POLICY ANALYSIS: CAN FINANCIAL INCENTIVES BOOST FERTILITY RATE, EVIDENCE FROM HONG KONG

BY

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12 Nov 2022

Abstract:

The purpose of this paper is to analysis the impact of Tax allowances for married person and young parents on the Total Fertility Rate (TFR) in Hong Kong. It is believed that many people today are avoiding or delaying giving birth due to the unaffordable costs associated with raising children. During the period 1989 to 2021 the amount of these tax allowances has increased significantly, as a form of a financial incentive, they bring extra income to a family, and I assume it has a positive effect on the TFR, based on the convention that the demand of child is often rise with income. This dynamic effect is analyzed by applying annual aggregate time series data during 1989 to 2021 to the Autoregressive Distributed (ARDL) Model, where the estimated benefit and other endogenous variables enters the right hands side of the equation, and the TFR enters the lefthand side. The empirical result suggests a positive impact of the financial incentives on the TFR; however, the impact is subtle. Some caveats of the current study are discussed at the end.

I. Introduction

Hong Kong, like many other developed economies in the world are facing a severe underpopulation problem. Its Total Fertility Rate (TFR) is among the lowest in the world and has been below the 2.1 replacement level (the minimum level required to sustain the population) for more than three decades. The persistently low fertility rate causes many adverse social issues. For one thing, the low fertility rate shrinks the working population, with less young people joining the labor force, the economy is in short of labor supply, and the economic growth slows down. On another aspect, a low fertility rate shifts the age structure of the society. As people's life expectancy becomes longer and the fertility rate of the society drops, the population on average will become older, and we have the problem of an aging society. When there are more retirees and less people working and paying taxes, both the government and households face huge financial burdens to finance the dependent. The situation aggravates when the increased public expenditure is coupled with slower economic growth caused by an aging society and threats the sustainability of the whole society.

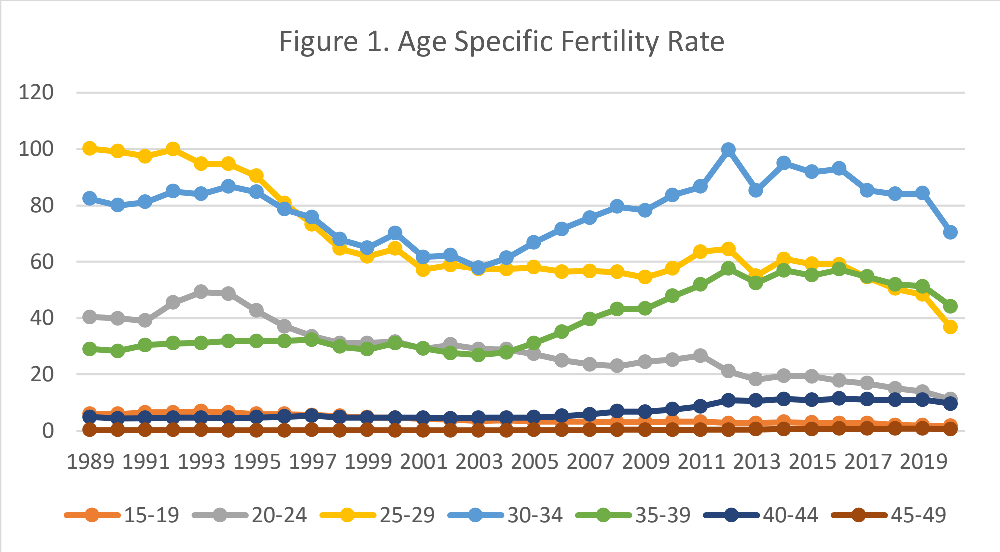
Boosting fertility rate has been the agenda of many governments across the world, and it is common to see that financial incentives have been using as a mean to encourage childbearing. Though marriage and childbearing are largely personal choices and lifestyle decisions, it is believed that some people are restrained from achieving the marriage and childbearing status they desire, because of the high costs associated with getting married and raising children. Financial support brings extra income to people who wants to get married and giving birth and as a result could bolster the aggregate fertility rate in a society.
In Hong Kong, the government has been providing tax allowances for married couples and young parents for a long time. The main objective of the tax policy is to ease the financial burden for newly married couples and provide financial incentives to give birth. During the period of my study (1989 – 2021) both the nominal and the inflation adjusted amount of these tax allowances have grown by folds, and this was coupled with the increase in TFR during the first decade in the new century. While this policy has consumed large amount of public resource, its effectiveness on boosting local fertility rate has not been analyzed.

Therefore, **the main objective of this study is to estimate the dynamic impact of the increase in tax allowances on the local TFR in Hong Kong.** And more specifically, we aim at estimating the real value of the benefit a couple could receive from these tax allowances during their lifetime and analysis whether at the aggregate level it has a significant positive impact on the TFR. Considering the effect of such benefit is often not a one-off impact and the increase in benefit in one period could also affects people's childbearing decision in the future, I applied the ARDL model to include the lagged difference terms of each interested variables into the equation to account for dynamic effects. Using the Autoregressive and Distributed Lag (ARDL) model enables me to answer two questions: **1) whether the financial incentives Granger cause**

the TFR, and **2) whether it has a long run propensity impact on TFR.** And these questions will be answered in the empirical result later in this article.

Researches on fertility at the aggregate level are usually encountered by the problems of non-stationarity and endogeneity. Variables to be included in the fertility equation, like the male and female earnings and female labour force participation are often integrated at their levels, directly applying nonstationary time series in a regression may lead to invalid results, this is also known as the spurious regression. To cope with the non-stationarity problem, I transformed the time series by including only the differenced logarithm terms and their lags of each variable into the regression, so that all the time series in the model are stationary and can be interpreted as growth rate. I also carefully implemented residual diagnostics to ensure that we are free of the auto-correlation in the residuals. As of the endogeneity problem, I included four other independent variables into the regression to control for the effect of these endogenous variables and the interpretation of Granger causality and long run propensity should not be affected much by the endogeneity problem.

It's important to know the major demographic shifts undergoing in Hong Kong in the last 33 years. These shifts are featured by three key characteristics: 1) Women are delaying marriage, according to the Census and Statistics Department The median age of women married for the first time has been increased from 26.1 in 1989 to 30.6 in 2021, this shift also reflects the shift in social norm. 2) The Age composition of women's first child has also changed dramatically. The Age Specific Fertility Rate (ASFT) shows the number of births per thousand women in seven different age groups. Although, the TFR declined over the years, the ASFR among women in the age groups of 35-39 and 40-44 has shown an upward trend over the year, indicates that women aged between 35 and 44 are having higher fertility rate than before. And the fertility rate among age groups 20-24 and 25-29 has seen most of the decline. This trend is worth noting, it indicates a major shift in the age profile of childbearing over the years. 3) The Children Dependency Ratio (CDR) has declined but the Elder Dependency Ratio (EDR) has raised drastically, while the Overall Dependency Ratio (ODR) barely changed over the years. This indicates the society's burden on financing the dependents has not changed much over the years, but more resources are used to finance the elderlies than used to raise the young. This could also be true for individual households. Figure 1 shows the change in the age profile of women's childbearing.



At last, I would like to acknowledge some caveats of the current study. First, using annual aggregate data incurs huge limitations to my study. Unable to disaggregate the data we are missing the age profile, the Total Fertility Rate only represents the total number of births during the designated year, it fails to capture in the change in age composition of childbearing women. And we also failed to identify any heteroskedasticity among our samples such as people's income and profession, these features are believed to have a huge impact on people's childbearing decisions, failing to control for these effects we cannot accurately estimate the effect of financial incentives on fertility. Any future studies should try to disaggregate the data and answer not only a yes or no question but also answers how the extra income effects people's decision does to give birth. Secondly, the method used in this paper to estimate the lifetime benefit a couple could receive from the current tax policy may overestimate the amount of it, this is discussed more in later part of the paper.

The rest of this article proceeds in the following manner: Section II is an introduction to Hong Kong's personal allowances, Section III is the theoretical hypothesis I propose, Section IV gives a brief description of the data used and runs some preliminary tests to understand the data, Section V shows the empirical results, and finally, Section VI concludes and discuss some of the limitations of the current study.

II. Tax Allowances

a. Hong Kong's personal allowances

We are interested in three specific tax allowances under the salary tax in Hong Kong, they comprised of the major component of the financial incentives that newly married couples and parents can receive from the government. The **Married Person Allowance (MPA)** is applicable for taxpayers who are legally married at the assessment year in Hong Kong, only one person of the couple can claim for this allowance, it's usually the one with the higher chargeable income to claim it, because the deducted amount will be higher. And a taxpayer can claim for the **Child Allowance (CA)** for every year and for each unmarried child he or she keeps until the child is 18, or 25 if the child receives full time education. Only one person of the couple is allowed to claim for CA. Both MPA and CA can be dated back to a long time, in 1989, the amount for MPA is 66,000 HK$, and the CA for the first child is 13,000HK$, with the second child the family can claim for another 9,000 HK$, this amount decreases further as they give birth to more children. Both MPA and CA have increased drastically over the years, in 2021, the MPA is 164,000 HK$ (three times larger) and the CA for the first child is 120,000 HK$ (grew by almost five folds).

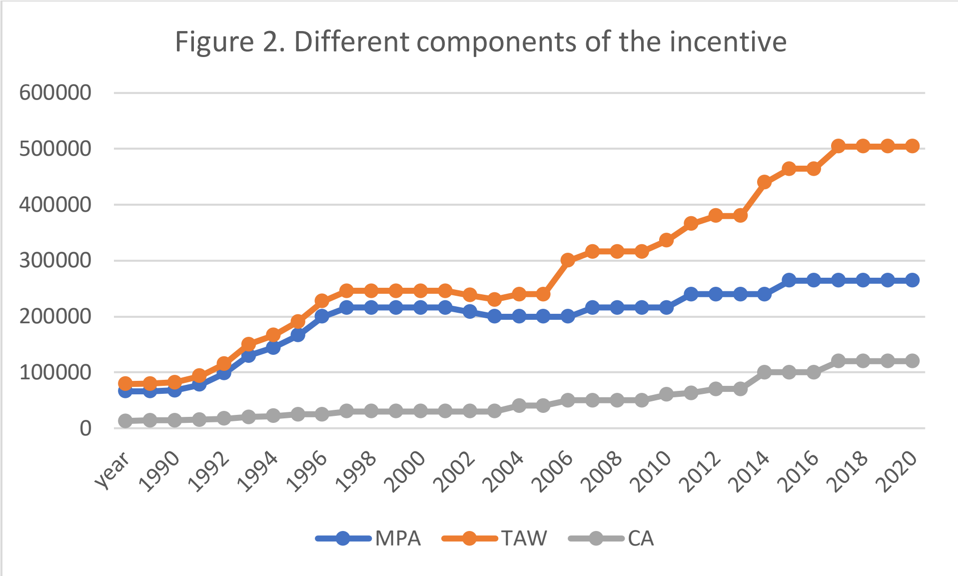
In 2007, to further ease the financial burden of families with dependent children, the government introduced the **Additional Child Allowance (ACA)** which is a one-off allowance that is only applicable at the year of giving birth. The ACA has been set to the same amount as the yearly CA since its' implementation. (GovHK, 2022) Other allowances such as single parent allowances which are not eligible for the mass population are not considered in this study.

Tax Allowance is **not the same** with cash incentives, and the amount of tax allowance is not equal to the cash equivalent of the benefit received by families, it is the amount of total income net deductions that can be exempt from the salary tax. In fact, the exact amount of cash equivalent of the allowances is very difficult to calculate. According to the GovHK official site (GovHK, 2022), The Net Income is the amount of total income net Deductions and the Net Chargeable Income of a taxpayer is equal to the Net Income net the Allowances, which means if a taxpayer's Net Income is less than the allowance amount he or she may not necessarily be able to claim the full amount of the allowances.

$$\boldsymbol{Net\ Income = Total\ Income - Deductions}$$
$$\boldsymbol{Net\ Chargeable\ Income = Net\ Income - Allowances}$$

Only the Net Chargeable Income is payable to salary tax. And the tax payable is calculated either at a progressive rate (ranges from 2% to 17%) or at a fixed rate of 15% whichever is lower. Besides this, the nominal amount of the allowances increased steadily over the years. We use TAW to represent the total amount of allowances a married couple can receive from the year they are married to the year they are having their first child; this amount has increased more than 538% over the period from 1989 to 2021. Figure 2 shows the upward climbing trend of financial incentives.

$$TAW_t = MPA_t + CA_t + ACA_t$$



b. Estimate the amount of benefits

To find the relationship between the dynamic of financial incentives and the fertility rate, we need to estimate the cash equivalent of the allowances and define new variables that can reflect the real value of the benefits. The complexity of the tax system posed a challenge to this task. As we have already discussed, the MPA and ACA are one-off allowance only applicable on the year of getting married or giving birth, however, the CA is a continuous account, applicable each year until the child is grown up. If we add a time dimension to our calculation, the total amount of benefit will depend on the family's expectation on gains in the future and the discount rate for the benefit receivable in the future. If we assume a typical family has a member who earns a Net Income higher than the Allowed amount so she can claim the full amount of the allowances, she chooses to opt for the 15% standard salary tax rate and she also expects the allowances to be maintained at the same level for the next 18 years. In this hypothesized situation, the amount of extra income the couple receives is estimated by summing the present value of all benefit receivable in the future in terms of their cash equivalent plus the benefits can be received today. This calculation is represented by:

$$PV\ of\ all\ benefit = 0.15 \times \left(\sum_{n=1}^{18} \frac{Child\ Allowances}{(1+r)^n} + MPA + CA \right)$$

Where r is the future value discount rate because the inflation is usually kept at the 2% target, we will set $r = 2\%$. This is only a rough estimation of the cash equivalent amount of benefit. In real life, people of different income may receive different amount of benefit and the above equation has also not taking the drastic increase of the allowances into account. However, it is good enough to serve as an indicator of the dynamic of the tax policy at the aggregate level. From this point and thereafter we name this newly crafted variable as **"benefit"**, looking at the dynamic of the estimated benefit, it increased by almost seven-folds during the last three decades.

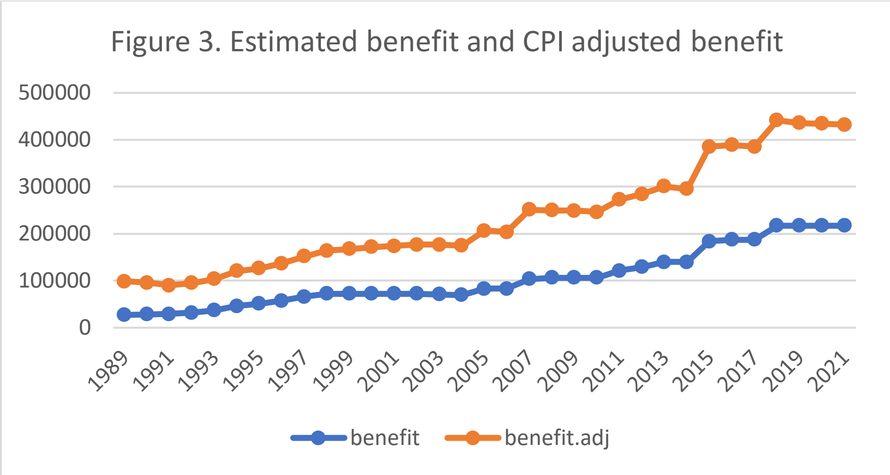
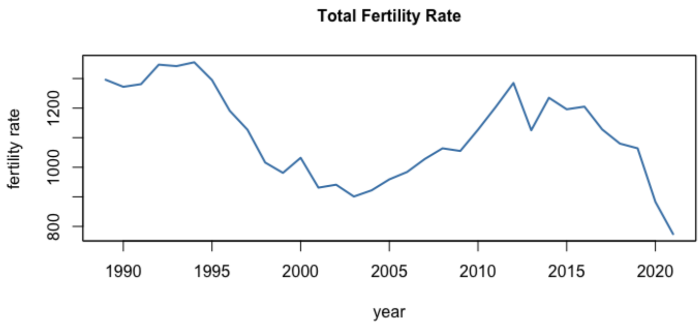
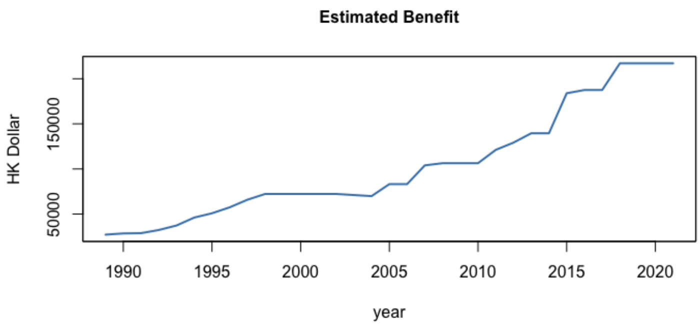


Figure 3. Estimated benefit and CPI adjusted benefit

The estimated benefit has seen a more intensive increase during the first decade of the 21st century, this coincides with the bounce back in fertility during the same period. Whether there exists a long run relationship between the benefits and fertility rate is subject to further study.





III. Hypothesis

Conventionally, children are view as normal goods, which means people tend to have more children and more incline to give birth if they have higher income, the increase in Married Person's Allowance and Child Allowance brings extra income to household if they decided to get married and giving birth, hence, people are more likely to get married and give birth if the benefit grows over time, this relationship is represented by equation (1). Housing Price also played an important role in childbearing decisions. Some recent empirical studies have found significant negative relationship between housing price and the fertility rate, the rationale behind this is that purchasing a property consumes a large portion of a family's financial resources and so is rearing children, the two consumption choices compete the limited resources. In Hong Kong, the housing price has a growth rate much higher than the GDP per Capita, plus, housing is often a prerequisite to get married and giving birth, therefore high housing prices will defer the couples' intention to give birth or postpone their childbearing plan. So, it's reasonable to presume the drastic increase in housing price in Hong Kong also has a significant negative effect on its fertility rate, this relationship is shown in equation (2).

The relationship between fertility and income is intensively discussed in relevant literature. traditional theories suggest childbearing positively related to male earning but negatively related to female earning, this is because the husband usually put in less time and effort in rearing the children than his wife. And with better employment opportunities, females have a higher opportunity cost to leave the workplace. Same reason applies with the labour force participation rate, the more developed the female labour market the less children women want to bear and we expect to see a negative relationship between the female labour force participation rate and the fertility. These relationships are represented by equation (3), (4) and (5). However, we must be aware the effect of income on childbearing could be quite complicated. In Gary Becker's famous work about fertility (Becker, 1960) he introduced a perspective that sees the childbearing decision as the families' demand on children. As there is demand, there is income elasticity for this demand, and when making the decision people faces the quality and quantity trade-off, which says, higher income may not necessarily means more children, but may be invest more financial recourses on the one child they have. This phenomenon is especially observed among the high society in the U.S.

In this paper, I introduce a new variable to account for the cost to raising children, which is the minimum allowed wage for foreign domestic helpers. Since the opening up of the domestic help market to foreign workers, Hong Kong families have hired a large number FDHs every year and they supplied a large portion of the domestic help demand for local families. Hong Kong government has been setting a Minimum allowable wage (MAW) every year so that the employers cannot pay a mount lower than the minimum wage allowed. The MAW can serve as an indicator for the dollar value cost of the housework needs to be done for rearing children. Because raising children requires a great deal of housework effort from the parents, we expect higher the cost lower the fertility rate will be, because this cost is often the mother's effort.

The relationship between total fertility rate (TFR) and other variables are showed as the following:

$$\frac{\partial TFR}{\partial Benefit} > 0 \qquad (1)$$

$$\frac{\partial TFR}{\partial HP} < 0 \qquad (2)$$

$$\frac{\partial TFR}{\partial ME} > 0 \qquad (3)$$

$$\frac{\partial TFR}{\partial FE} < 0 \qquad (4)$$

$$\frac{\partial TFR}{\partial FLFPR} < 0 \qquad (5)$$

$$\frac{\partial TFR}{\partial MAW} < 0 \qquad (6)$$

Variable Abbreviations

Independent Variable	TFR	Total fertility Rate (per thousand women)
Dependent Variable	Benefit	Estimated total benefit receivable from Child Allowances and Married Person Allowances
	HP	Housing Price Index
	FLFPR	Female Labor Force Participation Rate
	FE	Female Median Monthly Earnings
	ME	Male Median Monthly Earnings
	MAW	Minimum Allowable Wage for Foreign Domestic Helpers in Hong Kong

To sum up, the hypotheses I raise are as the following: we anticipate the estimated benefit and Male Earnings are positively related to TFR, whereas the HP inflation, Female Earnings and Female Labor Force Participation rate and the minimum wage is FDHs are negatively related to fertility rate.

IV. Data

a. Summary Statistics

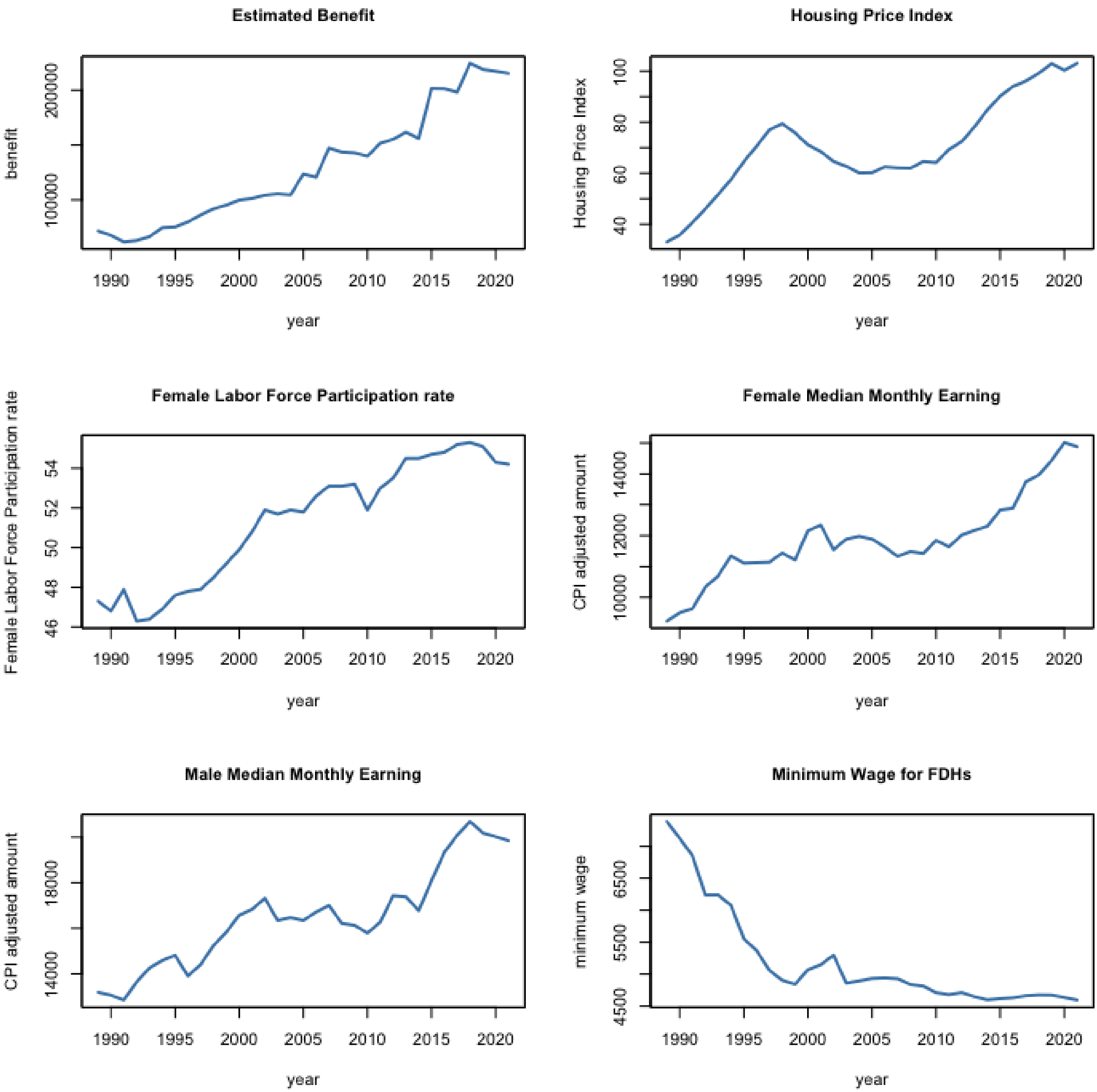
We used time series aggregate annual data in Hong Kong, from the period of 1989 to 2021. All the variables entering the model are in logarithm form, and the parameters should be interpreted as elasticities. Variables reported in nominal dollar amount in the first place such as male earnings, female earnings, the minimum allowable wage and the estimated benefit are adjusted by the CPI Composite to account for the effect of inflation over the years. The summary statistics of the transformed and adjusted series are reported in Table 1.

Table 1. Summary Statistics

Variables	Definition	N	Mean	SD	Min	Max
TFR	Total Fertility Rate	33	1109.88	154.38	774	1355
HP	Housing Price Index (=2000)	33	70.45	18.6	33.1	103
FLFPR	Female Labour Force Participation Rate	33	51.32	3.04	46.3	55.3
FE	Female Monthly Median Earning	33	9051.52	2917.63	3500	15000
ME	Male Monthly Median Earning	33	12575.76	4202.16	5000	20000
MAW	Minimum Allowable Wage for FDH	33	3759.39	475.08	2800	4630
Benefit	Estimated total benefit receivable	33	103728.01	61180.91	27180.63	217113.48

Note: all variables are aggregate data provided by government official sites.

The trajectories of the six independent variables are plotted below.



Both the estimated benefit and the housing price index have increased drastically over the years, this is consistent with our understanding, the estimated benefit enters the model is adjusted by inflation and the housing price index is calculated based on other macroeconomic indicators, so both variables can be interpreted as real value. The estimated benefit is the variable of main interest and the housing price is a major cost on giving birth. The female labour force participation rate has increased, this is largely due to the improvement of women's labour market during the same period. However, a rough look at the figure along may give us a wrong perspective on its movement, the rate has increased, but only moderately during the last three decades, from about 46% to 54%, this figure is much lower than that of the western developed countries. The CPI adjusted earnings for both Male and Female have shown upward trends during the years, as the labour market for women becomes more developed, so does female's earning, however, there still exists an income gap between the two sexes. The minimum wage for FDHs is the only variable decreases over time, part of the reason is this variable is adjusted by CPI index to account for the effect of inflation, so what the figure plotted is actually the real value of the minimum wage. The reason why this value has been declining is complicated, we will not go deeper into it. However, we still want to include this variable, because it reflects the estimated cost of the extra housework a family need to pay if they are having a baby.

By definition, a stationary time series should has a constant mean, variance and covariance over time, so that even though it fluctuates, it is still mean reverting in the long run. From visual inspection along, our time series either rose or declined quickly, none of them seems to be mean reverting over this 33 years span. Therefore our primary guess is all of them are integrated. To have a more convincing evidence on this account, we will need to run formal stationarity tests to see whether they are integrated or not.

b. Unit Root Test

To test the stationarity of our time series formally, we execute both Augmented Dicky-Fuller (ADF) test and the KPSS test on each series. The ADF test has null hypothesis of a unit root, and the KPSS test has a null hypothesis of stationary. The results of the above tests are reported in Table 2 and 3.

Table 2. ADF Tests

Type	H0	Statistics	TFR	HP	FLFPR	FE.adj	ME.adj	MAW.adj	Benefit.adj	5pct CV
No trend no drift	$\gamma=0$	$\tau1$	-1.1342	0.6653	2.1116	2.4951	1.6066	-1.8109	3.2168	-1.95
With drift no trend	$\gamma=0$	$\tau2$	-0.692	-2.2386	-1.2743	-0.7697	-1.3117	-3.7488	-0.2912	-2.93
	$\alpha\_0=\gamma=0$	$\varphi1$	0.8571	2.8762	3.1395	3.3929	2.2144	9.2783	5.1086	4.86
With trend with drift	$\gamma=0$	$\tau3$	-0.9794	-3.3933	-1.0649	-1.6312	-2.7057	-2.835	-4.0901	-3.5
	$0=\alpha\_2=\gamma=$	$\varphi2$	0.9772	4.1674	2.2656	3.0286	3.542	6.2925	10.8427	5.13
	$\alpha\_2=\gamma=0$	$\varphi3$	0.8436	5.8174	1.1037	1.3305	3.7419	7.2201	8.3727	6.73

Note: ADF test results, optimal lag length selected using "BIC" Criteria; the last column is the 5% critical value for each statistics.

For ADF tests, we run the tests with three different specifications, one with neither time trend and drift, one with only a drift term but no time trend another one with both a time trend and drift term. All the ADF tests have failed to reject to the null except the estimated benefit, which means most of our time series are integrated except the estimated benefit. To find the order of integration, we also run the ADF tests on the differences of all the above variables, only the fertility rate (TFR) and the housing price index (HP) becomes stationary after differenced twice, the other series all became stationary after differenced once.

Table 3. KPSS tests

CPI adjusted values	
Variables	P-value
TFR	0.1

HP	0.01686
FLFPR	0.01
FE	0.01
ME	0.01
MAW	0.01017
Benefit	0.01

Note: KPSS null = "Level"

The KPSS tests suggests similar results. All the time series except the fertility (TFR) are integrated at the levels, but after the first differencing, all of them have shown compelling evidence of stationary. Based on the above empirical evidence we can presume that most of our time series are integrated either by an order of one or two. The fertility (TFR) is very likely to be integrated as well, this suggests that a positive shock like providing financial incentives for married couples are very likely to have a persistent impact on fertility rate. And of course there may also exist negative shocks in the system.

c. Lag selection

The evidence from the formal stationarity tests suggests an optimal lag number of either one or two. We also employed four different information criteria and reported the results in Table 4. It suggests an optimal lag number of 3, therefore, our best guess of the optimal lag number ranges between one to three. In the rest of the empirical part of this paper we will run models with different number of lags and test on their residuals to find the model with the most accurate results.

Table 4. Optimal Lag Selection

AIC(n)	HQ(n)	SC(n)	FPE(n)
3	3	3	2

V. Empirical Results

a. Cointegration Analysis

The stationarity tests carried out earlier suggests most (if not all) of the time series in the model are following the I(1) process. We suspect the possibility of cointegration: the special relationship among I(1) series where the series are non-stationary by each of them along but together, they form an equilibrium relationship in the long run. We adopted the method of Johansen (1995) to conduct cointegration analysis. All interested variables (one dependent variable and five independent variables) are included in the system. Two approaches are applied, one using the Trace statistics another one using the Maximum Eigen Value statistics.

Table 5. The Cointegration Analysis

Johansen Test Statistics							
	Maximum Eigenvalue				Trace		
H0	H1	Statistics	5% CV	H0	H1	Statistics	5% CV
r <= 6	r > 6	7.66	9.24	r = 6	r = 7	7.66	9.24
r <= 5	r > 5	10.76	15.67	r = 5	r = 6	18.41	19.96
r <= 4	r > 4	18.46	22	r = 4	r = 5	36.87	34.91
r <= 3	r > 3	24.26	28.14	r = 3	r = 4	61.13	53.12
r <= 2	r > 2	29.44	34.4	r = 2	r = 3	90.57	76.07
r <= 1	r > 1	45.45	40.3	r = 1	r = 2	136.02	102.14
r = 0	r > 0	63.26	46.45	r = 0	r = 1	199.28	131.7

note: number of lag included is 2

Table 5 presents the results of the cointegration analysis for both Maximum Eigenvalue test and Trace test, where the r in the test hypothesis stands for the number cointegrating vectors exist in the system. The maximum eigenvalue test statistics suggest the existence of one integrating vector, whereas the results of the trace test indicate the existence of at least four integrating vector. Both the maximum eigenvalue and trace statistics provided evidence for cointegration, we may conclude that our time series have cointegration relationships which means by each series along they are non-stationary, but together their linear combination is stationary.

b. Estimating Autoregressive Distributed Lag Model

To estimate the effectiveness of the cash subsidies (estimated benefit) on raising fertility rate, we use the Autoregressive Distributed Lag Model (ARDL) to build a single equation regression where the only dependent variable is the logged fertility rate and all the other five variables in the model are included as independent variables. The independent variables are logged housing price index, logged Female labor force participation rate, logged Female earning and male earning, logged Minimum wage for FDHs, and lastly the variable of our interest, the logged estimated benefit a couple could receive until their child reaches adulthood. As previously discussed, all the independent variables are believed to have long-run impact on fertility rate, we include them into the regression to control their effects. Therefore, our most basic specification is represented as the following:

$$fert_t = \alpha_0 + \sum_{i=0}^{p} \alpha_i fert_{t-i} + \sum_{i=0}^{q} \boldsymbol{\beta_{k,i}} \boldsymbol{X_{k,t-i}} + \varepsilon_t$$

Where $fert_t$ is the dependent variable at the levels, p is the number of lags of the dependent variable included in the model and q is the number of lags included for each of the five independent variables, k is the number of regressors in this case it's 5. α_i is the coefficient for the lags of dependent variable, $\boldsymbol{\beta_{ki}}$ is a vector of coefficients of the k^{th} regressor in the $(t-1)^{th}$ lag and the $\boldsymbol{X_{t-i}}$ is a matrix of all the regressors of different lags.

The stationarity tests conducted earlier indicates that all the six variables in the model are integrated at the order of one, which means all the time series are nonstationary. Building regressions using non-stationary time series may ends up giving spurious results and invalid the whole regression, therefore we to transform our variables into stationary time series first. To avoid having spurious regression, we modify our model to include only the differenced terms of the variables. Our model becomes:

$$\Delta fert_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta fert_{t-i} + \sum_{i=0}^{q} \boldsymbol{\beta_{k,i}} \Delta \boldsymbol{X_{k,t-i}} + \varepsilon_t$$

Where $\Delta fert_t$is the differenced term of fertility rate and $\Delta \boldsymbol{X_{k,t-i}}$ is a matrix of the differenced regressors and their lagged differences. To account for the dynamic effect of the regressors on fertility rate we also included the lagged differenced terms, p is the number of lagged differences involved for the fertility rate and q is the number of lagged differences for independent variables. Please note, the value of p is started from 1, we didn't include the difference of the fertility in our model to make sure we didn't get an R-square close to one, because such situation will make the F-tests very difficult to estimate in the later stages.

According to the results of the stationarity tests, we have three choices of the number of lags (p and q) to involve, we try out three different specifications using different number of lags (p=q equals to either one, two or three) and test on the residual to find the best fitted model for our study, the differently specified models are shown below:

$$\Delta fert_t = \alpha_0 + \alpha_i \Delta fert_{t-1} + \boldsymbol{\beta_{k,i} \Delta X_{k,t-1}} + \varepsilon_t \quad \text{Eq(1)}$$

$$\Delta fert_t = \alpha_0 + \sum_{i=1}^{2} \alpha_i \Delta fert_{t-i} + \sum_{i=0}^{2} \boldsymbol{\beta_{k,i}} \Delta \boldsymbol{X_{k,t-i}} + \varepsilon_t \quad \text{Eq(2)}$$

$$\Delta fert_t = \alpha_0 + \sum_{i=1}^{3} \alpha_i \Delta fert_{t-i} + \sum_{i=1}^{3} \boldsymbol{\beta_{k,i}} \Delta \boldsymbol{X_{k,t-i}} + \varepsilon_t \quad \text{Eq(3)}$$

Where the Eq(1) only contained one difference and one lagged difference of every variable and the Eq(2) contains two lagged differenced terms, the Eq(3) contains three lagged differenced terms. We then run residual diagnostic tests on each specification for residual autocorrelation, normality and heteroskedasticity. The Durbin Watson test is used to test auto-correlation the null hypothesis is there is no autocorrelation. The

Jarque-Bera test is used to test for normality, the null indicates the residual is normally distributed. And the Breusch-Pagan test has a null against heteroskedasticity of the residual. The results are reported in Table 6.

Table 6. Residual Diagnosis

Model Specifications	Durbin Watson H0: no autocorrelation	Jarque Bera H0: normality	Breusch-Pagan H0: homoscedasticity
Eq (1):	d = 1.783 p-value: 0.2655	$\chi^2 = 0.99567$ p-value: 0.6078	$\chi^2 = 13.524$ p-value: 0.4082
Eq (2):	d = 1.9931 p-value: 0.3422	$\chi^2 = 0.958$ p-value: 0.254	$\chi^2 = 20.113$ p-value: 0.4509
Eq (3):	d = 1.9765 p-value: 2.2e-16	$\chi^2 = 1.7024$ p-value: 0.4269	$\chi^2 = 23.972$ p-value: 0.6319

Note: Both Eq(1) and Eq(2) have a residual free of autocorrelation and non-normality.

According to Table 6, both Eq(1) and Eq(2) are free of serial correlation and the nonnormality problem, this indicates our models are well fitted and we can now be much more confidence to use either Eq(1) or Eq(2) to estimate the effects. To be consistent we use Eq(1) as our benchmark model for the rest of this paper. At this point, we can execute the ARDL model and using F-test to find the overall impact of each independent regressor on fertility rate. Our hypotheses take three different forms:

$$H_0: \alpha_1 = \alpha_2 \dots = \alpha_p = 0 \qquad \text{(a)}$$

$$H_0: \beta_{k,0} = \beta_{k,1} \dots = \beta_{k,q} = 0 \qquad \text{(b)}$$

$$H_0: \beta_{k,0} + \beta_{k,1} \dots + \beta_{k,q} = 0 \qquad \text{(c)}$$

Where the null hypothesis (a) means the lagged terms of fertility rate has no effect on itself, the hypothesis (b) means the k^{th} regressor does not Granger cause the fertility rate and the hypothesis (c) means the k^{th} regressor has no long-run propensity impact on fertility. We run F-tests on all the independent variables based on all three null hypotheses listed above, and the results are reported below in Table 7.

Table7. F-test Statistics

the dependent variable is log(fertility)			
Equations	(a)	(b)	(c)
independent variables:			
$\Delta\ln(fert)$	0.3334 0.5712	- -	- -
$\Delta\ln(benefit)$	- -	0.3124 (0.74)	0.0232 (0.88)
$\Delta\ln(HP)$	- -	1.746 (0.20)	0.8969 (0.36)
$\Delta\ln(FLFPR)$	- -	1.2572 (0.31)	0.0136 (0.91)
$\Delta\ln(FE)$	-	1.3795	2.4052

	-	(0.28)	(0.14)
$\Delta\ln(ME)$	-	0.8034	0.5508
	-	(0.46)	(0.47)
$\Delta\ln(MAW)$	-	1.8041	0.5198
	-	(0.19)	(0.48)

Note: (a), (b) and (c) corresponds to three different null hypotheses of the F-test.

The results in Table 7 indicate we are failed to reject all the F-tests hypotheses, which suggests none of independent variable Granger causes the fertility rate to change, and the there is no significant long-run propensity impact on fertility either. However, we can hardly conclude that cash benefit has no impact on fertility rate. As at the present, young couples are longed for some form of financial support.

There are some possible reasons for the insignificant results. First, using aggregate data we fail to capture heterogenous effects among mothers. People in different age groups, income levels, and professions may have very different intention to give birth, without controlling for these effects our estimation may be biased. And there are also the possibility of overestimating the actual amount of benefit a couple could receive in their lifetime, which may lead to underestimation of the effect of financial incentive. Any further study in this topic should make the effort to disaggregate the data, so more can be interpreted from the analysis.

VI. Conclusion

The primary task of this paper is to identify the dynamic impact of financial incentives in the form of three specific tax allowances in Hong Kong on the local TFR. To do this, I applied annual aggregate data between the year 1989 and 2021 and run an Autoregressive Distributed Lag (ARDL) Model where the lagged difference terms of each variable are included to account for the dynamic effect. In the single equation ARDL model the TFR is the dependent variable and the estimated benefit, housing price, male and female earnings, female labor force participation and the minimum wage for FDHs are included as independent variables, all the variables are in logarithm so their differenced terms can be interpreted as growth rate. The empirical evidence shows that the financial incentive is positively related to the TFR however the effect is not significant. The insignificant effect cannot just conclude that financial incentive is useless in boosting fertility as our model used aggregate data, we missed out many heterogenous effect,

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