed by women and men, respectively. We normalize I^w and let $I^w = (0,1)$. Since the sex ratio is ϕ, the set of men $I^m = (0, \phi)$. Men and women are ordered in such a way that a higher value means a higher ranking by members of the opposite sex.

In equilibrium, there exists a unique mapping (π^w) for women in the marriage market.

$$\pi^w : I^w \to I^m$$

That is, woman i ($i \in I^w$) is mapped to man j ($j \in I^m$), given all the initial wealth and emotional utility draws. This implies a mapping from a combination (s_i^w, η_i^w) to another combination (s_j^m, η_j^m). In other words, for woman i, given all her rivals' (s_{-i}^w, η_{-i}^w) and all men's (s^m, η^m), the type of husband j she can marry depends on her (s_i^w, η_i^w). Before she enters the marriage market, she knows only the

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[2]   We use the word "market" informally here. The pairing of husbands and wives in this model is in fact not done through prices.

[3]   If only women can propose and men respond with deferred acceptance, the same matching outcomes will emerge. What we have to rule out is that both men and women can propose, in which case, one cannot prove that the matching is unique.

distribution of her own type but not the exact value. As a result, the type of her future husband (s_j^m, η_j^m) is also a random variable. Woman i's second period expected utility is

$$\int \max\left[u\left(c_{2w,i,j}\right) + \eta_{\pi^w\left(i|s_i^w,\eta_i^w,s_{-i}^w,\eta_{-i}^w,s^m,\eta^m\right)}^m, \quad u\left(Rs_i^w y_i^w\right)\right] dF^w(\eta_i^w)$$

$$= \int_{\bar{\pi}_i^w} \left[u\left(c_{2w,i,j}\right) + \eta_{\pi^w\left(i|s_i^w,\eta_i^w,s_{-i}^w,\eta_{-i}^w,s^m,\eta^m\right)}^m\right] dF^w(\eta_i^w) + \int^{\bar{\pi}_i^w} u\left(Rs_i^w y_i^w\right) dF^w(\eta_i^w)$$

where $\bar{\pi}_i^w$ is her threshold ranking on men such that she is indifferent between marriage or not. Any lower-ranked man, or any man with $\pi_i^w < \bar{\pi}_i^w$, won't be chosen by her.

Since we assume there are (weakly) fewer women than men, we expand the set I^w to $\tilde{I}^w$ so that $\tilde{I}^w = (0, \phi)$. In the expanded set, women in the marriage market start from value $\phi - 1$ to ϕ. The measure for women in the marriage market remains one. In equilibrium, there exists a unique mapping for men in the marriage market:

$$\pi^m : I^m \to \tilde{I}^w$$

where π^m maps man j ($j \in I^m$) to woman i ($i \in I^w$). Those men who are matched with a low value $i < \phi - 1$ in set $\tilde{I}^w$ will not be married. In that case, $\eta_{\pi^m(j)}^w = 0$ and $c_{2m,j,i} = Rs_j^m y_j^m$. In general, man j's second period expected utility is

$$\int \max\left[u\left(c_{2m,j,i}\right) + \eta_{\pi^m\left(j|s_j^m,\eta_j^m,s_{-j}^m,\eta_{-j}^m,s^w,\eta^w\right)}^w, \quad u\left(Rs_j^m y_j^m\right)\right] dF^m(\eta_j^m)$$

$$= \int_{\bar{\pi}_j^m} \left[u\left(c_{2m,j,i}\right) + \eta_{\pi^m\left(j|s_j^m,\eta_j^m,s_{-j}^m,\eta_{-j}^m,s^w,\eta^w\right)}^w\right] dF^m(\eta_j^m) + \int \int^{\bar{\pi}_j^m} u\left(Rs_j^m y_j^m\right) dF^m(\eta_j^m)$$

where $\bar{\pi}_j^m$ is his threshold ranking on all women. Any woman with a poorer rank, $\pi_j^m < \bar{\pi}_j^m$, will not be chosen by him.

We assume that the density functions of η^m and η^w are continuously differentiable. Since all men (women) in the marriage market have identical problems, they make the same savings decisions. In equilibrium, a *positive assortative matching* emerges for those men and women who are matched. In other words, there exists a mapping M from η^w to η^m such that

$$1 - F^w(\eta^w) = \phi\left(1 - F^m(M(\eta^w))\right)$$

$$\Leftrightarrow$$

$$M(\eta^w) = (F^m)^{-1}\left(\frac{F^w(\eta^w)}{\phi} + \frac{\phi-1}{\phi}\right)$$

For simplicity, we assume that η^w and η^m are drawn from the same distribution, $F^w = F^m = F$. The lowest possible value of emotional utility $\eta^{\min}$ is assumed to be sufficiently small (and can be negative) such that any person with a low realized value of emotional utility may not succeed in getting married. Define $\bar{\eta}^w$ and $\bar{\eta}^m$ as the threshold values of emotional utility for women and men, respectively, such that only those with emotional utilities higher than the threshold value will get married. In other words,

$$\bar{\eta}^w = \max\{u_{2m,n} - u_{2m}, M^{-1}(\bar{\eta}^m)\} \text{ and } \bar{\eta}^m = \max\{u_{2w,n} - u_{2w}, M(\bar{\eta}^w)\} \tag{5}$$

For woman i, given all her rivals' and men's savings decisions and η^w, her second period utility is

$$\delta_i^w u(\kappa(Rs_i^w y^w + Rs^m y^m)) + (1 - \delta_i^w)u(Rs^w y^w) + \int_{\tilde{\eta}_i^w \geq \bar{\eta}^w} M(\tilde{\eta}_i^w)dF(\eta_i^w)$$

where $\tilde{\eta}_i^w = u(\kappa(Rs_i^w y^w + Rs^m y^m)) - u(\kappa(Rs^w y^w + Rs^m y^m)) + \eta_i^w$. δ_i^w is the probability that she will get married,

$$\delta_i^w = \Pr(u(\kappa(Rs_i^w y^w + Rs^m y^m)) - u(\kappa(Rs^w y^w + Rs^m y^m)) + \eta_i^w \geq \bar{\eta}^w | Rs^w y^w, Rs^m y^m)$$

$$= 1 - F(\bar{\eta}^w - u(\kappa(Rs_i^w y^w + Rs^m y^m)) + u(\kappa(Rs^w y^w + Rs^m y^m))) \tag{6}$$

Due to symmetry (i.e., all women are identical ex ante), we drop sub-index i for women in subsequent discussions. Given men's savings decisions, the first order condition for her optimization problem is

$$-u_{1w}' y^w + \beta \left[\begin{array}{l} \delta^w u_{2w}' \dfrac{\partial c_{2w}}{\partial s^w} + (1 - \delta^w)u_{2w,n}' Ry^w + \dfrac{\partial \int_{\tilde{\eta}^w \geq \bar{\eta}^w} M(\tilde{\eta}^w)dF(\eta^w)}{\partial s^w} \\ + \dfrac{\partial \delta^w}{\partial s^w}(u_{2w} - u_{2w,n}) \end{array} \right] = 0 \tag{7}$$

where

$$\frac{\partial \int_{\tilde{\eta}^w \geq \bar{\eta}^w} M(\tilde{\eta}^w)dF(\eta^w)}{\partial s^w} = \kappa u_{2w}' Ry^w \left[\int_{\bar{\eta}^w} M'(\eta^w)dF(\eta^w) + M(\bar{\eta}^w)f(\bar{\eta}^w) \right]$$

$$\frac{\partial \delta^w}{\partial s^w} = f(\bar{\eta}^w)\kappa u_{2w}' Ry^w$$

Similarly, a representative man's second-period utility, given his rivals' and all women's savings

decisions, is

$$\delta_j^m u\left(\kappa\left(Rs^w y^w + Rs_j^m y^m\right)\right) + (1 - \delta_j^m)u(Rs_j^m y^m) + \int_{\tilde{\eta}_j^m \geq \bar{\eta}^m} M^{-1}\left(\tilde{\eta}_j^m\right)dF\left(\eta_j^m\right)$$

where $\tilde{\eta}_j^m = u\left(\kappa\left(Rs^w y^w + Rs_j^m y^m\right)\right) - u(\kappa(Rs^w y^w + Rs^m y^m)) + \eta_j^m$ and δ_j^m is his probability of marriage.

$$\delta_j^m = \Pr\left(u\left(\kappa\left(Rs^w y^w + Rs_j^m y^m\right)\right) - u(\kappa(Rs^w y^w + Rs^m y^m) + \eta_j^m \geq \bar{\eta}^m \Big| Rs^w y^w, Rs^m y^m\right)$$

$$= 1 - F\left(\bar{\eta}^m - u\left(\kappa\left(Rs^w y^w + Rs_j^m y^m\right)\right)\right) + u(\kappa(Rs^w y^w + Rs^m y^m)\right) \tag{8}$$

The first order condition for his optimization problem is

$$-u_{1m}' y^m + \beta\left[\begin{array}{c}\delta^m u_{2m}' \dfrac{\partial c_{2m}}{\partial s^m} + \dfrac{\partial \int_{\tilde{\eta}^m \geq \bar{\eta}^m} M^{-1}(\tilde{\eta}^m)dF(\eta^m)}{\partial s^m} + (1 - \delta^m)u_{2m,n}' Ry^m \\ + \dfrac{\partial \delta^m}{\partial s^m}(u_{2m} - u_{2m,n})\end{array}\right] = 0 \tag{9}$$

where

$$\frac{\partial \int_{\tilde{\eta}^m \geq \bar{\eta}^w} M^{-1}(\tilde{\eta}^m)dF(\eta^m)}{\partial s^m} = \kappa u_{2m}' Ry^m\left[\int_{\bar{\eta}^m} \frac{\partial M^{-1}(\eta^m)}{\partial \eta^m}dF(\eta^m) + M^{-1}(\bar{\eta}^m)f(\bar{\eta}^m)\right]$$

$$\frac{\partial \delta^m}{\partial s^m} = f(\bar{\eta}^m)\kappa u_{2m}' Ry^m$$

In the rest of the paper, we assume that the average value of emotional utility $E\eta$ is sufficiently high such that a representative man, ex ante, always prefers marriage to being single. For simplicity, we also assume $\beta R = 1$ througout the paper (except for the large country case).

3.4　Equilibrium Savings Rates

In the benchmark, we assume that all women and men automatically enter the marriage market (We will later consider an extension in which agents decide whether or not to enter the marriage market). An equilibrium is defined as a collecton of savings rates by men and women that solve their respective optimalization problems, taking all other men and women's decisions as given.

Definition 1 *An equilibrium is $\{s^w, s^m | y^w, y^m, F^w, F^m\}$ that satisfies the following conditions:*

$$s_i^w = \text{argmax}(V_i^w | s_{-i}^w, s^m, y^w, y^m, F^w, F^m)$$

and

$$s_j^m = \text{argmax}\left(V_j^m | s^w, s_{-j}^m, y^w, y^m, F^w, F^m\right)$$

where i and j stand for a representative woman and man, respectively, and $-i$ and $-j$ represent all women other than i and all men other than j, respectively. $s^w = (s_i^w, s_{-i}^w)$ and $s^m = \left(s_j^m, s_{-j}^m\right)$ are the sets of women's and men's savings rates respectively.

To simplify the discussion, we assume that the population growth rate is zero, and women and men receive the same first period income ($y^w = y^m = y$). Before period t, the economy has a balanced sex ratio. In this case, $s^w = s^m = s$, and s can be obtained from solving the set of first order conditions (7) or (9):

$$-u_{1w}' + 2\left(1 - F(\bar{\eta})\right)\kappa u_2' + F(\bar{\eta})u_{2n}' = 0 \tag{10}$$

and

$$\bar{\eta} = u_{2n} - u_2$$

where we use the fact that at $\phi = 1$, $M(\eta) = \eta$.

The first key proposition concerns the effect of a rise in the sex ratio on the aggregate savings rate. The thought experiment assumes that people in the old cohort have made their savings decision when the sex ratio is balanced. When the sex ratio rises, any change in the aggregate savings is driven by a change in the savings by the young cohort. This simplifying assumption is motivated by the reality: A rise in the sex ratio in almost all economies is a recent phenomenon, since large-scale sex-selective abortions are a recent phenomenon. More precisely, the diagnostic sonography used for prenatal checkups became gradually more affordable to people in countries that now have a high sex ratio only since the early 1980s. (The strict version of the Chinese family planning policy, another contributor to the spread of sex-selective abortions, was also put in place in the early 1980s.) For this reason, the savings pattern for the currently old was largely decided when there was no severe sex ratio imbalance.

In what follows, whenever we say a man (or woman), we mean a young man (or woman), unless otherwise specified. We first state the proposition formally, and then explain the intuition behind the key parts of the proposition. A detailed proof is provided in Appendix A.

Proposition 1 *Assume emotional utility η^w and η^m are drawn from an independent and identical*

uniform distribution $[\eta^{min}, \eta^{max}]$ *with a sufficiently low* η^{min} [4] *and the mean* $E\eta \geq 0$. *If* $u(c) = ln(c)$, *then, as the sex ratio rises, (1) the savings rate of the representative man goes up, but the change in women's savings is ambiguous; (2) however, the economy-wide savings rate increases unambiguously.*

Proof. See Appendix A.1.

A few remarks are in order. First, it is perhaps not surprising that the representative man raises his savings rate in response to a rise in the sex ratio since the need to compete in the marriage market becomes greater. Why is the impact of a higher sex ratio on a representative woman's savings rate ambiguous? The answer is that a higher sex ratio produces two offsetting effects for her. On the one hand, as she anticipates more savings from her future husband, she can free-ride and does not need to sacrifice her first-period consumption as much as she otherwise would have to. On the other hand, precisely because men have increased their savings rate in the first period in response to a higher sex ratio, they will be more reluctant to share their wealth with a woman with both a low savings rate and a low emotional utility. The last point raises the probability that low-savings women may not get married. Since the representative women also prefers marriage than spinsterhood, she may raise her savings rate to improve her chance in the marriage market. Because the two effects go in the opposite directions, the net effect of a higher sex ratio on a representative woman's savings is ambiguous.

Second, why does the aggregate savings rate rise unambiguously in response to a rise in the sex ratio even when women reduce their savings? The answer comes from both an intensive margin and an extensive margin. On the intensive margin, the increment in the representative man's savings can be shown to be greater than the reduction in the representative woman's savings. Heuristically, the representative man raises his savings rate for two separate reasons: in addition to improving his relative standing in the marriage market, he wants to smooth his consumption over the two periods and would raise his savings rate to make up for the lower savings rate by his future wife. The more his future wife is expected to cut down her savings, the more he would have to raise his own savings to compensate. This ensures that his incremental savings is more than enough to offset any reduction in his future wife's savings. On the extensive margin, a rise in the sex ratio implies a change in the mix of the population with relatively more higher-saving men and relatively fewer lower-saving women. While both margins contribute to a rise in the aggregate savings rate, we can verify in calibrations that the intensive margin is quantitatively more important.

Third, we use log utility function because its simplicity allows us to prove Proposition 1 relatively easily. While log utility is one of many possible choices for a utility function, it also turns out to have interesting empirical support. Using datasets across individuals with different income levels in different countries, Stevenson and Wolfers (2008) show that self-reported happiness rises approximately

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[4] This assumption greatly simplifies the proof. Relaxing the assumption will not change our qualitative result when the sex ratio is sufficiently unbalanced.

linearly in log income. They conclude that the "true" utility function should be close to a log utility function. We interpret the evidence as suggesting that log utility is a reasonable choice for our baseline case.

3.5   Mixed-Strategy Equilibrium

In this section, we extend our benchmark model by allowing men and women to choose to enter and exit the marriage market. Formally, this is a mixed-strategy game in which the representative woman chooses the probability of entering the marriage market ρ^w, a savings rate if she decides to enter, and a separate savings rate if she decides to abstain from the marriage market.

Conditional on deciding to enter the marriage market, she has the same optimization problem as in the previous section. However, she can also choose to be single, and conditional on such a choice, her life-time utility is

$$V_n^w = \max_{s_n^w} u(c_{1w,n}) + \beta u(c_{2w,n})$$

where V_n^w denotes the value function of a representative woman who is single throughout her life.

Her overall optimization problem when she is young is

$$\max_{\rho^w, s^w, s_n^w} \rho^w V^w + (1 - \rho^w) V_n^w$$

Obviously, she would choose $\rho^w = 1$ if and only if $V^w > V_n^w$.

Similarly, a representative man chooses the probability of entering the marriage market ρ^m as well as two potentially separate savings rates. His overall optimization problem is

$$\max_{\rho^m, s^m, s_n^m} \rho^m V^m + (1 - \rho^m) V_n^m$$

where V_n^m denotes the value function of a representative man who is single throughout his life. Obviously, the representative man decides to enter the marriage market with probability one if and only if the expected utility of doing so is greater than otherwise, or $V^m > V_n^m$.

Now we can re-define the equilibrium as following:

Definition 2 *An equilibrium is* $\{s^w, s^m, s_n^w, s_n^m, \rho^w, \rho^m | y^w, y^m, F^w, F^m\}$ *that satisfies the following conditions:*

$$\left(s_i^w, s_{n,i}^w, \rho_i^w\right) = \operatorname{argmax}\left(\rho_i^w V_i^w + (1 - \rho_i^w) V_{n,i}^w \middle| s_{-i}^w, s^m, s_{n,-i}^w, s_n^m, \rho_{-i}^w, \rho^m, y^w, y^m, F^w, F^m\right)$$

and

$$\left(s_j^m, s_{n,j}^m, \rho_j^m\right) = \operatorname{argmax}\left(\rho_j^m V_j^m + (1 - \rho_j^m) V_{n,j}^m \middle| s^w, s_{-j}^m, s_n^w, s_{n,-j}^m, \rho^w, \rho_{-j}^m, y^w, y^m, F^w, F^m\right)$$

where i and j stand for a representative woman and man, respectively, and $-i$ and $-j$ represent all women other than i and all men other than j, respectively. $s^w = \left(s_i^w, s_{-i}^w, s_{n,i}^w, s_{n,-i}^w\right)$ and $s^m = \left(s_j^m, s_{-j}^m, s_{n,j}^m, s_{n,-j}^m\right)$ are the sets of women's and men's savings rates respectively. $\rho^w = (\rho_i^w, \rho_{-i}^w)$ and $\rho^m = \left(\rho_j^m, \rho_{-j}^m\right)$ are the sets of women's and men's probabilities of entering the marriage market respectively.

We can show a more general proposition:

Proposition 2 *Under the same assumptions as those in Proposition 1, there exists a threshold value $\phi_1 > 1$ that satisfies $V^m = V_n^m$.*

(i) For $\phi < \phi_1$, both women and men choose to enter the marriage market with probability one. In addition, as the sex ratio rises, a representative man increases his savings rate while the change in the savings rate of a representative woman is ambiguous. However, the economy-wide savings rate increases unambiguously.

(ii) For $\phi \geq \phi_1$, as the sex ratio rises, a representative man chooses a positive probability of being single while a representative woman still chooses to enter the marriage market with probability one. The effect on the aggregate savings rate is ambiguous.

Proof. See Appendix A.2.

Three remarks are in order. First, for $\phi < \phi_1$, as the sex ratio rises, men endure a welfare loss while the effect on women's welfare is ambiguous. Men lose because (i) they face a lower probability of marriage, and (ii) the reductions in their first-period consumption do not in the end alter their probability of marriage. In comparison, women face two opposing effects. On the one hand, they may gain both from an ability to free ride on their future husbands' higher savings rates and from an improved chance to marry a man with a higher level of emotional utility. On the other hand, precisely because men have raised their savings, they become more choosy in their selection of a mate as sharing their higher savings rate with a low-type woman may be worse than being single. As a result, women ex ante may face a rising risk of not getting married. The net effect of a higher sex ratio on women's welfare is ambiguous.

Second, after the sex ratio reaching and then going beyond the threshold ϕ_1, with a savings rate

already very high, some men would find it better to skip the marriage market (or equivalently, the representative man would assign a positive probability for not entering the marriage market). Otherwise, they would have to share their high savings rate with a low-type woman, resulting in a lower level of welfare than being single. From women's point of view, however, as long as the mean level of emotional utility is high enough, they always achieve a higher level of welfare by choosing to enter the marriage market. In this case, the sex ratio in the marriage market is always equal to ϕ_1. Both men and women who choose to enter the marriage market will keep their savings rates constant. The rest of men choose another (constant) savings rate to maximize their utilities, but it is ambiguous whether the life-time bachelors' savings rate is lower than women's savings rate. Therefore, the effect of a rise in the sex ratio on the aggregate savings rate is ambiguous.

Third, the log utility assumption greatly simplifies the proof. More general functional forms for utility can also yield the same results if the mean of the emotional utility is sufficiently large such that (i) the condition in Proposition 1 holds

$$E(\eta) \geq \frac{R\kappa u_2'}{2} \sqrt{\frac{\max\left(0, \kappa u_2'\left(u_{2w,n}' + u_{2m,n}'\right) - u_{2w,n}' u_{2m,n}'\right)}{u_{1m}'' u_{1w}''}}$$

and (ii), at the balanced sex ratio, all women and men enter the marriage market.

3.6   A Production Economy

To analyze how the sex ratio affects a country's current account imbalance, we need to compare economy-wide savings with investments. We make the same assumptions as those in Proposition 1, and introduce a production sector. We assume perfect competition for both the final good market and the factor markets. The production function is Cobb-Douglas:

$$Q_t = \zeta K_t^\alpha L_t^{1-\alpha} \tag{11}$$

where K_t is the capital stock and L_t is the labor input. α is the share of capital input to total output and ζ is the total factor productivity (TFP). Everyone in the economy inelastically supplies one unit of labor and earns the same income[5].

A representative firm maximizes the profit

$$\max_{K_t, L_t} Q_t - R_t K_t - W_t L_t$$

The capital return and the wage rate are determined by

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[5]   Allowing men and women to earn different wages (with a fixed proportional gap) would not change our results.

$$R_t = \frac{\partial Q_t}{\partial K_t} = \alpha \zeta \left(\frac{1}{K_t} \right)^{1-\alpha} \tag{12}$$

$$W_t = \frac{\partial Q_t}{\partial L_t} = (1-\alpha)\zeta K_t^{\alpha} \tag{13}$$

where we normalize the aggregate labor supply in the economy to be 1, i.e., $L_t = 1$.

For simplicity, we assume no tax or government expenditure; then $y_t = W_t$ where y_t is the corresponding first period disposable income in the endowment economy. We also assume complete depreciation in each period. The aggregate capital supply in period $t+1$ is predetermined by the aggregate savings in period t

$$K_{t+1}^s = \frac{\phi}{1+\phi} s_t^m W_t + \frac{1}{1+\phi} s_t^w W_t \tag{14}$$

3.7   Current Account in a Small Open Economy

In a small open economy, we assume that capital can flow freely among countries and the gross interest rate R is exogenously determined by the rest of the world. By (12) and (13), the wage rate is also a constant, and the aggregate investment in the economy is

$$K_t^d = \frac{\alpha W_t}{(1-\alpha)R_t} \tag{15}$$

Substituting (12) and (15) into the production function, we have

$$Q_t = \frac{W_t}{1-\alpha}$$

The current account in period t equals the increase in net foreign assets,

$$\Delta NFA_t = Q_t + (R-1) \cdot NFA_{t-1} - C_{1t} - C_{2t} - K_{t+1}^d$$

where $(R-1) \cdot NFA_{t-1}$ is the factor income from abroad. C_{1t} and C_{2t} represent the aggregate consumptions by young and old people respectively. Then

$$\Delta NFA_t = \frac{\phi}{1+\phi} s_t^m W_t + \frac{1}{1+\phi} s_t^w W_t - NFA_{t-1} - K_{t+1}^d$$

We define the economy-wide savings rate as the aggregate private savings to GDP ratio; then

$$s_t^P = \frac{Q_t + (R-1) \cdot NFA_{t-1} - C_{1t} - C_{2t}}{Q_t} \tag{16}$$

We assume that the country has a balanced sex ratio in period $t-1$, and the sex ratio in the young cohort in period t, rises from one to $\phi(>1)$. Then the ratio of the current account to GDP is

$$ca_t = \frac{Q_t + (R-1) \cdot NFA_{t-1} - C_{1t} - C_{2t} - K_{t+1}^d}{Q_t} \tag{17}$$

$$= (1-\alpha)\left(\frac{\phi}{1+\phi}s_t^m + \frac{1}{1+\phi}s_t^w - s_{t-1}\right)$$

where the second equality holds because[6]

$$NFA_{t-1} = s_{t-1}W_{t-1} - K_t^d$$

where s_{t-1} is the savings rate by the cohort born in period $t-1$. Since the sex ratio is balanced at that time, both the women and the men will have the same savings rate.

Since the wage rate is constant in the small open economy, we can show that a country's current account rises as its sex ratio rises (up to a point).

Proposition 3 *In a small open economy with production, both the economy-wide savings rate and the current account would rise in response to a rise in the sex ratio.*

Proof. See Appendix A.3.

In this two-period model, the rise in the current account lasts for only one period in response to a one-time permanent rise in the sex ratio. From the second period onwards, the increase in old people's dis-savings completely offset the increment in young people's savings, and the economy achieves a new equilibrium in which the current account goes back to zero. In the calibration section, we consider a (more realistic) multi-period OLG model and generate longer lasting savings and current account responses to the same one-time rise in the sex ratio.

The assumption of an exogenous interest rate holds only for a small open economy. But some of the countries that motivate this study are large. An increase in the savings rate in such economies could lower the world interest rate, which could alter investment and savings decisions in all countries. We examine the large country case in the next subsection.

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[6] In overlapping generations models, net foreign asset is equal to the difference between the savings by the young cohort and the domestic investment demand.

4.   Parental Savings and Endogenous Sex Ratios

In this section, we make the sex ratio for any cohort to be an endogenous choice of their parents. We introduce parental savings for children, which is a part of the economy-wide household savings. To incorporate these features, we consider an OLG model in which every cohort lives two periods (young and old). Everyone works and earns labor income in the first period. If one gets married, the marriage takes place at the beginning of the second period, and the couple produces a single child right away.

As noted in Wei and Zhang (2011), widespread sex selective abortions are a relatively recent phenomenon because the inexpensive technology (especially Ultrasound B machines) employed to detect the gender of a fetus became available only since the 1980s. For example, 1985 was the first year in which half of the county-level hospitables in China acquired at least one ultrasound B machine (Li and Zheng, 2009). Therefore, the first cohort born with a severe sex ratio imbalance was entering the marriage market only after the start of the 21st century. To capture this feature of the data, we assume in the model that sex-selective abortions are not technologically feasible in periods before t_0 so that the sex ratio is always balanced. Starting from period t_0, parents can directly choose a sex ratio ϕ_t for the next cohort. As a result, parents in period t have a son with probability of $\frac{\phi_t}{1+\phi_t}$, and a daughter with probability of $\frac{1}{1+\phi_t}$.

Parents can save and invest in a risk-free bond for their child, and that savings potentially depends on the gender of their child. For simplicity, we assume that parents do not invest for girls[7]. Let τ_t be the rate of the parental savings for their son. In period $t + 1$, parents transfer the bond revenue to their son. If their son gets married in period $t + 1$, the son and his wife will share the transfer which yields a utility of $\chi\ln(\kappa R\tau_t y_{m,t}^P)$ to both of them,[8] where $y_{m,t}^P$ represents the wealth of the parents with a son in period t. If the son fails to get married in period $t + 1$, parental transfers will yield a utility of $\chi\ln(R\tau_t y_{m,t}^P)$ to the young man.

For simplicity, we assume that the parents' cohort dies when their grandchild's cohort is born. Parents derive emotional utility from both their child and their grand-child[9]. For a representative young woman who enters the marriage market

$$V_t^w = \max_{s_t^w}\left\{u(c_{1t}^w) + \beta E\left[u(c_{2,t+1}^w) + \chi\ln(T_{t+1})\right] + \beta\delta_t^w E\left[\eta^m + \frac{\phi_{t+1}\eta^s}{1+\phi_{t+1}} + \frac{\eta^d}{1+\phi_{t+1}}\right] + \beta\delta_t^w\Lambda_{t+2}\right\}$$

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[7]   This assumption is consistent with the historical evidence described by Botticini and Siow (2003).

[8]   In this case, the parental transfers are assumed to be spent on a partial public consumption good within the marriage. Similar to our benchmark model, κ is a congestion index.

[9]   If we allow parents to obtain emotional utility from their daughter-in-law or son-in-law, the results remain the same qualitatively. If we make a more general assumption by allowing parents to derive their altruistic utility from their child's utility, the model would be harder to sovle but the results are likely to be the same qualitatively.

where

$$\Lambda_{t+2} = \theta^s \frac{\phi_{t+1}\delta_{t+1}^m}{1+\phi_{t+1}}\left(\frac{\phi_{t+2}\eta^s}{1+\phi_{t+2}} + \frac{\eta^d}{1+\phi_{t+2}}\right) + \theta^d \frac{\delta_{t+1}^w}{1+\phi_{t+1}}\left(\frac{\phi_{t+2}\eta^s}{1+\phi_{t+2}} + \frac{\eta^d}{1+\phi_{t+2}}\right)$$

represents the expected emotional utility obtained by the woman if she has a grandchild at the end of her life. δ_t^w is the probability that the woman gets married. δ_{t+1}^w (δ_{t+1}^m) is the probability that her daughter (son) gets married. η^s and η^d are the emotional utilities each parent obtains from having a son and a daughter, respectively. θ^s and θ^d ($\theta^d < \theta^s < 1$) are the parameters representing the degree of the emotional utilities from her son's and daughter's child, respectively. T_{t+1} is the transfer from the parents to their child.

For a representative young man,

$$V_t^m = \max_{s_t^m}\left\{u(c_{1t}^m) + \beta E\left[u(c_{2,t+1}^m) + \chi\ln(T_{t+1})\right] + \beta\delta_t^m E\left[\eta^w + \frac{\phi_{t+1}\eta^s}{1+\phi_{t+1}} + \frac{\eta^d}{1+\phi_{t+1}}\right] + \beta\delta_t^m \Lambda_{t+2}\right\}$$

Let c_{1t}^w and s_t^w denote the representative woman's first-period consumption and savings rate, respectively. Naturally,

$$c_{1t}^w = (1-s_t^w)y_t^w$$

If she fails to get married, her second-period consumption is

$$c_{2,t+1}^{w,n} = Rs_t^w y_t^w$$

If she gets married, her second-period consumption is

$$c_{2,t+1}^{w,i} = \kappa\left(1-\tau_t^i\right)(Rs_t^w y_t^w + Rs_t^m y_t^m)$$

where s_t^m and y_t^m are the first period savings rate and income by a man, respectively. i (=w or m) stands for the child's gender.

Assume that $\eta^d (< \eta^s)$ is sufficiently large such that a woman (man) would not choose to be single if she/he can be matched with someone. One sufficient condition is

$$\eta^d \geq (1+\chi)\ln\kappa^{-1} - \eta^{\min}$$

For simplicity, we also assume that men do not observe women's wealth in the marriage market (but women do observe men's wealth). An important consequence of this assumption is that men rank women only by women's emotional utility. Young women and young men are assumed to earn the

same first period income, $y_t^w = y_t^m = y$. Furthermore, η^w and η^m are assumed to be drawn from the same uniform distribution. With log utility, $u(c) = \ln c$, the optimization condition for the representative woman is

$$-\frac{1}{1-s_t^w} + \beta\left[\frac{1-F(\bar{\eta}_t^w)}{s_t^w + s_t^m} + \frac{F(\bar{\eta}_t^w)}{s_t^w}\right] = 0 \tag{18}$$

where $\bar{\eta}^w$, similarly defined as in the benchmark model, is the lowest type of women who can get married. In this extension, $\bar{\eta}_t^w = \eta^{\min}$ and $\bar{\eta}_t^m = M(\eta^{\min})$.

For a representative man, similar to the benchmark model, the optimal condition is

$$-\frac{1}{1-s_t^m} + \beta\left[\begin{array}{l}\left((1+\phi_t)(1-F(\bar{\eta}_t^m)) + \eta^{\min}f(\bar{\eta}_t^m)\right)\dfrac{1}{s_t^w + s_t^m} + F(\bar{\eta}_t^m)\dfrac{1}{s_t^m} \\[2mm] +\dfrac{f(\bar{\eta}_t^m)}{s_t^w + s_t^m}\left(U_{t+1}^P + \chi\ln\kappa - u_{2,n,t+1}^m\right)\end{array}\right] = 0 \tag{19}$$

where $u_{2,t+1}^{w,m}$ and $u_{2,t+1}^{w,w}$ stand for the utilities obtained from consumption when the representative woman has a son and a daughter, respectively. U_{t+1}^P denotes the expected utility of parents

$$U_{t+1}^P = \frac{\phi_{t+1}\left(u_{2,t+1}^{w,m} + \eta^s + \theta^s\delta_{t+1}^m\left(\frac{\phi_{t+2}\eta^s}{1+\phi_{t+2}} + \frac{\eta^d}{1+\phi_{t+2}}\right)\right)}{1+\phi_{t+1}} + \frac{u_{2,t+1}^{w,w} + \eta^d + \theta^d\delta_{t+1}^w\left(\frac{\phi_{t+2}\eta^s}{1+\phi_{t+2}} + \frac{\eta^d}{1+\phi_{t+2}}\right)}{1+\phi_{t+1}}$$

Parents optimally choose how much to save for (and transfer to) their sons. For a representative couple i, given all other households' choices $\tau_{-i,t}$, and all young people's choices s_t^w and s_t^m, the probability that their son can get married is

$$\delta_{it}^m = \Pr\left(\eta_{it}^m + \chi\ln\left(\frac{\tau_{it}}{\tau_{-i,t}}\right) \geq \bar{\eta}_t^m \,\middle|\, \tau_{-i,t}, s_t^w, s_t^m\right)$$

The optimization problem for parents at time t is

$$\max_{\tau_t} u(c_{2,m,t}) + \theta^s\delta_t^m\left(\frac{\phi_{t+1}\eta^s}{1+\phi_{t+1}} + \frac{\eta^d}{1+\phi_{t+1}}\right)$$

where we drop the sub-index i due to the symmetry. The first order condition is

$$-\frac{1}{1-\tau_t} + \chi\theta^s\frac{f(\bar{\eta}_t^m)}{\tau_t}\left(\frac{\phi_{t+1}\eta^s}{1+\phi_{t+1}} + \frac{\eta^d}{1+\phi_{t+1}}\right) = 0 \tag{20}$$

Parents also choose the sex ratio (although they don't directly choose the gender of the child) to maximize their utility U_t^P. The first order condition on the sex ratio ϕ_t chosen by parents in period t is

$$
\left(u_{2,t}^{w,w} + \theta^d \delta_t^w \left(\frac{\phi_{t+1}\eta^s}{1+\phi_{t+1}} + \frac{\eta^d}{1+\phi_{t+1}}\right) + \eta^d\right) - \left(u_{2,t}^{w,m} + \theta^s \delta_t^m \left(\frac{\phi_{t+1}\eta^s}{1+\phi_{t+1}} + \frac{\eta^d}{1+\phi_{t+1}}\right) + \eta^s\right)
$$
$$
= 0 \tag{21}
$$

We assume that parents favor sons, $\eta^s > \eta^d$; furthermore, the difference $\eta^s - \eta^d$ is sufficiently large such that, when $\phi = 1$ in period $t_0 - 1$,

$$
\left(u_{2,t_0-1}^{w,w} + \frac{\theta^d}{2}(\eta^s + \eta^d) + \eta^d\right) - \left(\mathrm{u}_{2,t_0-1}^{w,m} + \frac{\theta^s}{2}(\eta^s + \eta^d) + \eta^s\right) < 0 \tag{22}
$$

We also make the Darwinian assumption that $E\eta^m$ and $E\eta^w$ are sufficiently large so that marriage is strongly attractive. Totally differentiating (18), (19), and (20), we have the following proposition:

Proposition 4 *Assume that the sex ratio becomes a choice variable from period t_0 onwards. Under the same assumptions as those in Proposition 1 and Proposition 3, if (22) holds, we can show that*

(i) $\phi_t > 1$ ($t \geq t_0$);

(ii) In period t_0, both young men and parents with a son have higher savings rates, but the savings rates by young women and parents with a daughter decline. In a small open economy, the aggregate savings rate rises and the country runs a current account surplus in period t_0.

 Proof. See Appendix A.4.

Note that the assumption that parents do not save for their daughter can be relaxed. Since daughters are assumed to bring a lower utility than boys to their parents if the sex ratio is balanced, parents will choose a higher sex ratio (more boys than girls) in period t_0. Then all women will get married even if parents with a daughter do not save for their child. As a result, parents with a daughter optimally choose zero savings for their daughter.

5.　Numerical Examples

Are the actual sex ratios observed in the data capable of generating a current account response whose magnitude is economically significant? We answer this question in this section by quantitative calibrations of the model. We start with a small open economy and allow endogenous entry/exit to the marriage market. Then we move on to two cases of a large economy. We also consider two extensions that would add some more realism to the model. First, we discuss potential intra-family bargaining between husband and wife, with their relative bargaining power depending in part on their

relative savings rate. Second, we extend the benchmark two-period model to a multi-period model.

5.1   The Small Open Economy

Assume that the utility function is of the log form

$$u(c) = \ln(c)$$

In the calibrations for a small open economy, we fix $R = \beta^{-1}$. (In the large country case, the interest rate is to be endogenously determined.)

The emotional utility η needs to follow a continuously differential distribution. We assume a normal distribution which might be more realistic than the uniform distribution used in the analytical model (for which the uniform distribution assumption is analytically more convenient). We choose the mean and the standard deviation of emotional utility by matching them with the empirical moments implied by the estimates in Blanchflower and Oswald (2004). To be precise, here is what we do to calibrate the mean. Note first that, within the model, we can compute the incremental income needed for a man to be indifferent between being married and being forever single when the sex ratio is balanced:

$$u(Rs^m y + my) = u(\kappa R(s^m + s^w)y) + E(\eta)$$

where $m \cdot y$ is the additional compensation paid to a life-time bachelor. Regressing a measure of subjective well-being on income and marital status (and other determinants of happiness) in the United States during 1972-1998, Blanchflower and Oswald (2004) estimate that, on average, a lasting marriage is equivalent to augmenting one's income by $100,000 (in 1990 dollars) per year every year. Since the average annual income per working person was about $48,000 in that period, a sustained marriage is worth twice the average income. We therefore choose $m = 2.08 \, (\simeq \frac{100,000}{48,000})$ as the benchmark. This implies that the mean value of emotional utility is:

$$E(\eta) = \ln\left(\frac{Rs^m + m}{\kappa R(s^m + s^w)}\right)$$

where s^w and s^m are solved for the case when $\phi = 1$. We will vary the value of m in the robustness checks.

We calibrate the standard deviation of emotional utility to match the standard errors for the coefficient on the marriage status dummy in the happiness regressions. Since the t-statistic for the marriage status dummy is around 20, the implied standard deviation of emotional utility, $\sigma = \frac{E\eta}{t.stat}$, is about 0.05. As a robustness check, we will also consider $\sigma = 0.1$.

For other parameters, whenever relevant data are available, we assign values that are consistent with

the data, and they are summarized in Table 3.

Figure 1 plots the aggregate savings rate as a function of the sex ratio.When the sex ratio goes up from 1 to 1.15, the savings rate would go up by 6.2 percentage points (=0.342-0.280).[10] As the sex ratio continues to rise, the savings rate continues to rise but, after a certain point (i.e., after the sex ratio approaches 1.4), it starts to decline. This is because the sex ratio has exceeded the threshold ϕ_1 in Proposition 2; some men quit the marriage market and choose a lower savings rate, which drives down the economy-wide savings rate. Note, since no economy in the real world has a sex ratio exceeding 1.4, we may not have an opportunity to observe the declining portion of the savings curve in the data.

For sensitivity analyses, we consider different combinations of parameter values involving $\kappa = 0.7, 0.8$ and 0.9, $m = 2.08$ and 0.5, and $\sigma = 0.05$, and 0.1. There are a few noteworthy patterns. First, the economy-wide savings rate always rises in response to a rise in the sex ratio (up to a relatively high threshold value of the sex ratio). Second, the response in the economy-wide savings rate is not sensitive to changes in parameter κ. Third, when the mean value of emotional utility becomes higher (e.g., comparing $m = 2.08$ to $m = 1$), both the economy-wide savings rate and the current account respond more strongly to a given rise in the sex ratio. This is intuitive since men have a stronger desire to compete for a marriage partner. Fourth, as the dispersion for emotional utility becomes smaller, the economy-wide savings rate and the current account respond more strongly to a rise in the sex ratio. The reason is similar to before: when men are more similar in terms of the amount of "love" they can offer to women, the need to compete on the basis of wealth also rises.

5.2   Multi-Period Model Calibrations

We now extend our benchmark model to a setting in which every cohort lives for 50 periods. Everyone works in the first 30 periods, and retires in the remaining 20 periods. If one gets married, the marriage take place in the τth period. We have not been able to solve the problem that allows for parental savings for their child in the 50-period setup. Instead, we study a case in which men and women save for themselves. However, as we recognize the quantitative importance of parental savings in the data, we choose $\tau = 10$ as our benchmark case so the timing of the marriage is somewhere between the typical number of working years by parents when their child gets married and the typical number of working years by children themselves when they get married. Besides the base case of $\tau = 10$, we also examine the case of $\tau = 20$ as a sensitivity check. Generally speaking, the greater the value of τ, the stronger is the aggregate savings response to a given rise in the sex ratio.

We consider the following experiment: at time 0, the sex ratios in all existing generations are one. Starting from period 1, the sex ratio in all newly-born generations becomes $\phi(> 1)$, which is not anticipated in previous periods. A representative woman's optimization problem is

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[10]   In Online Appendix Tables 1a, 1b and 1c, we also report the calibration results for individual savings when the sex ratio changes from 1 to 1.5.

$$\max \sum_{t=1}^{\tau-1} \beta^{t-1} u(c_t^w) + E_1 \left[\sum_{t=\tau}^{50} \beta^{t-1} (u(c_t^w) + \eta^m) \right]$$

For $t < \tau$, when the woman is still single, the intertemporal budget constraint is

$$A_{t+1} = R(A_t + y_t^w - c_t^w)$$

where A_t is her wealth level at the beginning of period t. After marriage ($t \geq \tau$), her family budget constraint becomes

$$A_{t+1}^H = \begin{cases} R(A_t^H + y_t^H - c_t^H/\kappa) & \text{if } t \leq 30 \\ R(A_t^H - c_t^H/\kappa) & \text{if } t > 30 \end{cases}$$

where A_t^H is the level of family wealth (held jointly by the wife and the husband) at the beginning of period t. c_t^H is the public good consumption by both spouses, which takes the same form as in the two period OLG model. The optimization problem for a represeative man is similar.

On the production side, we assume the same production function as in the benchmark except that we now assume an annual capital depreciation rate equal to 0.1.

Given the increase in the number of periods in a lifetime, we need to adjust some parameters in the calibrations. Following Song, Storesletten, and Zilibotti (2011), we take 1.0175 as the annual gross interest rate in China. The subjective discount factor is set at $\beta = 1/R$. All other parameters are the same as in the previous 2-period OLG model.

In this multi-period OLG setup, earning profiles may also have implications on the aggregate savings rate. The Chinese data suggest an interesting (and maybe peculiar) feature about a typical worker's life-time earnings profile. Using data from urban household surveys, Song and Yang (2011) document that a typical worker in China faces a fairly flat lifetime (real) earnings profile (although the starting salary of each successive cohort tends to rise fast). Within a given cohort, we also assume a flat earnings profile over time. Since we do not consider an exogenous growth in productivity, we do not feature a steady rise in income from one cohort to the next.

In Figure 2, we trace out the evolution of the aggregate savings and the current account when the sex ratio rises from 1 to 1.10 (and when the marriage is assumed to always take place in the 10th period). Over a period of nine years, both the economy-wide savings rate and current account rise by about 3.4% of GDP. Starting from the 10th period, the increased dis-savings by the old generation start to partially offset the increase in young generation's savings. Both aggregate savings rate and the current account begin falling. In the 50th period, the aggregate savings rate and the current account converge to the new equilibrium.

As a robustness check, consider the case in which marriages always take place in the 20th period. In this case, after the same rise in the sex ratio, the economy-wide savings rate and the current account would rise by about 5.7% of GDP in nineteen years. On the other hand, if marriages take place in the 5th period, the aggregate savings rate and current account would rise by about 1.7% of GDP (we do not report the corresponding figures to save space). Because in the real world, savings response come from both the young cohort and their parents, we think setting the timing of marriages in the 10th period is reasonable, as it represents a weighted average of the number of working years by the young cohort and their parents.

In all these experiments, we see clearly that, a higher sex ratio can generate responses in both the aggregate savings rate and the current account that are both sizable and long-lasting. For instance, in Figure 2, as the sex ratio rises from 1 to 1.10, the current account surplus will stay above 2% of GDP for more than 20 years (from the 6th to 29th period) after the shock.

5.3   Additional Extensions

We also study several additional extensions to the benchmark model. First, we consider a world with two large countries. If the two countries are identical in every respect except that Country 2 has a more unbalanced sex ratio than Country 1, we show analytically that Country 2 then runs a current account surplus while Country 1 runs a current account deficit. In a calibration, we consider a version in which the two countries mimic the United States and China in some important ways. In particular, while Country 1 (United States) always has a balanced sex ratio, we vary the sex ratio in Country 2 (China) from 1 to 1.5. When the Chinese sex ratio reaches 1.15, it runs a current account surplus on the order of 4.4% of its GDP. At the same time, the United States runs a current account deficit of 1.5% of its GDP. This calibration suggests that a rise in the sex ratio in a large economy may induce other countries to run a current account deficit (even though they have a balanced sex ratio). This analysis is presented in Online Appendix B.

Second, we analyze welfare implications from a rise in the sex ratio. With log utility function, we show that men's welfare under a decentralized equilibrium (our benchmark case) relative to the central planner's economy declines as the sex ratio increases. In comparison, women's relative welfare increases as the sex ratio goes up. With transferable utility, the social welfare (the sum of all men 's and women's welfare) goes down as the sex ratio rises. The details are reported in Online Appendix C.

Third, we incorporate intra-household bargaining between wives and husbands into the model. If the bargaining powers of the two parties depend on their initial relative wealth, women's savings rate in our simulations decline much more slowly as the sex ratio rises. If the sensitivity of the bargaining power to the relative wealth is high enough, and/or private consumption is important in women's second period consumption bundle, women may even raise their savings as the sex ratio goes up. For the aggregate savings rate, it responds more strongly to a rise in the sex ratio than in the benchmark case. This is reported in Online Appendix D.

Fourth, recognizing that, even out of a precautionary (or hedging) saving motive, the savings rate can go up in response to a higher sex ratio, we compare the relative quantitative importance of the competitive and precautionary saving motives. Changes in the savings rate due to a pure hedging or precautionary motive can be ascertained by making one's savings decision to be private information. If savings cannot be observed, it cannot used as a competitive weapon in the marriage market. As a result, the competitive saving motive is shut down. Numerical simulations show that the incremental savings due to a pure hedging motive is very small relative to the competitive saving motive. This means that when the sex ratio rises, much of the action in the savings response comes from the competitive motive. A detailed comparison is presented in Online Appendix E.

Fifth, as the sex ratio rises, raising savings rate may not be the only response in the real world. In particular, young man may increase human capital accumulation (or parents may invest more in their son's human capital). We incorporate this aspect into the model, and show both theoretically and numerically that a higher sex ratio still generates a significant increase in the savings rate. Intuitively, if both physical wealth and human capital can enhance a man's status in the marriage market, the optimal allocation in the first period must be such that marginal gains from additional savings and from additional education expenditure are equal. As both yield a diminishing returns, an interior solution emerges in which the man chooses to raise both the savings rate and human capital accumulation. The derivations and simulations can be found in Online Appendix F.

Sixth, since a man's savings/consumption choice depends on the elasticity of intertemporal substitution, we check for the robustness our results with a more general utility function (CRRA) in our numerical exercises. We find that, as the sex ratio rises, the aggregate savings rate and current account always go up. As the elasticity of intertemporal substitution becomes lower, the responses of the savings rate and current account become weaker but still economically significant. This is reported in Online Appendix G.

Finally, we investigate how income inequality may affect the savings and current account responses to sex ratio imbalances. Through simulaitons of a multi-period model, we find that greater inequality generally raises the savings and current account responses to a given rise in the sex ratio. There are two reasons for this result. For high income men, a rise in the income gap among women motivates men to try harder to be matched with a high-income woman. While the behavior of a low-income woman exhibits some non-monoticity, she also eventually raises her savings rate in response to a higher sex ratio. The details can be found in Online Appendix H.

6.   Concluding Remarks and Future Research

This paper builds a theoretical model to analyze whether and how a rise in the sex ratio may trigger a competitive race in the savings rate by men (or households with sons). Generally speaking, men raise their savings rate in order to improve their relative standing in the marriage market. If we don't consider intra-household bargaining, women may respond by reducing their savings rate because

they may free ride on the increased savings from their future husbands. If we consider intra-household bargaining, then the women's response becomes ambiguous because they also have an incentive to raise their savings rate in order to protect their bargaining power within a family. In any case, the aggregate savings always rises unambiguously in response to a rise in the sex ratio, as long as the sex ratio is below some threshold. We argue conceptually and through calibrations that the threshold is higher than the sex ratios in all real economies.

When the country with an unbalanced sex ratio is large, this could have global ramifications. In particular, as the sex ratio rises, the world interest rate becomes lower. Other countries with a balanced sex ratio could be induced to run a current account deficit. Calibration results suggest that the sex ratio effect could potentially explain about half of China's current account surplus and the U.S. current account deficit. In other words, the effect is economically significant.

The theory can be extended in a number of directions. Initial results in several extensions are presented in seven online appendices. In addition, while the model focuses on the responses of savings and current account to a rise in the sex ratio, one may extend it to study effects on entrepreneurship and economic growth.

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Table 1. Savings Rate Vs Sex Ratio, 1990-2010

	(1) Full Sample	(2)	(3)	(4)	(5) Excluding Outliers	(6)	(7)	(8)
$\|sex\,ratio(i,t)-1\|$	55.24***	57.02***	58.47***	58.51***	54.87***	56.66***	58.07***	58.11***
	(12.13)	(12.00)	(11.94)	(11.93)	(12.01)	(11.87)	(11.81)	(11.79)
$\|sex\,ratio(i,t)-1\| * \mathrm{dmy}(\text{if sex ratio}(i,t)<1)$	9.71	20.49	25.65	38.31	10.94	21.99	27.27	42.08
	(30.44)	(30.40)	(30.30)	(30.80)	(30.13)	(30.07)	(29.96)	(30.45)
$\mathrm{dmy}(\text{if sex ratio}(i,t)<1)$	2.78***	3.27***	3.00***	3.06***	2.78***	3.27***	2.99***	3.06***
	(0.859)	(0.858)	(0.881)	(0.880)	(0.851)	(0.849)	(0.871)	(0.870)
ln(real GDP per capita)	5.30***	6.68***	6.60***	16.67***	5.55***	6.97***	6.92***	18.70***
	(1.24)	(1.25)	(1.26)	(4.70)	(1.23)	(1.23)	(1.25)	(4.65)
Fiscal deficit, % of GDP	-0.477***	-0.415***	-0.422***	-0.425***	-0.467***	-0.404***	-0.411***	-0.414***
	(0.032)	(0.032)	(0.032)	(0.032)	(0.031)	(0.032)	(0.032)	(0.032)
Credit to private sector, % of GDP		-0.035***	-0.037***	-0.032***		-0.036***	-0.038***	-0.032***
		(0.008)	(0.008)	(0.008)		(0.008)	(0.008)	(0.008)
Dependency ratio			-0.014	0.002			-0.008	0.010
			(0.034)	(0.035)			(0.034)	(0.034)
ln(real GDP per capita) square				-0.704***				-0.822**
				(0.316)				(0.313)
Time fixed effect	Y	Y	Y	Y	Y	Y	Y	Y
Country fixed effect	Y	Y	Y	Y	Y	Y	Y	Y
Observations	2376	2344	2323	2323	2374	2342	2321	2321
R-squared	0.16	0.15	0.16	0.16	0.16	0.15	0.16	0.16
Number of countries	159	159	158	158	159	159	158	158

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

We use the sex ratio in age group 10-24. The data can be obtained from United Nations' Population Division (http://esa.un.org/unpd/wpp/Excel-Data/population.htm).
|sex ratio(i,t) – 1| is the absolute difference between country i's sex ratio at time t and one.
In Columns (5) to (8), we exclude the observations with extreme savings rate (with absolute value greater than 80% of GDP).

Table 2. CA/GDP Vs Sex Ratio, 1990-2010

	(1) Full Sample	(2)	(3)	(4)	(5) Excluding Outliers	(6)	(7)	(8)
$|sex\ ratio(i,t)-1|$	26.93**	29.18**	30.33**	29.87**	19.13*	21.32**	22.60**	22.27**
	(12.86)	(12.69)	(12.71)	(12.70)	(10.65)	(10.48)	(10.48)	(10.47)
$|sex\ ratio(i,t)-1|*\text{dmy(if sex ratio}(i,t)<1)$	19.13	32.09	36.46	24.54	35.24	46.01*	49.73*	37.80
	(32.92)	(32.75)	(32.85)	(33.36)	(26.91)	(26.69)	(26.73)	(27.14)
dmy(if sex ratio$(i,t)<1$)	0.744	1.07	0.655	0.578	2.28***	2.58***	2.21***	2.14***
	(0.949)	(0.943)	(0.973)	(0.973)	(0.781)	(0.774)	(0.797)	(0.797)
ln(real GDP per capita)	1.16	3.50**	4.14***	-6.26	1.78	3.84***	4.43***	-5.88
	(1.39)	(1.40)	(1.42)	(5.35)	(1.144)	(1.15)	(1.16)	(4.39)
Fiscal deficit, % of GDP	-0.189***	-0.136***	-0.139***	-0.137***	-0.136***	-0.098***	-0.103***	-0.100***
	(0.034)	(0.034)	(0.034)	(0.034)	(0.029)	(0.029)	(0.029)	(0.029)
Credit to private sector, % of GDP		-0.056***	-0.060***	-0.066***		-0.051***	-0.056***	-0.061***
		(0.009)	(0.009)	(0.009)		(0.007)	(0.007)	(0.008)
Dependency ratio			0.099***	0.084**			0.096***	0.080**
			(0.038)	(0.039)			(0.031)	(0.032)
ln(real GDP per capita) square				0.723**				0.717**
				(0.358)				(0.294)
Time fixed effect	Y	Y	Y	Y	Y	Y	Y	Y
Country fixed effect	Y	Y	Y	Y	Y	Y	Y	Y
Observations	2318	2293	2273	2273	2268	2243	2223	2223
R-squared	0.04	0.05	0.06	0.06	0.05	0.07	0.08	0.08
Number of countries	162	162	161	161	160	160	159	159

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

We use the sex ratio in age group 10-24. The data can be obtained from United Nations' Population Division (http://esa.un.org/unpd/wpp/Excel-Data/population.htm).
|sex ratio(i,t) – 1| is the absolute difference between country i's sex ratio at time t and one.
In Columns (5) to (8), we exclude the observations with extreme savings rate (with absolute value greater than 30% of GDP).

Table 3. Choice of Parameter Values

Parameters	Benchmark	Source and robustness checks
Discount factor	$\beta = 0.7$	$\beta = R^{-1}$. Song et al (2011) suggests that the annual gross deposit rate in China takes value around 1.0175. As we take 20 years as one period, we set $\beta = (1/1.0175)^{20} \simeq 0.7$
Share of capital input	$\alpha = 0.4$	From China's input-output table in year 2007
Congestion index	$\kappa = 0.8$	$\kappa = 0.7, 0.9$ in the robustness checks.
Love, standard deviation	$\sigma = 0.05$	$\sigma = 0.1$ in the robustness checks
Love, mean	$m = 2.08$	$m = 1$ in the robustness checks

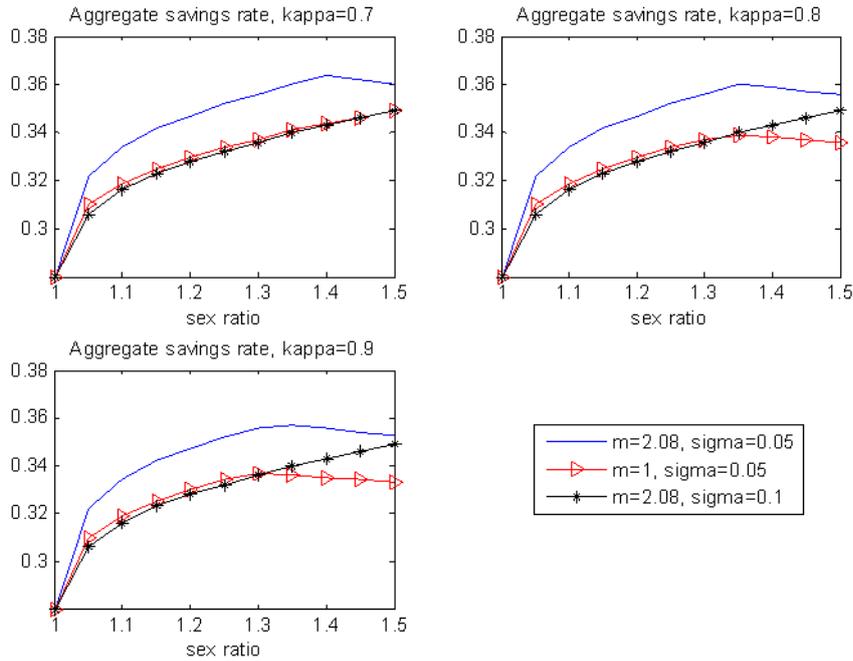**Figure 1. Economy-Wide Savings Rate Vs Sex Ratio**
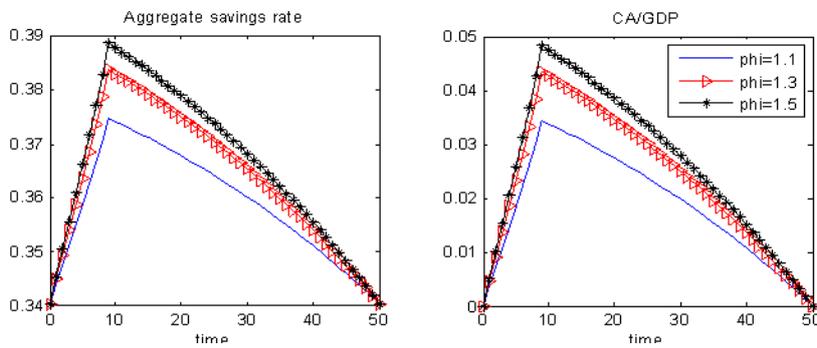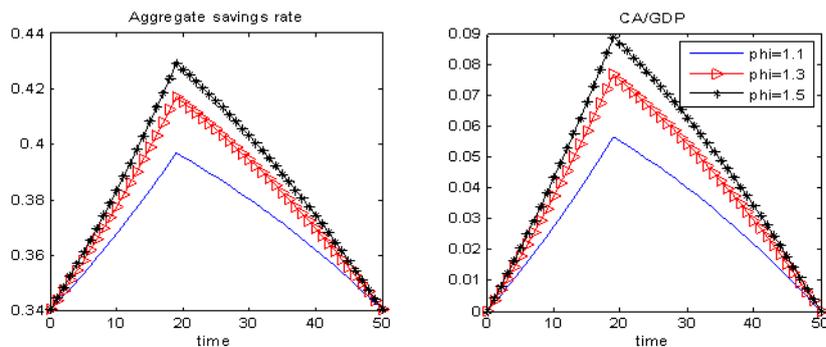

Figure 2. 50-Period Calibrations, τ=10, σ=0.05

Figure 3. 50-Period Calibrations, τ=20, σ=0.05

Note: Online appendices can be accessed by the following link

http://www.hkimr.org/uploads/publication/370/online-appendix.pdf