UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

House Price and Fertility Decisions: Evidence from Taiwan

Samuel Attafuah & Ko-Cheng Chang

Supervisor: Joseph Vecci

Master's thesis in Economics, 30 hec

Spring 2022

Graduate School, School of Business, Economics and Law, University of Gothenburg, Sweden

House Price and Fertility Decisions: Evidence from Taiwan

Abstract

Given the concurrent incidence of falling birth rates and increasing house prices experienced in Taiwan over the past two decades, the current thesis examines the role of house prices on fertility-related behaviors and outcomes among Taiwanese households. Acknowledging that housing is a major cost associated with childrearing and the theoretical assumption that children are normal goods, we hypothesize that house price inflation will adversely impact fertility and that current non-homeowners are the most affected due to the "resource exhaustion effect". Exploiting micro-level data and different econometric techniques, we capture the effect of house prices on fertility by three distinct models, namely a realized fertility (RF) model, a fertility intentions (LF) model, and a fertility gap (FG) model. The prevailing results showed a robust and statistically significant effect of house price inflation on the fertility gap, specifically, a one standard deviation increase in relative house price is associated with a 0.1 increase in the gap between desired fertility and actual fertility i.e., approximately 0.1 "missing babies" for every standard deviation increase in house prices. Additionally, we found that the fertility gap of current homeowners is less adversely impacted due to house price inflation compared to non-homeowners.

Keywords: House Price, Fertility, Taiwan, Realized Fertility (RF), Fertility Intentions (LF), Fertility Gap (FG)

Acknowledgment

We wish to express our sincere gratitude to our supervisor Joseph Vecci at the Department of Economics who provided us with constructive feedback, valuable guidance, and support throughout the entire project. Your effort and dedication have been very much appreciated.

We would also like to express our deepest gratitude to our families for their patience, support, and endless encouragement during this journey.

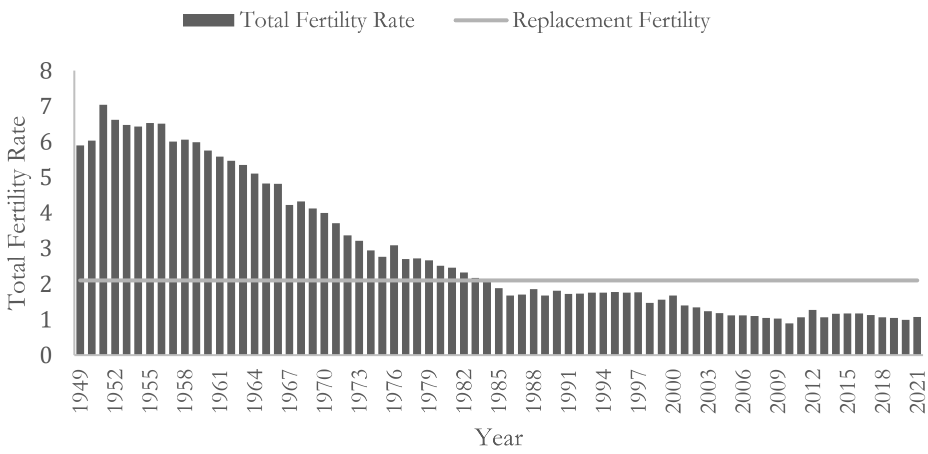
Table of Contents

1 Introduction

Taiwan remains one of the countries with the lowest fertility rate in the world (World Factbook, 2021). Pursuant to fertility data compiled by the U.S Central Intelligence Agency in 2021, Taiwan ranked last among 227 countries, with a reported fertility rate of 1.07 births per fertile woman, a level of fertility considered far below the threshold rate of 2.1 children per childbearing woman needed to sustain its aging population of about 23.5 million. In 2020, the East Asian country documented its first-ever negative[1] population growth registering a total of 165,249 births and 173,156 deaths (Ministry of the interior, 2020).

Taiwan's total fertility rate[2] (henceforth, TFR) has lingered below replacement levels[3] since 1984. As shown in Figure 1, the country's fertility dropped substantially between 1949 and 1984. These initial rapid declines can be ascribed to the demographic transition where industrialization and growing advancements in medicine reduced the rate of infant mortality and increased life expectancy at birth. During this period, TFR witnessed a remarkable decline from 7.04 children per fertile woman in 1951 to reaching the replacement fertility threshold by 1984.

Figure 1: Fertility Transition in Taiwan, 1949 – 2020



Author's graph, fertility data is retrieved from the "Department of household registration, ministry of the interior (M.O.I), Republic of China (Taiwan)."

Besides the demographic transition, the nationwide family planning programs initiated by the Taiwanese government in 1965 similarly helped contain fertility growth (Lee, 2009). After 1984, TFR

[1] Accounting for the number of emigrants and immigrants which were 980,229 and 946,251 persons respectively, total population growth in 2020 remains negative (Ministry of the interior, 2020).

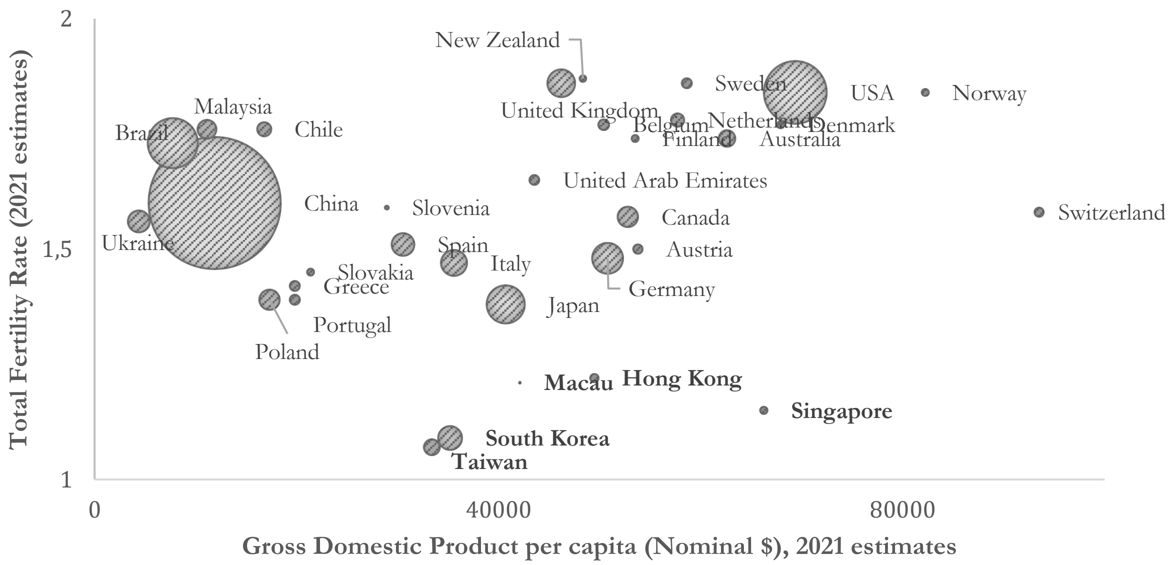
[2] Total fertility rate of childbearing aged women is defined as the total number of children that would be born to a woman over her lifetime if she bore children according to the age-specific fertility rate.

[3] The horizontal line in figure 1 is a fertility threshold defined by the UN population group. It is a level of fertility that ensures stable population growth in advanced economies. The replacement threshold is set at 2.1 children per fertile woman. In developing countries, the threshold can be as high as 3.4 children born per fertile woman to partly compensate for the rate of infant mortality but also the probability of having male offspring.

stagnated and oscillated below-replacement fertility levels. In 2021, TFR in Taiwan was ranked the lowest in the world (1.07 children per fertile woman), closely followed by South Korea (1.09), Singapore (1.15), Macau (1.21), and Hong Kong (1.22).

To put the Taiwanese TFR into perspective, Figure 2 provides a bubble plot of TFR and GDP per capita among selected Low TFR countries in 2021. Everything else equal, it suffices to say Taiwan should be on a similar TFR trajectory as Spain, Italy, Slovenia, etc. However, the reality is rather the opposite where TFR in Taiwan has been caught in a trailing state.

Figure 2: Total Fertility Rate and GDP per Capita In Selected Low Fertility Countries, 2021



Source: Author's graph, fertility data is obtained from the CIA'S World Factbook, GDP data from the International Monetary Fund World Economic outlook (2021), and population data is retrieved from the United Nations estimates and projections.

Falling fertility rates in Taiwan remain a great challenge for the Taiwanese government. To counter the issue of plummeting fertility rate in Taiwan, two contrasting views are in contention. The environmentalist[4] point of view contra the pro-natalist perspective. While the former view, perceives declining TFR as positive for the environment, its adverse ramifications on social and economic development are undeniable. The National Development Council (NDC) in Taiwan predicts that nearly 20% of its population will be over 65 years in 2025, growing to 30% by 2040. The NDC further forecasts that, if the declining fertility trend persists, Taiwan will lose its demographic dividend[5] by 2028, having a total workforce accounting for less than two-thirds of its entire population. These ex-ante projections pose threats to the country's socio-economic prosperity and wellbeing.

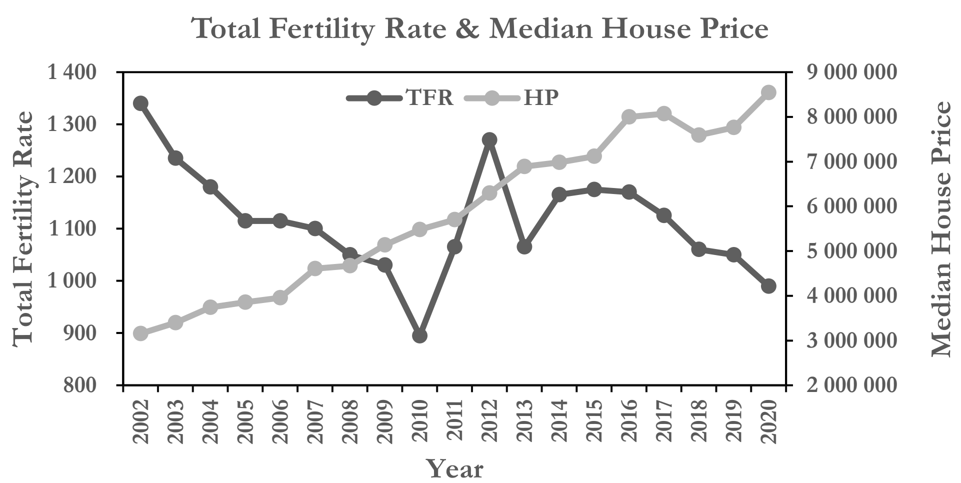
[4] From an environmentalist point of view, falling TFR means reduced carbon footprints, low extinction of species due to real estate developments, less strain on the environment, etc. Given the conflict between the pro-natalist view and the environmentalist views on fertility, the thesis will address the issue of falling birth rates in Taiwan from a pro-natalist perspective.

[5] Demographic dividend is an economic growth brought by a change in the age structure of the population. Usually when the proportion of the working population is high.

The long-term consequences of the sustained decrease in TFR below replacement levels in Taiwan is expected to reduce the share of younger people in the population and the size of the workforce (leading to a high dependency ratio, labor force shortages, and reductions in demographic dividend) establishing a possible momentum for future population declines. Not only will remarkably low TFR cause demographic unsustainability, but also it may generate a cycle that could be difficult to reverse. This, therefore, calls for more research to identify potential fertility growth constraints in the context of Taiwan to help inform policies to overcome the issue of "missing babies."

One potential reason for the low fertility rate is thought to be low growth in income compared to property and rental prices, which raises the economic cost of childbearing and childrearing (Chen, 2013; Lin, 2015; Chang et al., 2018). There is growing evidence that housing and housing markets impact fertility behavior. Among the initiatives and policies that the Taiwanese government has adopted to help curb the declining rate of fertility, relatively little attention has been paid to the role of the housing market as a possible factor constraining fertility, therefore, examining the role of house prices can provide a new dimension of knowledge to better understand the mechanisms behind the negative fertility trend.

Figure 3: House price and Total Fertility Growth Rate in Taiwan, 2002-2020



Note: Authors' graph, median house prices in real terms are given in Taiwanese dollars (NT$). Sources: "Department of household registration, ministry of the interior (M.O.I), Republic of China (Taiwan)."

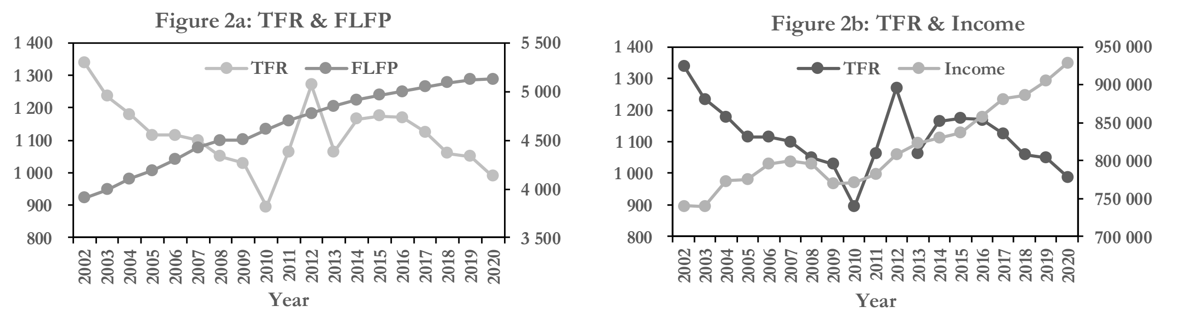
It remains irrefutable that housing plays a fundamental role in family formation. Given its functionality, housing also constitutes a major cost of childrearing in most societies. In most industrialized countries, the nuclear family is regarded as the predominant family "ideal," and the quality of children is highly preferred over quantity (Chen, 2021). Homeownership becomes an essential component of the ideal family formation; the rationale is that owning a house enhances the family's overall quality and standard of living through open and better-living spaces for childrearing

(Chen, 2021; Chang et al., 2018). The desire to have a larger family size while maintaining the quality of the children calls for a higher demand for quality housing spaces. With the current increasing trend of house prices in Taiwan, this desire may prove difficult to achieve due to possible liquidity constraints.

The unconditional relationship between house prices and TFR in Taiwan over the past 20 years exhibits a negative pattern as depicted in Figure 3[6]. During the last two decades (2002 to 2020), median house prices in Taiwan have seen a remarkable expansion of approximately 171%. This compared to about 219% increase in the capital city (Taipei). Across the country, price increments have been heterogeneous where the major cities stand out as the most affected areas. TFR on the contrary has declined by roughly -26% over the same period. A key observation in Figure 3 is the rise in TFR between 2010 to 2012, the fertility trend deviated quite substantially from the general trend, and we attribute this change to the lingering effect of the financial crisis, where given increases in unemployment rates, families adjusted their fertility timing i.e., the idea of realizing more fertility during economic downturns as opposed to economic booms to minimize sizable loss of labor income.

Besides house prices, which is the core focus in this paper, classical economic theories on fertility have also identified other factors relevant in determining fertility. Fertility theories identify among other things, income, female labor force participation rate, female education, etc., as key determinants of fertility. Figure 4 provides a graphical representation of how income and female labor force participation rate (hereafter, FLFP) have evolved in Taiwan over the last 20 years.

Figure 4: Female labor force participation, Income, and fertility rate growth, 2002-2020.



Notes: Authors' graph, income is measured in Taiwanese Dollars (NT$) and female labor force participation is (x1000 people). Sources: "Department of household registration, ministry of the interior (M.O.I), Republic of China (Taiwan)."

On the note of income, whether and how income increments affect fertility is not straightforward and depends on a myriad of confounding factors including who receives the income boost in the household. An aspect that has been emphasized in classical economic thinking is the role of women's wages in childbearing decisions. Given the incompatibility of family life and work and since women carry the larger share of the childrearing burden, it follows that higher female wages imply

[6] House price data only starts from 2002, the observation years are therefore restricted from 2002 to 2020.

a higher opportunity cost of childbearing and consequently lower fertility (Mincer, 1963; Becker, 1965).

In comparison to the growth rate of house prices established in Figure 3, the share of women participating in the labor force has surged by roughly 31% and the median level of income has likewise improved by just about 25% (Figure 4). The magnitude of growth in household's income has been minimal in comparison to the growth rate of house prices (171%). This may suggest an increased economic burden for Taiwanese households who regard housing as a necessity for childbearing and may lead to postponement of fertility. The heightened fiscal constraints caused by house price inflation may hinder the household from realizing its fertility goals. i.e., high house prices may mean that the household is unable to fulfill the goal of entering homeownership and childbearing simultaneously due to resource exhaustion[7] and may therefore be propelled to choose between homeownership or childbearing depending on the relative importance it attributes to homeownership in the childbearing decision (Chen, 2021).

Taiwan provides a unique setting to empirically examine the nature of the relationship between house prices and fertility-related decisions and outcomes. Despite the observed simultaneousness of house price inflation and the decreasing TFR as demonstrated in Figure 3, the scope of academic research investigating the house price fertility nexus in the context of Taiwan is limited. As far as we know, there are currently only two existing papers on this topic in the Taiwanese setting by Chen (2013) and Lin et al., (2016).

The current thesis exploits this gap by empirically examining the relative influence of house prices on fertility in Taiwan. This is achieved by three distinct models[8] and research questions. The first model (Realized fertility (RF)) aims to test whether house prices can explain the probability of birth(s), the second model (fertility intentions (LF)) intends to evaluate the association between house prices and the household desired number of children and lastly, a fertility gap (FG) model to investigate whether house price inflation shrinks or boosts the gap between households desired fertility and actual fertility.

The main findings are as follows; In the realized fertility model, parameter estimate from the logit regression indicates a conditional negative relationship between house prices and the probability of birth(s). However, when the presence of endogeneity is accounted for in a subsequent instrumental variable specification (IV-Probit), the estimated coefficient although remains negative becomes statistically insignificant. For the fertility intentions model, the results suggest a significant and robust conditional positive correlation between house prices and the fertility intentions of the household. Lastly, results from the fertility gap model show a significant and robust positive effect, where a one

[7] When the household affords a house before childbearing, the household has fewer resources left to afford children if house prices are exceptionally high.

[8] For further explanations on the respective models, refer to section 4.2.

standard deviation increase in the relative house price is associated with a 0.1 increase in the gap between ideal fertility and actual fertility i.e., approximately 0.1 "missing babies" for every standard deviation increase in house price. Additionally, we found that the fertility gap of homeowners is less adversely impacted by house price inflation compared to non-homeowners.

The remainder of the thesis proceeds as follows: The next section (2) presents a brief overview of the existing empirical literature. Section 3 presents a theoretical model of the relationship between house price and fertility and states the proposed hypotheses. Section 4 describes the data and specifies the econometric models. Section 5 reports the empirical findings and subsequent robustness checks and heterogeneity analysis. Finally, Section 6 discusses the findings, limitations of the research, and concludes.

2 Literature Review

As stated earlier, the effect of house prices on fertility in the setting of Taiwan has not received enough research attention. Recalling that statement, we made mention of two existing papers on the topic in Taiwan. In the study by Chen (2013), the author assessed the effect of housing cost on fertility by employing aggregate-level data, and a co-integration model. The researcher found a significant negative threshold effect based on which he concluded that house price policies should be managed from a pro-natal perspective. The research by Lin et al., (2016) on the other hand, examined the effect of housing options[9] on childbirth decisions using micro-data from the Taiwanese Panel Study of Family Dynamics (PSFD). The prevailing results were that homeowners delay their fertility, i.e., they tended to have their first child at an older age compared to renters. Moreover, they showed that families living with their parents or siblings became parents at a younger age.

The current thesis differs from the existing literature in Taiwan in the following respect, we consider a different house price measure in the form of median local house prices instead of housing options or the construction cost index (CCI) employed by Chen (2013) and Lin et al., (2016) respectively. Median house price at the county level is a more direct measure of house prices whiles housing options and the construction cost index are indirect (proxies). The construction cost index used by Lin et al., (2016) may suffer from unit root (non-stationarity) which may adversely impact exogeneity. Another unique aspect of the analysis in this paper is that due to the complexities in modelling fertility in general, we do not rely on a single model, instead we estimate three distinctive models capturing different dimensions of fertility. Furthermore, we use a different set of control variables to help capture exogenous variations of house prices on fertility which are deviant from the existing research.

[9] The authors evaluate five different housing options (including renting (control group), self-owned house, living with parents/siblings, living in a house bought by parents, and living in staff housing) on three fertility measures among others, female age at birth of first-child, time-gap from marriage to first birth, and the total number of children born.

Outside of the scope of Taiwan, the pool of empirical literature investigating the effect of house prices on fertility behavior has reached diverse outcomes, where on one hand some studies have found a conditional positive wealth effect (Lovenheim and Mumford, 2013; Dettling and Kearney, 2014; Clark and Ferrer, 2019; Atalay and Whelan, 2021) while others the opposite, i.e., a conditional negative price substitution effect on fertility (Yi and Zhang, 2010; Clark et al., 2020; Liu et al., 2020). These mixed results and lack of consensus highlight some of the intricacies in estimating fertility. Explicitly, whether and how increased house prices influence the fertility decisions of the households are undetermined, depending on various attributes of the households among others, homeownership status, the conditions of the living space, the price substitution elasticity, the income elasticity of children, the respective leisure of the family heads and the consumption of other composite goods (Yi and Zhang, 2010; Liu et al., 2020).

The ambiguity in the empirical findings can be partly explained by the relative dominance of the substitution and income effect. Conceptually, children and housing are considered normal goods and complementary in the economic model of fertility, it follows that high housing costs have an offsetting effect on the household's demand for children due to the increased cost of childrearing, in other words, as house prices increase so does the relative cost of children. Increased house prices reduce the households' purchasing power, crowding out their demand for children. Therefore, not only will house unaffordability prompt households to substitute away from other composite goods, but it may also reduce the household's demand for children depending on their relative substitutability between children and the consumption of other composite goods.

Clark et al., (2020) found empirical support in favor of a dominating substitution effect of the house price effect on the households' fertility in China. The findings showed that a 1% increase in house prices decreases the probability of having children below the age of 2 by 0.94 percentage points. In a more recent study, Liu et al., (2020) found a 1% increase in city-level house prices is associated with a 6.4‰ decrease in the likelihood of women giving birth in the past 12 months in China. The dominating substitution effect is further supported in the context of Hong Kong by Yi and Zhang (2010). Estimations from their cointegration analysis showed that a 1% increase in house prices significantly decrease TFR by around 0.45%.

The income effect of house prices on fertility on the other hand is more nuanced as it highly depends on various characteristics of the household. For homeowners, higher house prices that are perceived to be permanent will increase perceived lifetime wealth due to asset appreciation which can ultimately be used to afford additional children (Dettling and Kearney, 2014). According to the quantity/quality tradeoff (Becker, 1960), a permanent income increase will only boost the fertility of the households if their income elasticity of demand for the number of children exceeds their income elasticity of demand for quality. That being the case, whether the income effect will dominate the substitution effect due to property appreciation is quite inconclusive, nevertheless, if unaffordable house prices are a major factor that forces the household to demand fewer children, then considering everything else equal, increased house prices will increase fertility for homeowners compared to non-homeowners.

Dettling and Kearney (2014) found empirical support for a dominating income effect on homeowners' fertility due to house price inflation. Specifically, the authors demonstrated that a $10,000 increase in house prices lead to a 5% increase in current period fertility. For non-homeowners, the opposite effect was found namely a $10,000 increase in house prices lead to a 2.4% decrease in current period fertility. Estimating the relationship on the full sample, the researchers found an overall net positive effect of house price inflation on the fertility rate of women in the United States i.e., a $10,000 increase in house prices lead to a 0.8% increase in the current period fertility. They concluded that house prices exert a larger effect on birth rates than unemployment rates. In a similar study by Lovenheim and Mumford (2013), the researchers found no evidence of an effect of metropolitan area house price growth on fertility for renters, meanwhile, for homeowners, a $100,000 increase in house prices increases the probability of having a child by 16% to 18% based on which they concluded that growth in housing prices increase total fertility for homeowners. Clark and Ferrer (2019) found empirical support for a dominating wealth effect on fertility by distinguishing the house price effect between homeowners and tenanted women in Canada. The researchers estimated a positive effect of lagged house prices on the marginal fertility for homeowners and the effect was confined to non-movers, inferring that the wealth effect dominates the substitution effect for homeowners who did not move between properties. Lastly, recent findings by Atalay and Whelan (2021) in Australia found empirical support for a dominating income effect based on homeownership status. The researchers found that increased house prices have a positive impact on the fertility intentions of Australian homeowners who are young and mortgage holders. Yet, for renters with prior children, increased house prices diminish fertility intentions.

In contrast to the universe of existing empirical literature (Lovenheim and Mumford, 2013; Dettling and Kearney, 2014; Clark and Ferrer, 2019; Atalay and Whelan, 2021; Yi and Zhang, 2010; Clark et al., 2020; Liu et al., 2020; Chen, 2013; Lin et al., 2016), not only does the current paper consider the relationship between house prices and realized fertility and fertility intentions but it also estimates a fertility gap model which is indeed a novel aspect of the existing analysis investigating the house price fertility nexus. Overall, the aggregate contribution of the current paper to the existing academic literature is the house price fertility nexus captured by the fertility gap (FG) model. To the best of our knowledge, this is the first paper to study whether house prices increase or decrease the gap between desired fertility and actual fertility. It is our understanding that the "fertility gap" as a fertility measure is better at capturing the true effect of house price inflation.

3 Theoretical Framework

To study the effect of house prices on fertility-related decisions and outcomes, we utilize the overlapping generations[10] (henceforth, OLG) model proposed by Creina Day (2015). This theoretical framework is a micro-founded model inherently based on two classical fertility models: the quantity/quality framework[11] (Becker, 1960) and the cost of time hypothesis[12] (Mincer, 1963; Becker, 1965). The model aims to provide a theoretical explanation as to why fertility decline need not reverse despite the presence of a low gender wage gap (increased relative female wage) where housing land is scarce. We adopt this theoretical model because of its compatibility with the Taiwanese context. While relative female wages have soared over the past decades (Yi and Zhang, 2010), the incidence of land scarcity and high population density notably in the big cities of Taiwan could serve as potential triggers constraining fertility growth.

The theoretical framework[13] is based on the behavior and choices made by utility-maximizing households who live for more than one period and who care about the future. The model is built on the following assumptions: Consider an economy where the basic unit of analysis is the household which is comprised of the husband and the wife or a cohabiting male and female. The household lives for three periods (young working-age, middle working age, and old age). In the first, second, and third periods, the household belongs to a young, a middle-aged, and an old generation, respectively. The household determines their fertility targets by deciding on how many children to afford, how much of their time endowment to allocate to child-rearing and how much of their resource endowment to save for housing at an endogenously determined market price. A young working-age household consumes and saves for a deposit to afford housing in middle age, a middle-aged household rears children, amortizes mortgage, and saves for retirement. On retiring, the household finance old-age consumption through the sale of the housing property and interest on retirement savings (Creina Day, 2015).

3.1 The Household utility Function (Logarithmic Utility)

Wages are treated as exogenously given to focus the analysis on the effect of house prices on fertility (Creina Day, 2015). Let us denote the periods of young, middle-aged, and retired adulthood as 0, 1, 2,

[10] OLG model because in each period, there is a young, middle, and an old generation living at the same time.

[11] Becker's quantity/quality framework argues that the household is a rational decision-making entity that demands the number of children that maximize their lifetime utility subject to their budget constraints. The household has preferences for both the quantity and quality of children but if the income elasticity for quality exceeds the income elasticity for quantity, then as income soars, parents will substitute away from the number of children, toward quality per child. Explaining why income increments do not necessarily increase fertility.

[12] The cost of time hypothesis by Mincer and Becker explains the observed negative relationship between income and fertility in developed countries as a by-product of increased opportunity costs. It explicitly differentiates between the time of the wife and the husband and since it is archetypal that most childcare responsibilities rest with the woman, it is the time of the wife that is critical to the fertility decision of the household, consequently, the price of children is higher for high productivity women.

[13] We adopt the same model proposed by Creina Day to explain our context, the only modification is that we only consider three-time periods instead of the four-time periods in the original model.

correspondingly. For a representative young household who lives in period 0, the lifetime utility function to be maximized can be expressed as:

$$\Omega = u(c_0) + \delta[u(c_1, n)] + \delta^2 u(c_2) \quad 1)$$

From the utility function (1) it can be established that the household derives direct utility from the number of children, they do not necessarily derive any direct utility from housing, but it forms a necessary precondition for childrearing. The utility function takes a logarithmic linear form,

$$u(c_0) = \ln c_0 \quad 2a)$$

$$u(c_1, n) = \beta \ln c_1 + (1-\beta) \ln n \quad 2b)$$

$$u(c_2) = \ln c_2 \quad 2c)$$

where $(1-\beta) \in (0, 1)$ captures the households' relative preference for children and satisfies strict concavity of $\Omega(.)$, so that the desired number of children and consumption is expected to be strictly positive, and female relative wages will have a strictly negative effect on fertility when maternal time is used to rear children instead of allocated to the paid labor market.

From (1) and (2a) - (2c), the logarithmic household's lifetime utility function can thus be expressed as:

$$\Omega = \ln c_0 + \delta[\beta \ln c_1 + (1-\beta) \ln n] + \delta^2 \ln c_2 \quad 3)$$

where c_0, c_1, c_2 denote household consumption of young, middle-aged, and retired respectively, n denotes the number of children (fertility) and $\delta = \frac{1}{1+\rho}$ is the discount rate with a constant time preference parameter, ρ. Individuals do not own any assets in the first period of adulthood, young working adults can be thought of as living with their parents (Deaton and Laroque, 2001; Day, 2015). The theoretical framework further assumes that there is no utility from children or land in young and old age (Garino and Sarno, 2014; Creina Day, 2015), the household derives utility from consumption and the number of children and does not pass over assets to future generations.

3.2 The Household intertemporal budget constraint

Each agent of the household is endowed with a unit of labor supply. Men allocate their time to paid labor market outcomes. Women on the contrary, allocate a portion of their total time endowment, $\hat{z} \in (0,1)$ to childbearing and childrearing outcomes. The remaining time endowment $(1-\hat{z})$ is supplied to the paid labor force. The household receives in return for their labor supply real wages (w_t^m and w_t^f) when young and middle-aged, t=0, 1. The utility of the working-aged household comprises the number of children and consumption, to afford children the household needs a house. Retired households supply housing to the next generation of working-age households at the market price of p_2^h. The working-age households demand housing from newly retired households at the market price of p_1^h.

Working-age households purchase $\hat{h}$ units of housing per pair of children, so that each household demands $\hat{h}n$ units (square meters) of housing. The market price of housing is endogenously determined so that aggregate housing demand corresponds with aggregate housing supply, which in turn is affected by the ratio of working-age households to retired households (Creina Day, 2015).

A young working-age household faces the following intertemporal budget constraints at different periods in their lifecycle,

$$c_0+D_0=w_0^m+w_0^f \tag{4a}$$

$$c_1+(1+v_1)\left(p_1^h\hat{h}n-D_0\right)+w_1^f\hat{z}n+s_1=w_1^m+w_1^f \tag{4b}$$

$$c_2=(1+r_2)s_1+p_2^h\hat{h}n \tag{4c}$$

where equations 4a, 4b & 4c represent the households' intertemporal budget constraints when young, middle-aged, and retired, respectively. D_0 denotes deposit (down payment) and it is the amount optimally determined by the young working-age household for a home purchase in the next period. $P_1^h\hat{h}n$ is the price of the households' units of housing and $\left(p_1^h\hat{h}n-D_0\right)$ is equivalently the size of the households' mortgage. The mortgage repayment in middle-age is $(1+v_1)\left(p_1^h\hat{h}n-D_0\right)$, where v_1 symbolizes the real mortgage rate. On retiring the household sells their house and receives the prevailing real interest rate r_2, on savings in middle age s_1. Creina Day (2015) allows v_1 and r_2 to differ to capture differential mortgage and interest rates set by banks and other credit institutes.

Substituting for s_1 from (4c) in (4b) and for D_0 from (4b) in (4a) gives the lifetime household budget constraint,

$$(w_0^m+w_0^f)+\frac{(w_1^m+w_1^f)}{(1+v_1)}=c_0+\frac{1}{(1+v_1)}\left[c_1+p^n n+\frac{c_2}{(1+r_2)}\right] \tag{5}$$

where $p^n=\left[\left((1+v_1)p_1^h-\frac{p_2^h}{(1+r_2)}\right)\hat{h}+w_1^f\hat{z}\right]>0$ is the per-unit cost of childrearing. The lifetime budget constraint clarifies that we abstract housing from its investment role and consider it an input of childrearing. The household plays two fundamental roles in the economy, they act both as a consumer and a producer of children. As a producer, the household, given n, chooses the optimal inputs of $\hat{h}$ and $\hat{z}$ and as a consumer, the household treat $\hat{h}$ and $\hat{z}$ as given in the utility maximization problem and chooses the optimal number of children.

3.3 The Household utility maximization problem

In the static model, children are considered normal goods, and parents are utility-maximizing consumers who choose the number of children that maximizes their lifetime utility subject to their budget constraints. The objective function in (3) and the budget constraint in (5) define a constrained maximization problem that can be solved with a Lagrangian function.

$$\max \Omega = \ln c_0 + \delta[\beta \ln c_1 + (1\text{-}\beta) \ln n] + \delta^2 \ln c_2 + \lambda\left[(w_0^m + w_0^f) + \frac{(w_1^m + w_1^f)}{(1+v_1)} - c_0 - \frac{1}{(1+v_1)}\left[c_1 + p^n n + \frac{c_2}{(1+r_2)}\right]\right] \quad 6)$$

Where λ is the Lagrangian multiplier.

For a given childrearing[14] input mix, $\hat{h}$ and $\hat{z}$, the optimal fertility (n) that maximizes the household utility is derived as (cf. A.1):

$$\text{Fertility}^* = \frac{\delta(1\text{-}\beta)[(w_1^m + w_1^f)/(1+v_1) + (w_0^m + w_0^f)]}{[1+\delta(1+\delta)]p^n/(1+v_1)} \quad 7)$$

The optimal number of children depends crucially on three key factors, the household wealth, the opportunity cost of childrearing, and the cost of housing. An increase in the present value of lifetime income $\left(\frac{(w_1^m+w_1^f)}{(1+v_1)+(w_0^m+w_0^f)}\right)$, increases the level of desired fertility. An increase in housing cost increases the per-unit cost of childrearing (p^n) which has a diminishing effect on optimal fertility.

Intuitively, when children are considered a normal good and housing a prerequisite for childrearing, current house price inflation (t=0) is likely to affect optimal fertility in two ways. On one hand, it will tend to reduce the fertility intentions of young households that are saving for deposits in middle-age (t=1). Contrastingly, the young household also realizes that the family home is a means of storing and transferring wealth from the working-age to retirement (t=2). Therefore, an increase in the discounted value of future house prices has a positive wealth effect on the demand for children. This is consistent with empirical evidence that rising house prices reduce the fertility of non-homeowners and increase the fertility of homeowners via a dominating wealth effect channel (Dettling and Kearney, 2014; Creina Day, 2015).

Consequently, the predictions of the OLG model can be summarized as follows: In general, an increase in the price of housing will exert a negative substitution effect on the demand for children and this is because the space needed for childrearing becomes more expensive. For homeowners, if future house prices appreciate relative to current house prices such that the user cost of land decreases, then the wealth effect dominates, and fertility rises. The net effect of house prices on the fertility behaviors of homeowners therefore crucially depends on the total effect of the substitution and income effect. Hence for homeowners, one can expect a bidirectional impact on fertility due to an increase in

[14] The model assumes a general childrearing production function as $n = f(z, h)$, where z and h denote total time input and unit of housing, respectively. The household chooses the number of children to afford given an optimal mix of z and h that maximizes their lifetime utility subject to their budget constraint.

house prices, and which effect eclipses depends on the household's income demand elasticity for children. For renters and potential homebuyers however, increased house prices imply an economic constraint that may propel them to desire fewer children.

3.4 Hypotheses

Based on the theoretical framework and the past literature presented above, this thesis will test the following hypotheses about the house price fertility nexus:

Hypothesis 1: The relationship between house price and realized fertility is negative[15].

Hypothesis 2: The relationship between house price and the fertility gap is positive, i.e., as house prices go up the gap between ideal fertility and actual fertility becomes larger.

Hypothesis 3: The fertility gap of homeowners is less adversely impacted by house price increases compared to non-homeowners due to a dominating wealth effect.

It is worth stressing at this point that fertility decisions are not straightforward; they are rather quite complex and difficult to model in practice. Thus, we acknowledge that disentangling the effect of housing prices on fertility is not without complications. Fertility is to a considerable extent controllable by an individual's actions and preferences among other things, sexual activity, biological factors, contraception use, nuptiality, abortion, etc. Some of these factors are either unobserved or challenging to model. Therefore, the relative house price effects on fertility decisions and outcomes may not be fully captured in this research (Lovenheim and Mumford, 2013; Dettling and Kearney, 2014; Clark et al., 2020).

4 Methodology

4.1 Setting: The Taiwanese Housing Market

Taiwan is often described as a "crowded island," with an average population density of around 651 inhabitants per km^2 as of 2020, ranking 10th worldwide. Approximately two-thirds of the country's total land area is hostile to land development due to side gradients. Housing prices in Taiwan increase more rapidly than household income, creating affordability concerns (Tsai et al., 2010; 2011).

In 2020 the share of the population living in self-owned dwellings was about 90% compared to 85% in 2000 and over the same period, the share of people living in rental properties fell from 8.7% to 7.6% making self-owned properties the most common form of residence in Taiwan (cf. Table A1.1). The concurrency of increased house prices and the increased homeownership rate prevalent in Taiwan is quite intriguing and seems to suggest a strong inelastic preference for homeownership among Taiwanese households. According to Chang et al., (2018) this tendency is mainly driven by cultural

[15] The theoretical framework does not say anything about whether the household will realize fertility in a given year, hypothesis 1 is therefore mainly based on empirical findings from past literature.

beliefs and the idea of housing as a medium of wealth. The researchers argue that the traditional Chinese proverb that posits "to have a land is to have wealth" causes some irrationality in the housing market which incentivizes homebuyers to invest in homes even though their income may not be adequate to cope with the soaring market prices.

This underlying positive relationship between house price inflation and high homeownership rates implies increased resource exhaustion establishing a potential deferring effect on fertility as childrearing becomes more costly. The rental market makes up a small share of the housing market in Taiwan due to its often-low standards. The rate of substitutability between homeownership and rentals is exceptionally low and it is quite common for married couples who cannot afford their own living spaces to live with their parents (Lin and Chang, 2016). These characteristics of the Taiwanese housing market are likely to hurt the household's fertility decisions.

4.2 Data and selection

To examine the fertility behaviors and intentions of the household, individual-level fertility data, and other individual socio-demographic characteristics (age, marital status, education level, prior number of kids, income, etc.) are retrieved from the Taiwanese "Woman's Marriage, Fertility and Employment Surveys" from the periods 2003, 2006, 2010, 2013 and 2016. These individual-level data are matched to an aggregate variable, which is the unemployment rate at the county level. We restrict the sample to women aged 15 and 44 based on existing evidence that suggests a significant decline in fertility rate after age 45. The selected sample, therefore, traverses the prime period of fertility planning and childbearing (Atalay and Whelan, 2021). House price data by city/county[16] is collected from the Statistics Department of Taiwan and is given as the median house price.

The subject of the survey is women with Taiwanese citizenship, aged 15 years and above who reside in the Taiwan area. Individuals from various households are sampled and face-to-face interviews are conducted by trained researchers recruited by the Directorate-General of Budget, Accounting, and Statistics (DGBAS), to gather information about their marital status, fertility, family composition, and labor market data. The optimal goal of the information gathering is to acquire decisive statistics needed to stipulate population policies, improve labor market outcomes for women, and enhance overall social welfare measures. The size of the study subject is around 20000 women every survey period. The survey data is cross-sectional since different women are sampled and interviewed in different years and there are no follow-ups on the same participants. The key variables from the surveys that are relevant to our research are summarized below in Table 1.

[16] The microdata from the household survey does not contain house price information. House price at the household level is likely to suffer from endogeneity and measurement error since households simultaneously make their optimal choices on housing and childbearing based on their preferences and budget constraints and households may overestimate or underestimate the value of their house. House prices at the city level, however, can better enable us to evaluate the exogenous effect of house price changes on fertility and the incidence of measurement error is quite minimal.

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. dev	Min	Max
	(1)	(2)	(3)	(4)	(5)
Gave birth(s) last 12 months (Yes=1)	82,118	0.004	0.063	0.000	1.000
Ideal number of children (LF)	82,118	0.304	0.740	0.000	6.000
Fertility Gap (FG)	82,118	-0.523	1.249	-9.000	6.000
Relative house price (RHP)	82,118	1375530	1940148	-2768531	7262982
Rate of growth in house price (GRHP)	82,118	30.120	34.134	-28.716	99.764
Log house price(t)	82,118	15.490	0.429	14.670	16.640
Log house price(t-1)	82,118	15.410	0.426	14.650	16.700
Age	82,118	29.950	8.620	15.000	44.000
Log female income	82,118	3.074	4.738	0.000	13.820
Log male income	82,118	3.688	5.012	0.000	13.820
Previous number of children					
No prior birth	82,118	0.5878	0.4922	0.000	1.000
One prior birth	82,118	0.1090	0.3116	0.000	1.000
Two prior births	82,118	0.2095	0.4070	0.000	1.000
Three prior births	82,118	0.0791	0.2670	0.000	1.000
Four prior births	82,118	0.0146	0.1200	0.000	1.000
Total number of children	82,118	0.827	1.113	0.000	10.000
Marital status (Married=1)	82,118	0.424	0.494	0.000	1.000
Education Bracket					
Low education	82,118	0.00332	0.0576	0.000	1.000
Middle education	82,118	0.249	0.433	0.000	1.000
High education	82,118	0.747	0.435	0.000	1.000
Ownership status (owner=1)	82,118	0.319	0.466	0.000	1.000
Local unemployment (t)	82,118	4.384	0.572	3.400	5.400
Local unemployment (t-1)	82,118	4.552	0.780	3.500	6.000
Local population density	82,118	1857.685	2503.952	62.810	9917.98
Counties & Cities					
Yilan county	82,118	0.031	0.173	0.000	1.000
Hsinchu county	82,118	0.025	0.157	0.000	1.000
Miaoli county	82,118	0.032	0.175	0.000	1.000
Changhua county	82,118	0.062	0.242	0.000	1.000
Nantou county	82,118	0.032	0.175	0.000	1.000
Yunlin county	82,118	0.037	0.189	0.000	1.000
Chiayi county	82,118	0.030	0.171	0.000	1.000
Pingtung county	82,118	0.050	0.218	0.000	1.000
Taitung county	82,118	0.020	0.139	0.000	1.000
Hualien county	82,118	0.023	0.150	0.000	1.000
Penghu county	82,118	0.013	0.112	0.000	1.000
Keelung city	82,118	0.022	0.148	0.000	1.000
Hsinchu city	82,118	0.027	0.163	0.000	1.000
Chiayi city	82,118	0.025	0.155	0.000	1.000
Taipei city	82,118	0.079	0.270	0.000	1.000
Kaohsiung city	82,118	0.106	0.308	0.000	1.000
New Taipei city	82,118	0.109	0.312	0.000	1.000
Taichung city	82,118	0.104	0.305	0.000	1.000
Tainan city	82,118	0.097	0.296	0.000	1.000
Taoyuan city	82,118	0.079	0.265	0.000	1.000
Survey wave					
Year 2003	82,118	0.202	0.401	0.000	1.000
Year 2006	82,118	0.187	0.390	0.000	1.000
Year 2010	82,118	0.171	0.377	0.000	1.000
Year 2013	82,118	0.157	0.364	0.000	1.000
Year 2016	82,118	0.283	0.451	0.000	1.000

Summary statistics are based on data from the 2003, 2006-, 2010-, 2013- & 2016-women’s marriage, fertility and employment surveys, and house price data is retrieved from the statistics department of Taiwan

4.3 Econometric Models

4.3.1 Realized Fertility Model (RF)

To answer the first research question and hypothesis, we estimate equation 8 which intends to capture the relationship between house prices and realized fertility (RF).

$$RF_{ict}=\beta_{HP}\log(HP_{ct-1})+X'_{ict}\gamma+\alpha_c+\tau_t+\varepsilon_{ict} \qquad 8)$$

The realized fertility model is constructed as a household decision-making process; in this model, the household decides whether to give birth(s) or not in the next period based on current period house prices and other household[17] and county characteristics. The household decision model is constructed by exploiting information contained in the survey that captures the reproductive status and birth histories of the women. This retrospective information aid in the construction of the dependent variable (realized fertility). The RF model enables us to evaluate the relative influence of past-period house prices (i.e., the house cost in the year of conception) on current-period fertility.

Formally, RF_{ict} is a limited dependent variable equal to 1 if the household gave birth(s) within the past 12 months before the survey year and 0 if otherwise.

$$\begin{aligned} RF_{ict}&=1 \quad \text{if } \beta_{HP}\log(HP_{ct-1})+X'_{ict}\gamma+\alpha_c+\tau_t+\varepsilon_{ict}>0 \\ RF_{ict}&=0 \quad \text{if otherwise} \end{aligned} \qquad 9)$$

Assuming ε_{ict} to be logistically distributed, we can adopt the non-linear logit estimator. Estimations are carried out by the standard logistic likelihood function,

$$\begin{aligned} L=\prod_{ict}&\left[\Delta\left(\beta_{HP}\log(HP_{ct-1})+X'_{ict}\gamma+\alpha_c+\tau_t+\varepsilon_{ict}\right)\right]^{RF_{ict}} \\ &\times\left[1-\Delta\left(\beta_{HP}\log(HP_{ct-1})+X'_{ict}\gamma+\alpha_c+\tau_t+\varepsilon_{ict}\right)\right]^{1-RF_{ict}} \end{aligned} \qquad 10)$$

where $\Delta(.)$ denotes the logistic cumulative function. The subscripts i, c, t indexes the individual, county, and survey year, respectively. RF_{ict} is a dichotomous outcome variable; $\log(HP_{ct-1})$ is the log of county-level median house prices[18] in the year prior to the survey (this variable is invariant for all households living in the same county); β_{HP} is the parameter of interest to be estimated intended to model the conditional effect of the log of house prices on realized fertility; X'_{ict} is a matrix of the observable characteristics[19] of the women and their spouses or cohabiting partners and a county-level

[17] Since the household is observed at only one time period (i.e., during the survey year), we do not have information about some household characteristics (income, educational status, marital status, ownership status, etc.) in the year prior to the survey. For simplicity of analysis, we assume these factors have been stable between the survey year and the preceding year (1-year lag).

[18] The variable of interest (house price) enters the model in log form, the variable is logarithmic transformed for flexibility and lagged by one year because we are interested in the house price at the time of conception and not the house price at the time of delivery and to acknowledge for the fact that house price and realized fertility are not contemporaneous.

[19] The model controls for the following observable characteristics of the household, age and age-squared to capture differential effect (non-linearity) of age on realized fertility; educational attainment (a set of dummy variables denoting

indicator of macroeconomic performance[20]; α_c is the county fixed effect[21]; τ_t is the year fixed effect; ε_{ict} is the stochastic error term which captures the unexplained part of the fertility decision process. Errors are clustered at the county level to account for potential heteroscedasticity and serial correlation. The heteroscedasticity problem arises since households are clustered within their county of residence, it is probable that if the model overpredicts RF for one household within a county, it is likely to overpredict for other households within the same county, indicating a positive correlation (errors for different observations are correlated). By clustering errors at the county level, we mitigate possible downward bias of the standard non-robust and robust errors (Cameron, 2010).

4.3.2 Fertility Intentions Model (LF)

To answer the second research question, we estimate equation 11 which intends to capture the relationship between house prices and the fertility intentions of the household.

$$LF_{ict}=\beta_{HP}\log(HP_{ct})+X'_{ict}\gamma+\alpha_c+\tau_t+\varepsilon_{ict} \qquad 11)$$

The fertility intentions model (LF) captures the relationship between house prices and the households' latent demand for fertility. In contrast to the RF model, the dependent variable is treated as continuous, and the independent variable of interest is the log median house prices in the observation year. In this model specification, house price and fertility intentions are treated as contemporaneous i.e., when women are asked to state their ideal number of children, it is intuitive to assume that they decide based on the characteristics of their current states, hence we adopt the median house price in the year of the observation to predict the fertility intentions of the household. LF_{ict} is a subjective measure and is meant to measure the household latent demand for fertility since it cannot be directly observed. Another dissimilarity with the RF model is the control variable birth history which is the total number of children in the LF model as opposed to the prior number of children in the RF model. Besides these noted differences, the remaining control variables are kept unchanged in both model specifications.

---

discrete categories of educational attainment rather than treating the variable as continuous i.e., the years of education, the rationale is that education may not have a linear and monotonic impact on the probability of childbearing); marital status (a binary variable denoting 1 if the women are married or cohabiting and 0 if otherwise); the previous number of children in the household (the variable enters the model as five different categories namely no prior child, one prior child, two prior children, three prior children, and four or more prior children), the household income and a dummy for homeownership.

[20] Given the multifaceted nature of fertility decisions, county-level factors may also influence the household decision to afford children. To mitigate the risk of potential omitted variable bias and following Dettling and Kearney, (2014) & Liu et al., (2020), the model is further augmented with an additional control variable that accounts for variations in county-level economic performance, specifically, we further control for the rate of county-level unemployment.

[21] County fixed effect is included to account for county-level unobserved heterogeneity that influences fertility decisions and equivalently time-fixed effects allow for controlling unobservable systematic differences between observed time-units. There are in total 20 counties/cities and 5 time-periods in the dataset, and these will enter the regression in the form of county and time dummies.

4.3.3 Fertility Gap Model (FG)

Lastly, to answer the final research question and its associating hypotheses, we estimate equation 12 which aims to capture the relationship between house prices and the gap between desired fertility and actual fertility.

$$FG_{ict}=\beta_{HP}RHP+X'_{ict}\gamma+\alpha_c+\tau_t+\varepsilon_{ict} \qquad 12)$$

In contrast to the RF and LF models, both the dependent and independent variables of interest are different. Here, fertility is defined as the difference between desired fertility and actual fertility, and the house price variable is defined as the median house price in the observation year relative to the median house price in 2008, hence median house price in 2008 will serve as a base year. The control variables used in this model are the same as in the LF model. The fertility gap model is our most flexible model based on which subsequent heterogeneity analysis will be conducted.

Given the complexities in modeling fertility in an econometric model, the model specifications above enable us to control for observed individual characteristics but also allow for unobserved county-level heterogeneity by allowing for time-invariant county unobserved characteristics to correlate with the individual's observed characteristics. This flexibility permits us to control for county-level unobserved omitted variables in a fixed-effects specification[22]. The inclusion of a socio-economic performance indicator (i.e., unemployment rate) in all specified models enables us to reduce some potential omitted variable bias which is critical for identification and causality. The intuition is that the economic state of the county or city may covary with the real estate market and fertility timing decisions exerting a disproportionate effect on fertility decisions depending on the household's area of residence. Failure to account for this may violate the exogeneity assumption.

There are inherently two main threats to identification and causality in the baseline models. The first challenge pertains to the possibility that house prices may not be exogenous.[23] The second challenge is the cross-sectional design of the specification i.e., since the subjects are interviewed only once and there are no follow-ups, the possibility to allow unobserved individual heterogeneity to correlate with observed covariates remains unfeasible. This could result in the omission of unobserved individual traits that are fundamental to the fertility decisions and timing of the household. Based on these possible shortcomings, results from the specified baseline models are interpreted as mere conditional relationships and we refrain from making causal claims. Regardless, the baseline models will provide some key insights regarding the conditional correlations between house prices and the different fertility measures.

[22] Although house prices do not vary for households within a certain county, within a given year there are households from various counties which provides us with variations across counties. Since the unit of observation is the household and not the counties, we are able to estimate a fixed-effects specification model.

[23] Refer to section 5.4 for elaborative discussion on endogeneity.

5 Empirical Results

In this section, we report the results from the proposed baseline fertility models to gain a holistic view of the relative role of house prices on the fertility decisions and behaviors of the household. Thereafter, robustness and sensitivity checks of the baseline models are performed to ascertain the stability of the estimated parameters. Lastly, heterogeneity analysis is conducted to identify the mechanisms and the potential channels through which house price inflation influences fertility.

5.1 Main Results

Table 2 reports the baseline specifications results, we have controlled for both county and time-fixed effects to ensure that the estimated coefficients are not due to differences in reproductive norms or fertility behaviors across counties, nor due to changes in reproductive behavior over time.

Table 2: Main Results

	Realized Fertility (RF)	Fertility Intentions (LF)	Fertility Gap (FG)
	(I)	(II)	(III)
$LogHP_{t-1}$	-0.006***		
	(0.002)		
$LogHP_{t}$		0.173***	
		(0.061)	
Relative HP			0.046***
			(0.016)
Individual controls	YES	YES	YES
County controls	YES	YES	YES
County fixed effect	YES	YES	YES
Year fixed effect	YES	YES	YES
Observations	82118	82118	82118

Notes: Here we present the partial results from the baseline models (cf. Table A1.2 for full summary). The parameter estimate under RF is the average marginal effect (AME). Robust standard errors are clustered at the county level (in parentheses); standard errors are computed using the delta method. * Significant at 10%, ** significant at 5%, *** significant at 1%.

Column (I) reports estimation results from the realized fertility model (RF), the coefficient on $LogHP_{t-1}$ i.e., the estimated conditional relationship between the log of median county house prices in the year prior to the survey and the likelihood of birth(s) in the past 12 months. This parameter estimate is negative and highly statistically significant at the 1% level with a magnitude of -0.006. An increase in the log of median house prices is conditionally negatively correlated with the probability of birth(s). This preliminary result is indicative of a negative impact of house prices on realized fertility, however, results are only interpreted as mere conditional relationships and no causal interpretations are made at this juncture due to the concerns highlighted earlier in section 4. While the estimated coefficient may seem modest, it is very much aligned with the past literature. For instance, Liu et al., 2020 used an identical specification to show that a 1% increase in house prices explain about a 6.4‰ decrease in the likelihood of birth(s) in the past 12 months in the context of China. Results are also in line with Dettling and Kearney (2014); Clark and Ferrer (2019); Atalay and Whelan (2021). The empirical finding from the realized fertility model confirms the proposed **hypothesis 1**, in that there is a conditional negative relationship between house price inflation and the probability of birth(s). The estimated relationship can be interpreted as a "crowding-out effect" where increased house prices raise the cost of childbearing, and this exerts a constraint on the households' budget leading them to realize fewer children than optimum.

The second column (II) reports findings from the fertility intentions model. The dependent variable (latent fertility) which is a measure of women's ideal number of children is an imperfect measure of the households' latent demand for fertility due to potential measurement error. The results treat women's ideal number of children as identical to the households' latent demand for fertility, however, women's fertility intentions may not coincide with the fertility intentions of their spouse; hence it is important to highlight that the stated ideal number of children could be either understated or overstated. Despite this, the estimated parameter on house price ($LogHP_t$) is positive and highly statistically significant at the 1% level with a size of 0.173. An increase in the log of median county house prices is conditionally positively associated with the household's fertility intentions. Findings are similar to Liu et al., (2020) who estimated an effect size of 0.0015 in China.

The final column (III) presents the parameter estimate on the standardized relative house price in the fertility gap model. The estimated parameter is positive and highly statistically significant at the 1% level with a magnitude of 0.046. Assuming fulfillment of exogeneity, the estimated parameter can be interpreted as a one standard deviation increases in relative house price accounts for a 0.046 proportionate increase in the gap between latent fertility and actual fertility. The estimated parameter implies that as house prices go up the fertility gap of the household becomes larger. The direction of the coefficient estimate supports our proposed **hypothesis 2** i.e., increased house prices are conditionally positively associated with the fertility gap.

5.2 Robustness Analysis

In this sub-section, we run sensitivity checks on the baseline models to examine the stability of estimates to different functional forms and different estimators. But first, we offer some discussion on and solution to the endogeneity concerns raised earlier in Section 4 using an instrumental variable approach.

5.2.1 Endogeneity

Thus far, we have refrained from making causal interpretations of the baseline models. While we have accounted for all the appropriate variables available in the dataset, possible endogeneity concerns remain a potential threat due to unobserved factors that are uncontrolled for in the model and hence embedded in the error term. These probable omitted variables may co-influence house prices and fertility decisions making our baseline estimates endogenous. House price may be susceptible to endogeneity, the intuition is that house prices may not be exogenously determined since it is highly influenced by several factors among other things, changes in the size of the population, the state of the economy, real interest rate, property taxes, real income level, etc. As a robustness check, and to mitigate some endogeneity concerns, an instrumental variable (IV) econometric strategy is also considered.[24]

Finding a good instrument is always a great challenge in IV-regression. In the case of Taiwan, there has not been particularly any massive policy change during the past two decades targeted directly towards the housing market with the aim of neutralizing the soaring house market prices that we can exploit as a candidate instrument. From Figure 3, it can be ascertained that the evolution of house prices has been strictly positive over the last 20 years with barely any significant dips. This observation provides evidence of no significant policy impact in constraining house price growth. According to an article by Chen 2015, the skyrocketed house prices have become a major political topic since 2010, making policies and efforts to bring down house prices slow, a result of resistance from different interest groups.

For the sensitivity check, the best candidate instrument that we can find information on is the population density. Hence, population density per county is therefore utilized as an instrument in the forthcoming instrumental variable analysis. Population density is deemed a valid instrument because it has a strong influence on the housing market but does not necessarily have an obvious relationship with fertility. Nevertheless, the success of an instrumental variable regression is contingent on the uncompromising fulfillments of its instrument assumptions (i.e., instrument relevancy and instrument exogeneity).

5.2.1.1 Instrument relevance

If the variable (RHP) is endogenous then

$$E[\epsilon_i|RHP]\neq 0 \qquad 13)$$

this indicates that the conditional expectation of the error term given RHP is non-zero. In this case, the OLS estimator is biased, inconsistent, inefficient, and insufficient as it is no longer identified. First, results from the Durbin-Wu-Hausman test for endogeneity of the regressor relative house price (RHP) produce a p-value =0.000. We, therefore, reject the null hypothesis of exogeneity and conclude that the variable relative house price is indeed endogenous (cf. Table A1.3).

[24] Note: IV-estimates of all three models are presented below in Table 3, Instrumental validity and relevance diagnostics are conducted in all the estimated models but to minimize repetition we only provide extensive discussion and diagnostics test results on the fertility gap model.

The instrument relevance condition requires the instrument (population density per county) to capably extract the part of house price that is endogenous and merely use the exogenous part of house price to capture its relative effect on the different measures of fertility. In other words, the instrument should not be weak.[25] To determine this, we use the correlation matrix and the value of the first-stage F-statistics.[26] The computed correlation between relative house price and population density is approximately 32,4% (cf. Table A1.4). The obtained first-stage partial F-statistic value is roughly 7342, a magnitude that far exceeds the threshold value of 10 (cf. Table A1.5). Based on these statistics, we infer that our instrument population density is not weak and thus satisfies the instrument relevance condition.

5.2.1.2 Instrument exogeneity

$$E[\epsilon_i|\text{Population density}]=0 \qquad 14)$$

This implies that population density is uncorrelated with the error term. The instrumental variable regression model is exactly identified, i.e., there is a single instrument and a single endogenous regressor. In the absence of overidentification[27], there is no formal approximation technique to certify the fulfillment of the instrument exogeneity assumption. Our justification of the satisfaction of instrument exogeneity of population density will therefore be based on intuition and economic reasoning.

Intuitively, two primary factors influence population density which are changes in the size of the population and changes in the total landmass. Since the total land area is almost involatile, the only outstanding factor likely to influence population density is changes in population growth. Changes in population growth are in turn triggered by factors such as immigration and emigration, the rate of mortality, and the rate of birth. By controlling for county fixed effects in all model specifications, we mitigate the risk of omitted variable bias which may potentially render our instrument endogenous. We, therefore, argue that population density per county is plausibly exogenous[28].

[25] An instrument is considered weak when its correlation with the endogenous regressor is low. A weak instrument undermines the precision of the IV-estimator and may bias the coefficient estimates towards the OLS estimator in a finite sample. The size of the bias is positively correlated to the weakness of the instrument and inversely related to the sample size. Since it is practically difficult to find a perfect instrument, the IV estimator will in general be a little biased, but we want to minimize potential bias by finding strong instrument(s) and using a large sample size.

[26] The rule of thumb is that if the value of the first-stage partial F-statistics exceeds 10 then the instrument can be considered not weak.

[27] An instrumental variable model is overidentified when the number of instruments exceeds the number of endogenous regressors. In this case the exogeneity assumption can be econometrically corroborated with the help of the J-statistics.

[28] Although the instrument exogeneity assumption is verified intuitively, it is important to note that it has not been possible to certify that the instrument (population density) satisfies the assumption formally, hence, our intuition may not be completely valid, and this adversely impacts the IV-estimates. results from our IV-model should be interpreted with caution.

Table 3: Sensitivity Checks

	Realized Fertility (RF)			Fertility Intentions (LF)			Fertility Gap (FG)	
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
	Logit	Probit	IV-Probit	OLS	Poisson	2SLS	OLS	2SLS
LogHP_{t-1}	-0.006***	-0.005***	-0.003	0.163***	0.090**	0.526***		
	(0.002)	(0.002)	(0.006)	(0.050)	(0.042)	(0.201)		
LogHP_{t}	-0.005*	-0.005*	-0.003	0.173***	0.096**	1.007**		
	(0.003)	(0.003)	(0.018)	(0.061)	(0.043)	(0.500)		
Relative HP							0.046***	0.103***
							(0.010)	(0.035)
Rate of growth in HP							0.001***	0.008**
							(0.000)	(0.004)
Individual controls (a)	YES	YES	YES	YES	YES	YES	YES	YES
County controls (b)	YES	YES	YES	YES	YES	YES	YES	YES
County fixed effect (c)	YES	YES	YES	YES	YES	YES	YES	YES
Year fixed effect (d)	YES	YES	YES	YES	YES	YES	YES	YES
Observations	82118	82118	82118	82118	82118	82118	82118	82118

Note: Here we present the partial results from the sensitivity check. The logit, probit, IV-probit, and Poisson estimates are average marginal effects (AME). (a) socio-demographic variables including subjects' age, ownership, education, marital status, birth record, and household income. (b) one country control variable in the form of the county-level unemployment rate. (c) 20 dummies representing the different counties/cities used in the estimations. (d) 5-year dummies representing the different survey waves. Robust standard errors are clustered at the county level (in parentheses); standard errors are computed using the delta method. * Significant at 10%, ** significant at 5%, *** significant at 1%.

Table 3 reports a side-by-side comparison between the estimated baseline models and alternative estimators. In the realized fertility model, we report estimates from three distinct estimators (a logit, probit[29], and an IV-probit estimator) and an alternative measure of the house price variable.

In column (II), the magnitude of the negative coefficient estimate is marginally smaller with the probit estimator (-0.005) compared to the baseline logit estimate (-0.006) in column (I), but the coefficient remains highly statistically significant at the 1% level. However, when the potential presence of endogeneity is accounted for in the instrumental variable specification, the size of the estimated coefficient in column (III) that measures the relationship between house price and the probability of birth(s) shrinks by 50% and loses statistical significance in the process. The conclusion that can be drawn from this is that, when ignoring the existence of probable endogeneity, the logit and probit estimates are overestimated. Thus, although there is an underlying negative conditional correlation between house price and realized fertility, the size of the parameter estimate as depicted by the 2SLS is not statistically significant.

In the LF model, the true nature of the dependent variable (ideal number of children) is a count variable rather than continuous since it is not possible to prefer for instance, half (0.5) a child. In the baseline model specification, the variable was treated as a continuous variable and subsequently estimated with ordinary least squares. To ascertain the stability of the OLS estimator, we adopt an alternative estimator properly suited for count variables in the form of Poisson regression. Prevailing results show that the estimated Poisson coefficient (column (V)) is slightly smaller than the OLS estimate (IV) and less precisely estimated, however, the OLS estimates remain stable even under the Poisson estimator. When accounting for the presence of endogeneity, the magnitude of the parameter in the 2SLS regression is 1.007 (column VI) compared to 0.173 in the OLS regression (column IV). Although both coefficients are statistically significant at the 5% and 1% level respectively, the OLS estimate is undervalued.

In terms of evaluating sensitivity to an alternative measure[30] of house price, we substitute $LogHP_t$ with $LogHP_{t-1}$ in the RF model and conversely, $LogHP_{t-1}$ with $LogHP_t$ in the LF model. The results, as given in columns (I) – (VI) indicate that the alternative house price variable does not alter the baseline coefficient estimates in any meaningful way, thus this indicates the stability of estimates and suggests that the choice of the house price measure in the baseline models account for most of the relevant selection.

Lastly, when accounting for endogeneity the magnitude of the estimated coefficients in the

[29] The main reason behind the probit estimator besides ascertaining the stability of estimates to different estimators is to enable direct comparison with the IV-probit model since Stata does not have an in-built package for estimating instrumental logit regressions.

[30] The purpose of using a different variant of the house price variable in alternative specifications is to ensure that the baseline results are not driven by attenuation bias caused by potential measurement errors.

fertility gap model (columns (VII) – (VIII)) show a much larger positive effect, an increase from 0.046 to 0.103 and from 0.001 to 0.008 when using relative house price and the rate of growth in house price, respectively. The significance level, however, remains intact.

Overall, the following can be established from the comparative analysis above. In terms of the direction of the estimated coefficients, the baseline estimators remain robust since the sign of the estimated parameters are the same as in the instrumental variable estimations suggesting that the baseline relationships are non-spurious.

The instrumental variable results help us to make causal inferences. We, therefore, interpret our model of interest, i.e., the fertility gap as follows; a one standard deviation increase in the relative median county house prices increases the gap between the household's ideal number of children and their realized fertility by approximately 0.1 children, ceteris paribus. The coefficient is highly statistically significant at the 1% level. One way to interpret the effect on the rate of growth in house price and the fertility gap is as follows; Given that FG and the rate of growth in house price have a total standard deviation equal to 1.25 and 34.13 respectively, then one standard deviation increase in the rate of growth in house price accounts for an increase of roughly 2.7% of a standard deviation in FG (or a 6.5% increase in mean FG). This figure is around 21.8% when we control for endogeneity.

5.2.2 Sensitivity to different samples

How do we know that the estimated positive relationship between house price and the fertility gap is not driven by sample selection bias? A potential argument to discredit the baseline results could be to argue that the estimated positive coefficient captured by the FG model is driven by sample selection bias in the form of including women who are considered too young. For example, women between the ages of 15-and 44 years have not completed their fertility cycle (i.e., fertility is still ongoing). This group will tend to have a positive difference between ideal fertility and actual birth(s).

To determine the stability of the baseline estimates, we re-evaluate the FG model using a different sample selection. For a sub-sample of the respondents in the surveys, there is information about women who have either completed or are in the latter stages of their reproductive cycle (45-107 years). We run a sub-regression on these groups of individuals to determine whether the positive correlation between house price and the fertility gap persists. If the positive gap remains, then we can be certain that the baseline results are robust and not driven by sample selection bias.

Results in Table 4 suggest that the estimated positive fertility gap remains stable but marginally larger for the sub-sample of women older than 44. The instrumental variable results indicate that a one standard deviation increase in the relative house price leads to approximately 0,2 missing babies. Therefore, the estimated positive fertility gap in both specifications (i.e., the baseline and the alternative sample) suggest that the baseline model is robust and does not suffer from sample selection bias.

Table 4: Estimates of the House Price effect on the Fertility Gap: Robustness Analysis

	Ongoing Fertility		Completed Fertility	
	OLS	2SLS	OLS	2SLS
Relative HP	0.046***	0.103***	0.108***	0.167***
	(0.010)	(0.035)	(0.019)	(0.050)
Rate of growth in HP	0.001***	0.008**	0.003***	0.014**
	(0.000)	(0.004)	(0.001)	(0.006)
Individual controls	YES	YES	YES	YES
County controls	YES	YES	YES	YES
County fixed effect	YES	YES	YES	YES
Year fixed effect	YES	YES	YES	YES
Observations	82118	82118	76803	76803

Notes: Robust standard errors clustered at the county level (in parentheses); standard errors are computed using the delta method. * Significant at 10%, ** significant at 5%, *** significant at 1%.

5.2.3 Estimation without Household income, education, and marital status

A major concern with the control variables household income, education, and marital status is that information on these variables is only observed in the observation year (survey year), so, we have thus far assumed that there have not been any systematic differences in the relative wealth of the household over time, that education and marital status have been comparatively stable. To ascertain the validity of this assumption, we revisit the fertility gap model and re-estimate the model by instrumental variable regression without the inclusion of the stated variables to ascertain the robustness of the parameter estimates. The statistically significant positive gap remains at the 1% level even after excluding income, education, and marital status. The magnitude of the estimated coefficient however increases from 0.103 to 0.108 when omitting the variables. From this, we can be assured that the baseline results remain robust even under the assumption of no systematic changes in the relative income, education, and marital status of the women[31].

5.3 Heterogeneity Analysis

In this section, we explore different mechanisms to fully understand the effect of house prices on fertility using an interaction model technique[32] and the fertility gap model. To capture the heterogeneity

[31] Summary results from this regression are not presented, however they are available upon request.

[32] We adopt interactions to capture heterogeneity instead of splitting the data into subsamples, the rationale is that not only are we interested in estimating different coefficient values for different sub-groups, but we are also interested in evaluating whether variations between the subgroups are significantly different from each other. Using interaction models give us this flexibility and we can exploit the full dataset without loss of efficiency. Splitting the data may come with some potential caveats as it is not always possible to gain significant coefficient estimates especially when the sample size is small,

of the house price effect, we linearly interact the standardized relative house price variable with a series of socio-demographic characteristics including homeownership status, age, prior birth(s), marital status, educational attainment, and area of residence. This will provide some insights as to whether the effect of housing costs on fertility varies among different types of women. Results from the heterogeneity analysis[33] are summarized below in Table 5.

Table 5: Heterogeneity Analysis (Fertility Gap Model)

	(I)	(II)	(III)	(IV)	(V)	(VI)
	Ownership Status	Age	Prior births	Marital Status	Education	Place of Residence
	Owner	> Median	No Child	Married	Low Educated	Megacity
Relative HP	-0.086***	-0.091***	-0.062*	-0.074**	-0.079*	0.204**
	(0.029)	(0.036)	(0.039)	(0.034)	(0.048)	(0.087)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes
County controls	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
# of observations	82118	82118	82118	82118	82118	82118

Notes: Instrumental variable regression, robust standard errors clustered at the county level (in parentheses); standard errors are computed using the delta method. * Significant at 10%, ** significant at 5%, *** significant at 1%.

We first examine how homeownership status influences the house price effect and check the validity of our proposed hypothesis 3. One prediction of our theoretical framework is that fertility and childbearing are jointly determined, therefore house price appreciation increases homeowners' fertility, ceteris paribus. In column (I), we find that the inhibitive impact of house price on the fertility gap is more prominent among homeowners than renters. Existing homeowners are better positioned to afford more children even as house price increases due to asset appreciation. This tends to shrink their fertility gap more than renters or potential homebuyers. The negative interaction term is highly statistically significant at the 1% level. The significant negative parameter estimate confirms our proposed **hypothesis 3**, i.e., homeownership increases realized fertility more than non-homeownership and has a tendency of shrinking the fertility gap for homeowners compared to non-homeowners.

In the main results (see Appendix Table A1.2), we included two variants of the variable age, precisely, a level form and a second-order polynomial to capture non-linearity. The prevailing results justified this choice by the opposing directions of the estimated age variables. The positive sign on the level variable and the negative sign on the polynomial term suggest that age and fertility increase in tandem until a tipping point where fertility falls as age increases further. Column (II) compares the fertility gap effect of house price inflation depending on age by categorizing women into two age groups (≤ median age or > median age). Interaction between women older than the median sample age (30 years) and the relative house price produced a negative coefficient estimate. This prevailing negative

and since the estimates are conducted on a limited number of observations, the estimated standard errors tend to be much larger on average compared to the standard errors computed with the interaction models.

[33] Each interaction term is obtained with a separate regression.

coefficient posits that women who are older than the median sample age, are less influenced by house price increases compared to women who are below the median sample age. This effect is intuitive since the probability of realized fertility is lower for women between 15-and 30 than for those between 31- and 44 years. The estimated negative parameter is statistically significant at the 1% level, indicating a heterogeneous effect of age on the fertility gap.

We next consider whether the fertility of women with no prior birth history is more sensitive to house price changes compared to women with prior birth(s) in column (III). The idea is that women with no children are often much younger, unmarried, and do not own their housing, therefore increased house prices serve as a disincentive for these women to desire many children if they view housing as a fundamental prerequisite for childbearing. The prevailing parameter estimate on the interaction term is negative and marginally significant at the 10% level and aligns with the notion of the "no house, no children" dilemma argued by Chang et al., (2018).

In column (IV), we explore the role of nuptiality in the house price effect on the fertility gap by interacting a dummy variable for marriage with relative house prices. The hunch behind this interaction term revolves around the conception of Taiwan as a conservative society that upholds its social norms. It is rare for Taiwanese families to have children outside of wedlock due to social stigmatization. Given this perception, it is, therefore, logical to expect a differential influence of house prices on the fertility gap due to marital status. The resulting coefficient estimate is negative and statistically significant at the 5% level, which is reasonable since the highest number of birth(s) is realized in marriages resulting in a smaller fertility gap.

Furthermore, the cost of time hypothesis (Mincer, 1963; Becker, 1965) suggests a higher opportunity cost of childrearing for highly educated and productive households. The estimation results in column (V) find a depressing effect of education on the fertility gap where women with less education realize more fertility compared to women with high education thereby shrinking the fertility gap more for the former than for the latter. This finding although just moderately significant at the 10% level is in complete alignment with the hypothesis of the delaying effect of higher education on fertility due to increased opportunity cost. Another interpretation of the differing effect is attributable to the household bargaining power between low and high educated women. That is, highly educated women are better informed and are thus well-positioned to actively partake in the household decision-making regarding the number of children that is optimal for the household to afford.

Finally, in the opening section of the introduction, we stated that house price inflation has been heterogeneous across the island of Taiwan over the past two decades. While the overall growth in house prices has been roughly 171% between 2002-and 2020, the increase has been much more profound in the capital city of Taiwan (219%). Therefore, to examine whether the place of residence of the household matters for the house price effect on the fertility gap, an interaction term between a dummy variable for the six megacities[34] in Taiwan and relative house price (RHP) is estimated and this produces a significant positive coefficient (Table 5, column VI). The result finds confirmation that indeed an individual's area of residence matters, where house prices have been exceptionally high, the household tends to have fewer and fewer children to better cope with the increased cost of childrearing. This is also intuitive, women in big cities are often more educated and have fewer children but this could also simply imply a higher opportunity cost of having children in the megacities.

The heterogeneity analysis provides an important framework of different mechanisms contributing to the increasing fertility gap. From this, it can be established that the positive effect of house price inflation on the fertility gap is driven by women who live in the megacities of Taiwan due to the reason discussed above namely increased economic constraints due to a high cost of childbearing. A representative household who happens to reside in the vicinities of Taipei City, New Taipei City, Kaohsiung City, Taichung City, Tainan City, and Taoyuan City are consequently more likely to realize fewer children than would otherwise prevail in a counterfactual state as a consequence of the high housing costs.

6 Discussion and Conclusion

The current thesis investigates the relationship between house prices and three different measures of households' fertility including realized fertility (RF), fertility intentions (LF), and fertility gap (FG). To begin with, results from the logit regression evaluating the effect of house prices on realized fertility (RF) show a strong negative conditional relationship between house price inflation and the probability that a representative household gave birth(s) within the past 12 months before the survey year. The coefficient however becomes statistically insignificant when the presence of endogeneity is accounted for in a subsequent instrumental variable regression. In the second model, house prices are weighed against the household fertility intentions (LF) to ascertain the effect house prices have on the household desire for children. Results from the OLS estimations suggest a strong and significant conditional positive correlation between house prices and the desired number of children a woman aspires to have. The significant effect remains intact even when accounting for endogeneity. Given the contradictory signs of the first and second models, the third model (the fertility gap) measures the role of house price to ascertain whether it depreciates or appreciates the gap between LF and RF over time. The prevailing results suggest that higher house prices increase the fertility gap i.e., as house prices increase the household faces more difficulties to fully afford the total number of children they desire to have. House prices exert a fiscal constraint on the households' budget that potentially restricts the fulfillment of the households' fertility goals.

---

[34] Taipei City, New Taipei City, Kaohsiung City, Taichung City, Tainan City, and Taoyuan City

The theoretical framework employed in this paper implicitly assumes that the households are homeowners at middle-age because the demand for children and homeownership are jointly determined. The empirical results of the RF and FG models are in complete harmony with the predictions of the overlapping generations model in that increased house prices have a mitigating influence on the households' realized fertility. The prevailing gap between the households' latent demand for fertility and their actual level of fertility is likely the aftermath of economic constraints which are primarily triggered by increased house prices.

An empirical regularity in the dynamics of fertility is the concept that as countries develop, the households' perceptions of children are altered predominantly from the traditional notions of "children as a source of income and insurance" to the view of children as "costs" to the household because of investments in their human capital (in terms of education, health, access to material goods, assets endowments, etc.) The view of children[35] by the household has therefore undergone a shift from an initial high preference for quantity to a strong preference for quality (Becker, 1981; De Janvry et al., 2016; Galor, 2010). A consequence of the shift in fertility preferences is the household's demand for housing solutions with large and better-living spaces. Homeownership has become a necessity for many households in Taiwan as it accounted for approximately 89.6% of all residential homes in the year 2020 (cf. Table A1.1). With the recent house price increases, the financial burdens of the households have increased markedly since the rate of growth in house prices has witnessed a more notable appreciation compared to the rate of growth in income of the household.

The empirical findings from this thesis support a "resource exhaustion" effect of house price inflation on the household's realized fertility. The estimated positive effect between house prices and the fertility gap ("missing babies") is a potential indication that not all fertility goals are being realized. The households have adjusted their fertility intentions to better reflect their economic state by accounting for the heightened financial burden caused by increased house prices. Therefore, as house prices increase the gap between "what the household wants" and "what they can afford" becomes larger. This also underscores the tradeoff between quantity and quality preferences. Therefore, pro-natal policies targeted toward the real estate market to keep house price inflations in check can help contract the gap between the households' fertility intention and their actual fertility and therefore establish a possible momentum for fertility growth.

The main problem of identification in the proposed baseline econometric models was that of

[35] De Janvry et al., (2016) argue that parents consider three types of benefits (income, insurance, and satisfaction) when deciding their demand for children. During the Pre-demographic transition epoch, children were seen as a source of additional income through the rendering of services at home and in the fields and factories. Children were also regarded as a source of insurance, "a large number of children allows a household to diversify its sources of income for risk management, receive transfers from children for risk coping following a shock, provide physical protection to parents and offer them old-age security." The perception of children as a source of satisfaction has remained constant over time just that in the modern era "the quality of children is increasingly valued over quantity, leading to declines in TFR through a price and taste effect."

endogeneity, i.e., the difficulty to ensure the exogeneity of house prices. This major concern arises primarily from two key sources, partly from possible omitted variables which cannot be either directly observed or excluded from the model specifications but also on intrinsic factors of the household such as the motivations or flexibility to relocate when house prices go up. To mitigate the influence of possible endogeneity on the coefficient estimates, an instrumental variable analysis is carried out using population density as an exogenous instrument to re-evaluate the relative effect of house prices on fertility. Empirical results from the IV-regressions show that the effect of house prices was overestimated (upward bias) in the baseline logit specification but underestimated (downward bias) in the OLS specifications, when endogeneity is accounted for in the fertility gap model, the coefficient estimate increases from 0.046 children to 0.103 children when house prices increase by one standard deviation. Therefore, in the IV-model specification, the fertility gap grows larger in response to house price inflation.

Besides the endogeneity of house prices, is also the concern of reverse causality or rather simultaneity i.e., the notion that house prices affect fertility, but fertility also influences house prices. The impact of simultaneity bias on the identification of the econometric models, if any, is quite negligible because the channel from fertility to house price is indirect. Fertility does not directly increase house prices but may indirectly promote hikes in house prices via increased population growth. Given that fertility in Taiwan has remained exceptionally low below the threshold level over a long period of time (Figure 1), it unlikely that the upsurge in house prices is a direct product of increased fertility and therefore population growth.

Another key issue of identification is data constraints. We lacked decisive information in the dataset on the households' previous residential addresses to be able to establish whether the households have moved across counties. The reason knowledge of this information may prove important for model identification is that if households are responsive to house price inflation by moving between different homes in different cities, then we cannot guarantee that a unit change in house price will have an exogenous impact on fertility. Whether households have moved will be incorporated in the error term and hence a change in house price will also induce a change in the error term. Data was also unavailable on housing purchasing information including when the household acquired the house, the acquisition price, the size of their mortgage and down payment information, knowledge about their mortgage rate, etc. Knowing this information will enable the assessments of whether the household affords children before a home purchase or after a home purchase and how these decisions affect their overall fertility.

Measurement error in the income variable of the household poses another potential limitation, when women are asked to report the income of their spouses, measurement error is likely to occur due to three main reasons. Firstly, due to the lack of information about the earnings of their spouses, secondly due to informal jobs where income flows are either not constant or known, and lastly, due to disinclination to share income information as it may be deemed too sensitive. As a results data on the household income may not be representative.

The possible shortcomings to the empirical results as highlighted above, are primarily due to data constraints. Despite attempting to overcome these challenges with the help of proxies, it suffices to say that these techniques are still imperfect and cannot completely overcome the challenges. For further research, the utilization of a longitudinal survey and a panel dataset can enable us to better estimate the relative influence of house prices on fertility. Studying the household over time will not only provide a much better and richer dataset but also provide the opportunity to account for unobserved individual heterogeneity.

Unlike previous contributions, this paper examines the fertility gap which is a more reflective measure of fertility since it tells us whether the household can fully realize its intended fertility goals. This allows us to estimate a much more precise magnitude of the constraint increased house prices implies for the households' fertility decision.

To conclude, house price inflation has had an unequivocal depressing effect on the rate of fertility in Taiwan. Findings from the current paper suggest that a one standard deviation increase in the relative house price leads to around 0.1 missing babies. The adverse effect of house price inflation on the missing baby dilemma has been disproportionate where some households have been affected more severely than others. From the heterogeneity analysis, it was established that women who reside in the big cities in Taiwan are the most affected groups. Given the demographics of Taiwan, it is unlikely that house prices in the megacities will trend downwards in the near future due to growing land scarcity and increasing urban population density.

As attempts to reverse the negative fertility cycle, both the national and local governments have provided subsidies and other transfer payments to help reduce the cost of childbearing and childrearing (cf. A.5; Table A1.6). Most of these policies are quite recent and therefore their effect may not be immediate due to potential policy lag effects and the slow-changing nature of fertility. Nevertheless, the governing bodies of Taiwan can do more to help curtail the negative fertility trend to ensure sustainable population growth. Besides the current relief packages, Taiwan can also benefit from a more holistic growth approach strategy, where great emphasis is placed on providing incentives to households that motivate relocation outside of the big cities by providing better and equal opportunities for all in the form of better jobs, education, healthcare, infrastructure, and good investment climates irrespective of geographical residence. This will smooth house prices across the country over time and limit the unwarranted concentration of house price inflation confined solely to certain geographical areas.

R Reference

Atalay, K., Li, A. & Whelan, S., 2021. Housing wealth, fertility intentions and fertility. *Journal of housing economics*, 54, p.101787

Becker, G.S., 1960 "An Economic Analysis of Fertility" In Demographic and Economic Change in Developed Countries. Princeton, NJ: Princeton

Becker, G.S., 1965 "A theory of the Allocation of Time." Economic Journal 75(299):493-517

Becker, G.S., 1981 "A Treatise on the family." Cambridge, MA: Harvard university press.

Cameron, A.C. & Trivedi, P.K., 2010. *Microeconometrics using Stata* Rev., College Station, Tex.: Stata Press, pp.82-83

Chang, C. & Chen, M.-C., 2015. "Taiwan: Housing Bubbles and Affordability" Global Housing Markets: Crises, Policies, and Institutions, pp.447-463

Chang, C. & Chen, S.-M., 2018. "Dilemma of Housing Demand in Taiwan" *international real estate review,* vol.21, No.3: pp.397-418

Chen, W. Y., 2013. Does housing cost affect birth rates in Taiwan? The ADL test for threshold co-integration. *Romanian Journal of Economic Forecasting*, *16*(3), 90-103.

Chen, C.-L., 2021. Essays on the Joint Dynamics of Family Housing and Childbearing Decisions. ProQuest Dissertations Publishing

Chen, Y.-L., 2020. "Housing Prices Never Fall": The Development of Housing Finance in Taiwan. *Housing policy debate*, 30(4), pp.623–639.

Chen, Yi-Ling., 2015. The factors and implications of rising house prices in Taiwan. (Assessed on 2022-05-20)

Clark, J. & Ferrer, A., 2019. The effect of house prices on fertility: evidence from Canada. *Economics.* The open-access, open-assessment e-journal, 2019–12-01, Vol.13 (1).

Clark, W. A. V., Yi, D. and Zhang, X., 2020 'Do House Prices Affect Fertility Behavior in China? An Empirical Examination, *International Regional Science Review*, 43(5), pp. 423–449

Construction and Planning Agency., 2005 "2005 Report on the Housing Status Survey". Ministry of the Interior. (Assessed on 2022-01-13).

Construction and Planning Agency., 2020 "Housing Statistics Annual Report". Ministry of the Interior. (Assessed on 2022-01-13).

Day, C., 2015. Fertility and housing, China Economic Journal, 8:2,172-190

Deaton, A., & G, Laroque., 2001. "Housing, Land Prices, and Growth." Journal of Economic Growth 6 (2): 87–105.

De Janvry, A. & Sadoulet, E., 2016. Development economics: Theory and practice, pp. 403-428

Dettling, L. J., & Kearney, M. S., 2014. House prices and birth rates: The impact of the real estate market on the decision to have a baby. *Journal of Public Economics*, *110*, 82-100.

Directorate-General of Budget, Accounting, and Statistics (DGBAS), Executive Yuan, R.O.C., Woman's Marriage, Fertility and Employment Surveys from 2003, 2006, 2010, 2013 & 2016. Available from Survey Research Data Archive, Academia Sinica.

Directorate-General of Budget, Accounting, and Statistics (DGBAS), Executive Yuan, R.O.C., 2020. 00 Statistical yearbook of the Republic of China 2020. Ministry of Interior, Taiwan.

Galor. O., 2010. "The demographic transition: Causes and Consequence." Cliometrica 6(1): 1-28

Garino, G., and G, Sarno., 2004. "Speculative Bubbles in UK House Prices: Some New Evidence." Southern Economic Journal 70 (4): 777–795.

Kan, M. Y., & Hertog, E., 2017. Domestic division of labor and fertility preference in China, Japan, South Korea, and Taiwan. *Demographic Research*, *36*, 557-588.

Lee, M., 2009. "Transition to Below Replacement Fertility and Policy Response in Taiwan" *The Japanese journal of population, Vol.7, No.1*

Lin, P.S. and Chang, C.O., 2016. No House, No Child? Buying House, Dare not Having Children: Studies on the Impact of House Purchase on the Time of Fertility, Taiwanese Journal of Sociology, 59, 93-138 (in Chinese).

Lin, Y.J., Chang, C.O. and Chen, C.L., 2014, Why Homebuyers Have a High Housing Affordability Problem: Quantile Regression Analysis, Habitat International, 43, 41-47.

Lin, P.S., 2015. The Relationship between House Buying and the Fertility Behavior of Households: Resource Exclusion and Motivated Stimulus, Journal of Housing Studies, 24(1), 89-115 (in Chinese).

Lin, P.-S., Chang, C.-O. & Foo Sing, T., 2016. Do housing options affect childbirth decisions? Evidence from Taiwan. *Urban studies (Edinburgh, Scotland)*, 53(16), pp.3527–3546.

Liu, J., Xing, C. & Zhang, Q., 2020. House price, fertility rates, and reproductive intentions. *China economic review*, 62, p.101496.

Lovenheim, M. F., & Mumford, K. J., 2013. Do family wealth shocks affect fertility choices? Evidence from the housing market. *Review of Economics and Statistics*, *95*(2), 464-475.

Mincer, J., 1963. Market Prices, Opportunity Costs, and Income Effects. Measurement in Economics: Studies in Mathematical Economics and Econometrics in Memory of Yehuda Grunfeld. Stanford University Press.

Ministry of Interior., 2021. House price data. (Assessed 2021-12-06)

Ministry of Interior., 2022. Population density data. (Assessed 2022-02-03)

Nation Development Council, 2021.Population projections for R.O.C (Taiwan); (Assessed 2022-05-20)

Tsai, I.-C. & Peng, C.-W., 2011. Bubbles in the Taiwan housing market: The determinants and effects. *Habitat International*, 35(2), pp.379–390.

Tsai, I.-C. & Peng, C.-W., 2010. A panel data analysis for housing affordability in Taiwan. *Journal of economics and finance*, 36(2), pp.335–350.

Yi, J., & J, Zhang., 2010. "The Effect of House Price on Fertility: Evidence from Hong Kong." Economic Inquiry 48 (3): 635–650.

A Appendix

A.1 Utility maximization problem

$$\max \Omega = \ln c_0 + \delta[\beta \ln c_1 + (1\text{-}\beta)\ln n] + \delta^2 \ln c_2$$
$$+\lambda\left[(w_0^m + w_0^f) + \frac{(w_1^m + w_1^f)}{(1+v_1)} \text{-} c_0 \text{-} \frac{1}{(1+v_1)}\left[c_1 + p^n n + \frac{c_2}{(1+r_2)}\right]\right]$$

The first-order conditions (F.O.Cs) for c_0, c_1, n, c_2 and λ can be derived as:

$$\frac{\partial\Omega}{\partial c_0} = \frac{1}{c_0} \text{-}\lambda = 0 \Rightarrow c_0 = \frac{1}{\lambda} \quad \text{A1.1)}$$

$$\frac{\partial\Omega}{\partial c_1} = \frac{\delta\beta}{c_1} \text{-} \frac{\lambda}{(1+v_1)} = 0 \Rightarrow c_1 = \frac{\delta\beta(1+v_1)}{\lambda} \quad \text{A1.2)}$$

$$\frac{\partial\Omega}{\partial n} = \frac{\delta(1\text{-}\beta)}{n} \text{-} \frac{\lambda p^n}{(1+v_1)} = 0 \Rightarrow n = \frac{\delta(1\text{-}\beta)(1+v_1)}{\lambda p^n} \quad \text{A1.3)}$$

$$\frac{\partial\Omega}{\partial c_2} = \frac{\delta^2}{c_2} \text{-} \frac{\lambda}{(1+v_1)(1+r_2)} = 0 \Rightarrow c_2 = \frac{\delta^2(1+v_1)(1+r_2)}{\lambda} \quad \text{A1.4)}$$

$$\frac{\partial\Omega}{\partial\lambda} = (w_0^m + w_0^f) + \frac{(w_1^m + w_1^f)}{(1+v_1)} \text{-} c_0 \text{-} \frac{1}{(1+v_1)}\left[c_1 + p^n n + \frac{c_2}{(1+r_2)}\right] \quad \text{A1.5)}$$

Let $\alpha = (w_0^m + w_0^f) + \frac{(w_1^m + w_1^f)}{(1+v_1)}$, Solve for λ by substituting in c_0, c_1, c_2 and n into (A1.5)

$$a\text{-}\frac{1}{\lambda} + \frac{1}{(1+v_1)}\left[\frac{\delta\beta(1+v_1)}{\lambda} + p^n \frac{\delta(1\text{-}\beta)(1+v_1)}{\lambda p^n} + \frac{1}{(1+r_2)} \times \frac{\delta^2(1+v_1)(1+r_2)}{\lambda}\right] = 0$$

This gives

$$\lambda = \frac{[1\text{-}\delta(1+\delta)]}{a} \quad \text{A1.6)}$$

Insert (A1.6) into (A1.3) to derive optimal fertility

$$n = \frac{\delta(1\text{-}\beta)(1+v_1)}{\left(\frac{[1\text{-}\delta(1+\delta)]}{a}\right) p^n}$$

Optimal fertility

$$n^* = \frac{\delta(1\text{-}\beta)(a)(1+v_1)}{[1\text{-}\delta(1+\delta)]p^n} \quad \text{A1.7)}$$

Where $\alpha = (w_0^m + w_0^f) + \frac{(w_1^m + w_1^f)}{(1+v_1)}$.

A.2

Table A1.1: The Taiwanese Housing Market statistics

	2000	2010	2020	Change in 20 years (%)
Household Demand and supply				
Households (1000 households)	6802	8058	8934	31,34
Housing stock[36] (1000 units)	6993	8075	9022	29,1
Housing supply ratio (%)	102.8	100,2	100.1	-2,7
Housing Surplus (1000 units)	191	17	88	-53,93
Housing tenure				
Ownership[37] (%)	85.4	88.3	89.60	4,92
Rented	8.78	8.50	7.60	-15.5
Issued, leased, and others	5.87	3.2	2.80	-109.6
Dwelling level (m^2)				
Average person per household	3.9	3.6	2.6	-50
Mean living space per person	36.9	43.8	50.8	37.6
Mean living space per household	133.6	142.5	148,4	11.1
Housing market				
The ratio of housing price to income		7.1	9.2	
Mortgage payment-to-income ratio		29.3	36.8	
The ratio of rent to income			13.5%	
Housing expenditure			16%	

Sources: Authors' tabulations based on data from the Housing Statistics Annual Report (2020), Construction and Planning Agency, Ministry of the Interior. Directorate-General of Budget, Accounting, and Statistics (DGBAS), Executive Yuan, R.O.C. (Taiwan). Retrieved from database 2021-11-13.

[36] Only residential homes.

[37] Ownership is classified as the sum of self-owned house and house owned by the nuclear family (Spouse, parent, or children not living together). Other forms of ownership are not included for example allotted, borrowed, or those living in the collective quarters.

A.3

Table A1.2: Full Summary of Main Results

	Realized Fertility (RF)	Fertility Intentions (LF)	Fertility Gap (FG)
	(I)	(II)	(III)
$\text{Log}(\text{HP}_{t-1})$	-0.006***		
	(0.002)		
$\text{Log}(\text{HP}_t)$		0.173***	
		(0.061)	
Relative HP			0.046***
			(0.010)
Ownership	0.003***	0.004	0.004
	(0.001)	(0.009)	(0.010)
Age	0.001***	0.029***	(0.030)***
	(0.000)	(0.002)	(0.002)
Age-Squared	-0.000***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)
Education Level			
Middle	-0.004	0.045	0.044
	(0.003)	(0.054)	(0.054)
High	-0.007**	0.007	0.007
	(0.003)	(0.053)	(0.053)
Prior # of birth(s)			
One (a)	0.001*		
	(0.001)		
Two (a)	0.000		
	(0.000)		
Three (a)	0.001		
	(0.001)		
Four or More (a)	0.060***		
	(0.001)		
Married	-0.001	0.576***	0.574***
	(0.001)	(0.019)	(0.019)
Log (household Income)	0.000	0.007***	0.006***
	(0.000)	(0.001)	(0.001)
Total # of birth(s)			
One (b)		-0.280***	-1.277***
		(0.018)	(0.018)
Two (b)		-0.530***	-2.528***
		(0.019)	(0.019)
Three (b)		-0.380***	-3.378***
		(0.023)	(0.023)
Four (b)		-0.114***	-4.114***
		(0.031)	(0.032)
Five or more (b)		-0.154	-5.470***
		(0.114)	(0.181)
Macroeconomic condition			
Unemployment rate	0.001	-0.063	-0.106
	(0.002)	(0.097)	(0.091)
Constant	0.004***	-1.687	1.166**
	(0.000)	(1.123)	(0.456)
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
# of observations	82118	82118	82118

Note: *, **, *** indicate significance levels at 10%, 5% and 1% respectively. (a) & (b) omitted category is "no children"

A.4 Endogeneity and instrument diagnostics (FG Model)

Table A1.3: Test of endogeneity

Durbin-Wu-Hausman Test		
HO: Variables are exogenous		
Robust score chi2(1)	=46.164	(P=0.000)
Robust regression F (1,82079)	=46.450	(P=0.000)

Table A1.4: Correlation

	Population density
Relative House Price	0.324

Table A1.5: First stage regression summary statistics

Variable	R-squared	Adjusted R-squared	Partial R-squared	Robust F (1,82075)	Prob> F
Relative house price (RHP)	0.7502	0.7501	0.1997	7342.21	0.0000

A.5 Fertility policies in Taiwan (National policies and local policies)

Taiwan's fertility policies at the national level can be classified into three main categories, namely, childbearing policies, daycare policies (childrearing), and parental leave allowances. Most of these policies are new and are the direct response of the government to help restrain the falling rate of fertility. Below are some of the fertility-related policies in Taiwan, the eligibility criterion, and the magnitude of the subsidies.

1. Childbearing policy

To be eligible for this subsidy, the household must fulfill the following requirements: (I) The annual income of the household must be below the 20% tax rate threshold which was roughly $1.2 million NT as of 2021; (II) The household must not be a recipient of a daycare subsidy or receive parental allowances; (III) The household must not be a utilizer of public or quasi-public daycare institutions.

The subsidy is implemented in different phases, in phase I (August 2018 to July 2021) of the implementation, households who just meet the threshold receive $2,500 NT / month and per child, and households whose annual income is significantly lower than the threshold can receive extended benefits not larger than $5,000 NT per month and birth. In phase II (August 2021 to July 2022) of the policy implementation, eligible households can receive a higher subsidy per month but not more than $5,000 NT / month (first child); $6,000 NT / month (second child); $7,000 NT / month (third child and above). In phase III (from August 2022) of the implementation all households that meets the subsidy requirements are granted the same amount of grant which is $5,500 NT / month (first child);

$6,000 NT / month (second child); $7,000 NT / month (third child and above). The subsidy expires when the child turns two[38] (Ministry of health and welfare).

2. Daycare subsidy

Eligibility to obtain the daycare subsidy is, besides the fulfillment of requirements (I) & (II) stated in the preceding policy, the household must also be a user of public or quasi-public daycare institutions and must also have children below the age of 3 (Ministry of education).

(I) Public Daycare institutions

From August 2018 to July 2021, the households who meets the subsidy requirements is granted no more than $7,000 NT / month (first child); $7,000 NT / month (second child); $8,000 NT / month (third child and above). From August 2021 to July 2022, the subsidy increases to no more than $8,000 NT / month (first child); $9,000 NT / month (second child); $10,000 NT / month (third child and above). Lastly, from August 2022 households that meets the subsidy requirements can receive up until $9,500 NT / month (first child); $10,500 NT / month (second child); $11,500 NT / month (third child and above).

(II) Quasi-Public Daycare institutions

From August 2018 to July 2021, the households who meets the subsidy requirements is granted no more than $7,000 NT / month (first child); $7,000 NT / month (second child); $11,000 NT / month (third child and above). From August 2021 to July 2022, the subsidy increases to no more than $11,000 NT / month (first child); $12,000 NT / month (second child); $13,000 NT / month (third child and above). Lastly, from August 2022 households that meets the subsidy requirements can receive up until $12,500 NT / month (first child); $13,500 NT / month (second child); $14,500 NT / month (third child and above).

3. Parental leave allowance

The parent must be a member of an employee insurance at least for 12 months and have a child below the age of three. The parent must apply for the parental leave allowance according to the prescribed law and both parents are qualified to apply.

Since 2002, an employee who is in the same job for at least 6 months can apply for parental leave if the child is below age 3. From May 2009 to June 2021, eligible parents are entitled to a parental leave allowance granting them 60% of their monthly salaries over 6 months. From July 2021, parents can receive 80% of their monthly salaries. The parental leave allowance is such that each parent is granted a maximum of 2 years and a maximum of 6 months per child, hence a single parent can apply continuously up until the 4th child (Bureau of labor insurance, Ministry of labor).

[38] There is another version of this subsidy where households with children between the ages of 2 and 5 are eligible to apply.

A1.6 Summary of some fertility policies at the county level

County/City	Birth subsidy (per birth)	Childrearing subsidy	Requirements	Source
Taipei City	$ 20,000 NT	$ 2,500 NT per month until the child is 5 years old.	From Jan 2011, must be a resident for at least 10 months.	Department of civil affairs, Taipei city government.
New Taipei City	$ 20,000 NT	$ 2,500 NT – $ 5000 NT per month until the child is 2 years old.	From Jan 2011, must be a resident for at least 10 months.	Department of civil affairs, New Taipei city government
Keelung City	$ 20,000 NT	$ 2,500 NT – $ 5000 NT per month until the child is 2 years old.	From April 2015, must be a resident for at least 12 months.	Keelung city government.
Taoyuan City	$ 30,000 NT	$ 2,500 NT per until the child is 3 years old.	From August 2019, must be a resident for at least 12 months.	Department of social welfare, Taoyuan
Hsinchu City	$ 30,000 NT	$ 2,500 NT – $ 5000 NT per month until the child is 2 years old.	From December 2019, must be a resident for at least 12 months.	Hsinchu city government.
Miaoli County	$ 10,000 NT		From January 2021, must be a resident for at least 12 months.	Miaoli county government
Taichung City	$ 20,000 NT		From January 2022, must be a resident for at least 6 months.	Social affairs bureau Taichung city government
Changhua County	$ 30,000 NT		From January 2015, must be a resident for at least 12 months.	Changhua county government
Nantou County	$ 10,000 NT		From January 2018, must be a resident for at least 12 months.	Nantou county government
Yunlin County	$ 10,000 NT		From May 2021, must be a resident for at least 12 months.	Yunlin county government
Chiayi City	$ 8,000 NT		From November 2015, must be a resident for at least 12 months.	Social affairs department of Chiayi city government
Chiayi County	$ 12,000 NT		From July 2018, must be a resident for at least 12 months.	Social affairs bureau of Chiayi County government
Tainan City	$ 10,000 NT		From January 2022, must be a resident for at least 6 months.	Social affairs bureau Tainan city government
Kaohsiung City	$ 20,000 NT		From January 2020, must be a resident for at least 12 months.	Social affairs bureau of Kaohsiung city government
Pingtung County	$ 15,000 NT		From April 2019, must be a resident for at least 12 months.	Pingtung social affairs department
Hualien County	$ 20,000 NT	$ 2,500 NT – $ 5000 NT per month until the child is 2 years old.	From August 2018, must be a resident for at least 12 months.	Hualien social affairs department
Taitung County	$ 30,000 NT	$ 2,500 NT – $ 5000 NT per month until the child is 2 years old.	From January 2022, must be a resident for at least 6 months.	Taitung household registration office Taitung County

Note: information from sources is assessed on April 7th, 2022.