House prices and fertility in South Africa: A spatial econometric analysis

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21 May 2020

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Abstract. In this paper, the effect of house prices on fertility is analysed across South African provinces using spatial Durbin model. This approach assumes spatial linkages through both endogenous and exogenous variables while allowing the total housing effect on fertility to be decomposed into direct and indirect effects. Empirical results using provincial annual data from 1998 to 2015 indicate that housing market plays an important role in the fertility decision besides female job participation and labour market condition. Particularly, an increase in regional house prices results in a decrease in local and subsequently national fertility rate. However, the spillover effect to adjacent provinces appears to be positive and significant, except in the small housing segment; suggesting that an increase in regional house prices will spur fertility in other regions. Intuitively, house price inflation in a province makes housing relatively affordable in adjacent regions; housing affordability being an important driver of fertility. Alternatively, this positive effect might also capture the income effect felt by homeowners following a rise in house prices, which might in turn be favourable to fertility due to financial edge. The insignificant indirect effect from the small housing segment might reflect the fact that small houses are less likely to be the family residential choice. These findings confirm the importance of spatiotemporal economic behavior in shaping regional fertility in South Africa.

Keywords. House prices, fertility, spatial panel

JEL classification. C23, J13, R31

1- Introduction

Literature abounds on how macroeconomic and financial variables interact with housing prices. For example, Cho (2011) investigates the effect of house price changes on consumption using household level data from Korea. Empirical results show that housing price do not affect total household consumption in Korea. According to the author, this neutral effect is explained by the fact that a positive wealth effect of homeowners, associated with the increase in home prices, is offset by a negative wealth effect of non-homeowners related to high rental cost. Still on the importance of housing price on consumption, Dong at al. (2017) show that the effects of housing price on consumption in 35 major cities in china are asymmetric in that the wealth effect and the substitution effect depend on a specific threshold determined by the housing prices. Moreover, many studies have alluded to the interaction between housing price and monetary policy stance. For example, Amador-Torres et al. (2018) assess the determinants of housing price bubbles' duration for a set of OECD countries between 1970 and 2015. The authors show that a prolonged domestic monetary policy easing increase the duration of housing price bubbles and the tightening of monetary policy contributes in accelerating the termination of a housing bubble in OECD countries. Hui et al. (2016) assess the relationship between housing price and mortgage lending in two housing sub-market of Hong Kong by distinguishing between mass housing market and the luxury housing market. The authors find a one-way relationship in that both types of housing markets affect mortgage lending, while the change in mortgage lending has no effect in the housing market in Hong-Kong.

However, there are limited studies that relate the housing market and demographic-related variables, such as fertility. Clark and Ferrer (2019) assess the effect of housing price on fertility in Canada by combining longitudinal data from the Canadian Survey of Labour Income Dynamics (SLID) with housing price data from the Canadian Real Estate Association. For the authors, the rationale of the relationship between house price and fertility is supported by the fact that higher housing prices may lead homeowners to desire more children, especially if they have low substitution between children and other goods in their utility function. Nonetheless, high housing prices might negatively affect the fertility decision of renters for the same reason. The empirical results show that lagged housing prices have a positive effect on marginal fertility for homeowners. However, for renters the authors find no significant effects. Mizutoni (2015) attempts to evaluate empirically how household resources, especially housing wealth, affect fertility decision in Japan. Making use of data from the Japanese Panel Survey of Consumers, the author finds that an increase in home value increases the possibility of homeowners with housing loans to bear a child. However, for homeowner without housing loans and renters, the change in housing wealth has no effect on fertility decision. Lin et al. (2016) assess how various housing options impact on fertility decision in Taiwan. These options include renting, owning, living with parents or siblings, living in house bought by parents and living in staff housing. Making use of micro-data obtained from the Taiwanese Panel Study of Family Dynamics (PSFD), the authors find that homeowners have their first child at an old age and families living with their siblings bear their first child at a younger age.

While many studies on the housing price and fertility nexus focus on how different characteristics of housing homeownership affect fertility decisions, none of the studies on this topic have addressed the issues of spatial interaction and structure in housing prices and their effects on fertility decisions. A number of studies discuss the diffusion effects of housing prices by assessing how shocks in one region may spread to neighbouring regions. For example, in assessing the relationship between housing price and economic growth, Simo-Kengne et al. (2012) show that spatial effects are highly important in the South African housing markets and they need to be taken into account when assessing the link between housing price and economic growth at provincial or regional level. Moreover, geo-statistical spatiotemporal methods have recently been documented to be useful for modeling fertility dynamics (De Iaco et al., 2015). This indicates that spatial dependence is indeed an important characteristic of the data generating process of fertility evolution. Another shortcoming in the literature on the link between housing prices and fertility reside on the coverage of past studies. While fertility issues are important in the African continent, none of the past studies endeavour to assess how housing prices affect fertility in the continent. In order to remedy these shortcomings, this paper contributes to the literature on housing price and fertility nexus in three ways. Firstly, the paper accounts for spatial interaction between different locations and potential endogeneity that may arise from simultaneity, measurement errors and omission bias. To this end, use is made of the lagged-regressors identification strategy based on spatial econometrics (see Islama, et al., 2019). Secondly, the paper disaggregates a specific segment of housings into different sections, i.e., the middle housing segment, which is the focus of this study, is subdivided into three different sections: the large-middle section (221 square meters–400 square meters), the medium middle section (141 square meters–220 square meters), and the small-middle section (80 square meters–140 square meters). Thirdly, this is the first paper, to the best of our knowledge, which focuses on the issue of housing price and fertility in the African continent, especially in South Africa. Studies show that fertility stalls in Sub-Saharan African are not widespread compared to other continents (see Schoumaker, 2019). Thus, it is important to analyse the contribution of housing prices in determining fertility decision in Africa.

This paper will focus on South Africa by assessing how the interaction between the different provinces of the country contributes to the relationship between house prices and fertility. The choice of South Africa is important given the high development of its property market compared to other Sub-Saharan African countries. South Africa's residential property market is the largest section of the South African property market, comprising the majority of property assets within the country and an important component of household wealth. CAHFA (2015) show that the growth of residential property value outpaces interest on savings, salary increases, and most businesses, and that homeownership is among the most powerful ways for wealth creation in South Africa.

The remainder of the paper is structured as follows; section 2 discusses the spatial process in the context of fertility-housing nexus, section 3 presents the methodology and the data used in the paper, section 4 presents the estimation and discuss the main results and section 5 concludes the paper.

3. Methodology and data

Assuming that fertility and house prices are geospatial stochastic processes. This may lead to the following general specification:

$$TFR_{it} = \rho WTFR_{it} + \beta X_{it} + \gamma WX_{it} + \theta Wu_{it} + \varepsilon_{it} \quad (1)$$

where TFR is the fertility variables proxied by the total fertility rate, X is the vector of covariates including female labour force participation (FLFP), real wage (RW) and the real house price of the entire middle segment (EHP), the large middle (LHP), the medium middle (MHP) or the small middle (SHP). The subscripts *i* and *t* denote provinces of South Africa and time dimension, respectively. Three nested scenarios can be obtained from Equation (1). W represents the weight matrix.

When$\theta = 0$, Equation (1) becomes a Spatial Durbin Model (SDM)[1] with the following specification:

$$TFR_{it} = \rho WTFR_{it} + \beta X_{it} + \gamma WX_{it} + \varepsilon_{it} \quad (2)$$

Unlike binary weights, our study uses the distance weight based on the assumption that regions that do not share border might exhibit spatial dependence based on their geographical coordinates. Accordingly, the distance weight is defined as:

$$W_{ij} = \begin{cases} \frac{1}{d_{ij}} & if\ i \neq j \\ 0 & if\ i = j \end{cases} \quad (3)$$

with d_{ij} representing the distance between the geographical centers of both regions i and j.

Besides the benefits of the traditional panel techniques, the major attraction of the considered models lies on their ability to control for spatial dependence, which is assumed prevalent in characterizing the fertility-housing nexus. In fact, because of internal migration, individuals with different levels of fertility appetite might migrate from one region to another; thus affecting the fertility rate of both the origin and the destination regions. Likewise, individuals' decision to relocate might be prompted by regional dissimilarities in fertility drivers such as labour market conditions and socioeconomic characteristics. This leads to the conjecture that spatial interaction, if any, affecting the fertility-housing nexus may originate from the fertility and/or its determinants (known and unknown). Of central interest

[1] Besides the classical SDM, a Spatial Durbin Error Model (SDEM) exists, that nests the spatial interaction from exogenous variables and the error term.

is the housing determinant of fertility and this study hypothesizes and tests the indirect effect of housing prompted by migration on provincial fertility rate. In other words, house price variations in one province might affect interprovincial fertility rate.

From the statistics perspective, the overall scenario of fertility changes at the interregional level is referred to as global spatial autocorrelation and investigated using the Global Moran's I index. This global spatial autocorrelation test uses a spatial matrix to analyse the similarity between units in each province and adjacent provinces (Griffith, and Anselin, 1989).

If W is the spatial weight matrix, Moran's I is computed as follow:

$$Moran's\ I = N \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}\,(x_i-\bar{x})(x_j-\bar{x})}{\sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}\ \sum_{i=1}^{N}(x_i-\bar{x})^2} = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}\,(x_i-\bar{x})(x_j-\bar{x})}{\sigma^2 \sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}} \quad (4)$$

where $\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$ and $\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2$ are respectively the mean and the variance of the observations across provinces. x_i and x_j denote the observations in ith and jth spatial unit, respectively. N is the number of Provinces. Moran's I Index ranges between [-1, 1] with the high (low) value indicating the strong (weak) group. If Moran's I >0, there is a positive spatial autocorrelation indicating that a high (low) value unit is adjacent to high (low) value unit. Similarly in the presence of a negative spatial autocorrelation, a high (low) value unit is adjacent to low (high) value unit. Finally, when Moran's I=0, there is no spatial autocorrelation.

The significance of the spatial autocorrelation index is given by the standardized statistics given by:

$$Z = \frac{I-E(I)}{\sqrt{V(I)}} \quad (5)$$

where I is the Moran's I; $E(I)$ and $V(I)$ denoting the mean and the variance of the Moran's I, respectively. At the conventional level of significance (5%), the spatial autocorrelation is significant if $|Z| > 1.96$.

Based on the availability of provincial data for all the variables understudied, the empirical investigation covers the sample period from 1998 to 2015 for the nine (9) South African provinces. Apart from the fertility, all the variables were obtained through Quantec Easy Data. House prices data are compiled by the Allied Bank of South Africa (ABSA), which classifies housing into three main segments depending on the price: the luxury segment (ZAR 3.5 million–ZAR 12.8 million), the middle segment (ZAR 480,000–ZAR 3.5 million), and the affordable segment (below ZAR 480,000 and area between 40 square meters–79 square meters). This study analyses the middle housing segment, as regional data are not available for the luxury and affordable categories. In addition the middle housing segment is grouped into three more sections depending on the size: the large-middle section (221 square meters–400 square meters), the medium middle section (141 square meters–220 square meters), and the small-middle section (80 square meters–140 square meters). This makes it possible a disaggregated analysis of the middle house prices in relation to fertility.

While the regional fertility data is not available in South Africa, the authors make use of the regional birth registration data to approximate the total fertility using the formula: $TFR = 5 \sum ASFR\ a$ (for 5-year age groups) where ASFRa = age-specific fertility rate for women in age group *a* (approximated by the ratio number of live birth/number of women).

Table 1. Summary statistics

Panel A. Descriptive statistics					
	Obs	Mean	Std. Dev.	Min	Max
TFR	162	1.2214	0.32	0.67	2.06
AHP	162	14.63	0.64	13.37	15.65
LHP	162	14.95	0.68	13.60	16.00
MHP	162	14.56	0.66	13.27	15.60
SHP	162	14.27	0.62	13.04	15.31
FLFP	162	3.80	0.20	3.37	4.17
RW	162	11.39	0.82	9.71	13.25

Panel B. Panel Unit root test			
	Fisher test based on ADF test	IPS test	Decision
TFR	31.166**	-1.49*	I(0)
AHP	77.387***	-2.972***	I(0)
LHP	76.252	-2.862***	I(0)
MHP	74.602***	-2.728***	I(0)
SHP	27.815*	-1.971**	I(0)
FLFP	61.740***	-1.529*	I(0)
RW	44.007***	-1.306*	I(0)

Panel C. Spatial detection test			
	Global spatial autocorrelation (Global Moran MI and Robust LM test)	Spatial dependence (Pesaran CD test)	Serial autocorrelation (Wooldridge F-test)
Entire middle housing	Global Moran MI=-0.169*** Robust LM=33.241***	9.796***	28.166***
Large-middle housing	Global Moran MI=-0.162*** Robust LM=33.36***	9.347***	29.695***
Medium-middle housing	Global Moran MI=-0.168*** Robust LM=33.49***	9.179***	26.446***
Small-middle housing	Global Moran MI=-0.17*** Robust LM=28.03***	9.461 ***	27.030***

Note. The variables are all in their logarithm forms. *** p<0.01, ** p<0.05, * p<0.1. If the general global spatial autocorrelation can well be detected using the Moran's I, it is unlikely to depict the source of spatial connection, which can occur through observed (spatial lag model) and unobserved variable (spatial error model). To complement MI, the robust-LM test is provided, which is robust in the presence of spatial lag models or spatial error models.

As summarized in Table 1, the regional average real house prices in log form ranges from 14.27 to 14.95 across housing categories while the standard deviation is about 0.6, suggesting that the prices of housing in the middle segment are very close to each other. In addition, the average total fertility rate is 1.2214 in log form; that is about 3 children over the sample period consistently with the average national TFR of 2.61 over the same sample period based on fertility data extracted from the Federal Reserves of St Louis database. This implies a minimum computation bias in our regional TFR, which is thus, believed to be of marginal impact on the empirical results.

The stationary property of the variables is worth noting. This is important as it determines the appropriateness of the estimation techniques. Panel B of Table 1 displays the panel unit root test results and all the variables appear to be stationary, that is I(0) based on Fisher type panel unit root test.

Finally, the spatial diagnostic tests provided in Panel C (Table 1) confirm the presence of global autocorrelation. The Moran's I index is statistically significant and negative across the different housing segment considered indicating that province with high house price index is adjacent with low house price index province and vice versa. This is quite intuitive as individuals are likely to move from high (low) house price region to low (high) ones. In addition, the robust LM test result is favourable to the existence of spatial autocorrelation whether from spatial lag origin or from spatial error cause. Given that spatial autocorrelation implies dependence across spatial units as well as serial autocorrelation, the Pesaran CD test of cross sectional dependence and the Wooldridge F-test of serial correlation could not reject this assumption. It appears that provinces exhibit a strong dependence to each other with significant serial autocorrelation of errors, at least for the first order.

4. Empirical results

The baseline outputs from non-spatial regressions are provided in Table 2 and indicate a negative effect of house prices on fertility rates. It emerges that the endogeneity bias is downward sloping as the estimates become greater in absolute values once endogeneity is controlled for while the goodness of fit tends to improve with controlling for endogeneity. Similarly, the heterogeneity bias appears to be downward sloping when endogeneity is accounted for (although upward sloping when endogeneity is ignored). These results remain informative and point to the imperative to control for endogeneity and heterogeneity.

Besides endogeneity, the use of SDM to analyze the impact of house prices on fertility rate is reasonable as the spatial autoregression coefficients are all significant. As displayed in Table 3, these coefficients are 0.235, 0.278, 0.341 and 0.221 for the entire middle housing segment, the large middle housing segment, the medium middle housing segment and the small middle housing segment, respectively. They are all positive and indicate that fertility rate of adjacent provinces have positive impact on local fertility rate. Therefore, a decrease in one percentage point in fertility rate in adjacent provinces leads to a decrease in local fertility rate by 0.235, 0.278, 0.341 and 0.221 percentage point, respectively across housing segments.

According to LeSage and Pace (2009), the correct spatial spillover effects of variables should be explained in terms of direct and indirect effects as the significance of the coefficent estimates cannot compare between non-spatial and spatial models. Table 4 displays the marginal effects decomposed into direct, indirects and total effects of explanatory variables on fertility rate. In line with the non-spatial estimates which substantiate the imperative to control for endogeneity, the endogeneity based output is preferred (that is estimates “with endogeneity”).

Starting from the house prices, the direct and total effects are negative and significant across housing categories. The increase in regional house prices will result in a decrease in the local and eventually national fertility rate. Therefore, 1 percent increase in provincial house prices from the entire middle, large middle, medium middle and small middle housing segments will dampen the local fertility rate by 0.733, 0.731, 0.732 and 0.71 percentage point, respectively. This single percentage point increase in house prices across different segments will further translate into a decline in the national fertility rate by 0.52, 0.514, 0.491 and 0.514 percentage point, respectively.

However, the indirect effect of house prices is positive across housing segments and significant except in the small middle housing. This implies that the increase in regional house prices will significantly rise fertility rate in adjacent regions. This is unsurprising since house price inflation in one province makes housing relatively affordable in adjacent regions; housing affordability being an important driver of fertility (Clark, 2012). Alternatively, this positive effect migt also capture the income effect felt by homeowners following a rise in house prices, which in turn encourages more babies as income increases. The indirect effect of house prices on fertility appears insignificant for the small middle housing segment; possibly due to its reduce size and hence its limited impact on fertility decision given that large size families are less likely to settle in small sized houses.

Table 2. Non-spatial estimates of house prices on fertility across South African provinces

	Entire Middle Housing Segment		Middle Large Housing Segment		Middle Medium Housing Segment		Middle Small Housing Segment	
	Without Endogeneity	With Endogeneity	Without Endogeneity	With Endogeneity	Without Endogeneity	With Endogeneity	Without Endogeneity	With Endogeneity
Panel A: Pooled regression with robust standard errors								
house price	-0.167***	-0.280***	-0.161***	-0.265***	-0.159***	-0.264***	-2.326***	-0.279***
	(0.0247)	(0.0287)	(0.0229)	(0.0272)	(0.0236)	(0.0276)	(0.366)	(0.0288)
Female labour force participation rate	-2.493***	-0.766***	-2.519***		-2.532***	-0.779***	-2.418***	-0.741***
	(0.280)	(0.0841)	(0.275)	(0.0838)	(0.276)	(0.0845)	(0.286)	(0.0844)
Real wage	-0.220	0.0422*	-0.176	0.0485**	-0.230	0.0411*	-0.335	0.0269
	(0.211)	(0.0234)	(0.211)	(0.0237)	(0.212)	(0.0238)	(0.210)	(0.0231)
Intercept	6.471***	7.636***	6.363***	7.463***	6.424***	7.452***	10.39***	7.597***
	(0.504)	(0.437)	(0.495)	(0.426)	(0.502)	(0.423)	(0.906)	(0.426)
Observations	162	117	162	117	162	117	162	117
R-squared	0.553	0.720	0.556	0.720	0.549	0.716	0.542	0.716
Panel B: Fixed effect Estimates								
Real house price	-0.0203	-0.364***	-0.0356	-0.344***	-0.0189	-0.354***	-0.0812	-0.366***
	(0.0663)	(0.0474)	(0.0512)	(0.0381)	(0.0591)	(0.0492)	(0.886)	(0.0592)
Female labour force participation rate	1.142	0.0125	1.267	0.0184	1.139	0.0206	1.044	-0.0487
	(0.768)	(0.599)	(0.716)	(0.571)	(0.733)	(0.615)	(0.785)	(0.627)
Real wage	-7.904**	0.429	-7.228**	0.397	-7.945**	0.461	-8.504**	0.448
	(3.226)	(0.449)	(3.019)	(0.409)	(3.113)	(0.464)	(2.738)	(0.483)
Intercept	18.15**	1.504	16.57**	1.662	18.23**	0.944	19.66***	1.426
	(7.453)	(6.574)	(7.018)	(6.092)	(7.198)	(6.763)	(5.683)	(6.992)
Observations	*162*	*117*	*162*	*117*	*162*	*117*	*162*	*117*
R-squared	*0486*	*0.616*	*0.488*	*0.620*	*0.486*	*0.614*	*0.485*	*0.605*
Heterogeneity F-test	*16.07 (Pr=0.000)*	*2.19 (Pr=0.034)*	*15.65 (Pr=0.000)*	*2.39 (Pr=0.021)*	*15.27 (Pr=0.000)*	*2.36 (Pr=0.023)*	*15.36 (Pr=0.000)*	*1.97 (Pr=0.058)*
Hausman test	*50.36 (Pr=0.000)*	*10.73(Pr=0.013)*	*46.39 (Pr=0.000)*	*10.10(Pr=0.018)*	*46.73 (Pr=0.000)*	*10.00(Pr=0.019)*	*48.06 (Pr=0.000)*	*8.03(Pr=0.045)*

Note. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The endogenous results are based on the regression of fertility variables from 2003 to 2015 on exogenous variables from 1998 to 2010.

Table 3: SDM estimates explaining the fertility rate across housing segments

	Total middle housing segment		*Large middle housing segment*		*Medium middle housing segment*		*Small middle housing segment*	
	Without Endogeneity	With Endogeneity	Without Endogeneity	With Endogeneity	Without Endogeneity	With Endogeneity	Without Endogeneity	With Endogeneity
Real house price	-0.179	-0.742***	-0.263**	-0.741***	-0.194*	-0.744***	-1.582	-0.718***
	(0.114)	(0.0586)	(0.115)	(0.0607)	(0.111)	(0.0505)	(1.568)	(0.0666)
Female Labour participation	0.813	-0.878**	1.083*	-0.759**	0.900*	-0.869**	0.727	-1.004**
	(0.540)	(0.434)	(0.558)	(0.370)	(0.537)	(0.415)	(0.517)	(0.488)
Real wage	-1.496	0.923***	-0.0342	0.789***	-0.786	1.015***	-2.868	1.014***
	(2.102)	(0.190)	(2.237)	(0.215)	(2.532)	(0.202)	(1.838)	(0.175)
W*Real house price	0.377***	0.424***	0.459***	0.450***	0.377***	0.508***	4.105**	0.397***
	(0.124)	(0.133)	(0.126)	(0.129)	(0.128)	(0.110)	(1.719)	(0.148)
W*Female Labour participation	-0.887	1.942***	-1.111	1.800***	-0.891	1.790***	-0.654	1.998***
	(1.219)	(0.630)	(1.199)	(0.541)	(1.253)	(0.627)	(1.171)	(0.660)
W*Real wage	-18.58***	0.0314	-19.06***	0.256	-18.63***	-0.266	-16.81***	-0.123
	(3.460)	(0.437)	(3.418)	(0.450)	(3.678)	(0.437)	(3.208)	(0.529)
Rho	-0.145	0.235**	-0.0845	0.278***	-0.130	0.341***	-0.188	0.227**
	(0.209)	(0.0925)	(0.198)	(0.108)	(0.207)	(0.0975)	(0.220)	(0.105)
Sigma	0.0136***	0.0138***	0.0132***	0.0130***	0.0136***	0.0133***	0.0138***	0.0146***
	(0.00200)	(0.00388)	(0.00200)	(0.00369)	(0.00196)	(0.00369)	(0.00206)	(0.00411)
Hausman	*195.37(Pr=0.000)*	*35.56(Pr=0.000)*	*139.28(Pr=0.000)*	*72.94(Pr=0.000)*	*406.66(Pr=0.000)*	*25.22(Pr=0.000)*	*64.99(Pr=0.000)*	*147.00(Pr=0.000)*

Note**.** Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. the figures displayed are fixed effect version of the SDM as the Husman test rejects the suitability of random effect alternative.

Table 4: Marginal effects of house prices on fertility rate across housing segments

	Total middle housing segment		***Large middle housing segment***		***Medium middle housing segment***		***Small middle housing segment***	
	Without Endogeneity	With Endogeneity	Without Endogeneity	With Endogeneity	Without Endogeneity	With Endogeneity	Without Endogeneity	With Endogeneity
Panel A: Direct effect of house prices on fertility rate								
Real house price	-0.179	-0.733***	-0.262**	-0.731***	-0.194*	-0.732***	-1.586	-0.710***
	(0.117)	(0.0576)	(0.117)	(0.0593)	(0.114)	(0.0503)	(1.617)	(0.0658)
Female Labour participation	0.806	-0.846**	1.071*	-0.719**	0.893*	-0.818**	0.721	-0.975**
	(0.541)	(0.405)	(0.561)	(0.344)	(0.541)	(0.383)	(0.517)	(0.453)
Real wage	-1.157	0.948***	0.212	0.821***	-0.474	1.038***	-2.495	1.035***
	(1.940)	(0.192)	(2.066)	(0.222)	(2.416)	(0.211)	(1.642)	(0.173)
Panel B: Indirect or spatial spillover effects of house prices on fertility rate								
Real house price	0.274***	0.213*	0.341***	0.217**	0.276***	0.241**	2.900**	0.196
	(0.101)	(0.115)	(0.102)	(0.100)	(0.103)	(0.107)	(1.419)	(0.141)
Female Labour participation	-0.563	1.632***	-0.734	1.552***	-0.571	1.552***	-0.399	1.650***
	(0.893)	(0.473)	(0.915)	(0.413)	(0.933)	(0.485)	(0.848)	(0.507)
Real wage	-12.78***	0.302	-13.76***	0.529	-13.01***	0.165	-11.09***	0.175
	(1.890)	(0.438)	(2.078)	(0.435)	(2.352)	(0.500)	(1.776)	(0.522)
Panel B: Total effects of house prices on fertility rate								
Real house price	0.0945***	-0.520***	0.0788**	-0.514***	0.0825**	-0.491***	1.314***	-0.514***
	(0.0360)	(0.0957)	(0.0365)	(0.0972)	(0.0346)	(0.109)	(0.456)	(0.102)
Female Labour participation	0.243	0.786***	0.337	0.833***	0.322	0.734**	0.322	0.674**
	(0.932)	(0.281)	(0.933)	(0.285)	(0.971)	(0.338)	(0.923)	(0.285)
Real wage	-13.93***	1.250**	-13.55***	1.351**	-13.48***	1.202*	-13.59***	1.210**
	(1.415)	(0.550)	(1.519)	(0.565)	(1.351)	(0.647)	(1.147)	(0.576)

Note**.** Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Similar to house prices, female labour force participation has both positive and negative effect. Its direct effect is negative and significant across housing segment, confirming the well documented trade-off between female employment and making babies. Accordingly, the increase in regional female work participation will reduce the fertility rate in the local area. On the other hand, the indirect and total effects are positive and significant consistently to the income effect of female labour participation. The increase of female worker in one province will increase the fertility rate in adjacent regions and subsequently the national fertility rate.

Finally, the real wage exhibits a mixed effect on fertility rate. The direct and total effects are positive and significant; implying that increasing regional real wage has the potential to stimulate regional and eventually national fertility rate because of the income effect. The richer women become, the more likely they are to increase the family size given the financial edge. However, though positive, the indirect effect of real wage on fertility is found to be insignificant. This suggests no spillover effect from one region to adjacent areas.

Overall, besides female job participation as well as labour market conditions, housing market exhibits a robust effect on fertility decision. Moreover, the association between regional fertility and these variables is subject to a number of econometric issues, namely heterogeneity, endogeneity and spatial dependence. Expectedly, house price inflation deters fertility although it might induce possible income effect from female homeowners. However, this income effect cannot be measured given the lack of data on home ownership by gender; at least at the provincial level.

5. Conclusion

This paper uses annual panel data for 9 provinces from 1998 to 2015 to investigate the housing effect of regional fertility in South Africa. The analysis focuses on middle housing segments and its subcategories given the availability of regional house price data. When heterogeneity, endogeneity and spatial dependence are controlled for, the empirical results from spatial Durbin model show negative and significant direct and total effects of house prices on regional fertility rate. Consistent across housing categories, these results imply that the increase in provincial house prices will lead to the decline in the local and subsequently national fertility rate. However, the indirect housing effects are positive and significant; suggesting positive spillover effects to adjacent geographical areas following an increase in regional house prices.

Besides housing markets, the negative and significant direct marginal effects and the positive and significant indirect marginal effects, respectively evidence the trade-off as well as the income effects of female job participation on fertility decision. The positive and significant direct and total marginal effects of real wage on fertility rate further confirm the income effect. These findings highlight the crucial role of spatiotemporal economic behavior in shaping regional fertility in South Africa. However, the spatial interactions assumed to channel through dependent and independent variables in the SDM may occur through alternative channels such as errors and individual or time heterogeneities. Therefore, our paper offers a benchmarking framework against which housing effects of regional fertility from alternative spatial specifications can compare. These can eventually be addressed in future research.

References

Amador-Torres, J.S. ; Gomes-Gonzales, J.E. and Sanin-Restrepo, S. (2018). " Determinants of housing bubbles'duration in OECD countries". *International Finance 21(2): 140-157*

Apergis, N., Simo-Kengne B.D. and Gupta, R. 2015. "Convergence in provincial-level South African house prices: Evidence from the Club convergence and clustering procedure." *Review of Urban and Regional Development Studies* 27 (1): 2-17.

Basu, S., and Thibodeau, T.G. 1998. ". Analysis of spatial autocorrelation in house prices." *Journal of Real Estate Finance and Economics* 17 (1): 61–85.

Clark, W.A.V. 2012. "Do women delay family formation in expensive housing markets?" *Demographic Research* 27 (1): 1–24.

Clark, J. and Ferrer, A. (2019). "The effect of house prices on fertility: Evidence from Canada," *Economics - The Open-Access, Open-Assessment E-Journal 13(1): 1-32.*

Cohen, J.P. and Coughlin, C.C. 2008. "Spatial hedonic models of airport noise, proximity and housing prices. ." *Journal of Regional Sciences* 48 (5): 859–878.

De Iaco, S., Palma, M. and Posa, D. 2015. "Spatio-temporal geostatistical modeling for French fertility predictions." *Spatial Statistics* 14: 546–562.

DeSilva, S., Pham, A. and Smith, M. 2012. "Racial and ethnic price differentials in a small urban housing market." *Housing Policy Debate* 22 (2): 241–269.

Dong, Z.; Hui, E.C.M and Jia, S. (2017). "How does housing price effect consumption in China: wealth effect or substitution effect? Cities 64(1): 1-8

Fernández-Avilés, G., Minguez, R. and Montero, J.-M. . 2012. " Geostatistical air pollution indexes in spatial hedonic models: the case of Madrid, Spain." *Journal of Real Estate Research* 34 (2): 243–274.

Griffith, D.A. and Anselin, L. 1989. "Spatial econometrics: methods and models." *Economic Geography* 65 (2): 160.

Hui, E.C.M. and Ng, I.M.N. (2016). "Access to mortgage credit and housing price dynamics". *International Journal of Strategic Property Management, 20(1): 64-76*

Islama, Md. R., Madsena, J.B. and Doucouliagosb, H. 2019. "Does inequality constrain the power to tax? Evidence from the OECD." *European Journal of Political Economy* 52: 1-17.

Kamata, K. 2016. " Diffusion process of fertility transition in Japan: regional analysis using spatial panel econometric model." Mainz, Germany: European Population Conference.

LeSage, J.P. and Pace, R.K. . 2009. *Introduction to Spatial Econometrics.* Boca Raton.: CRC Press Taylor & Francis Group.

Lin, P.S ; Chang, C.O and Foo Sing, T. (2016). "Do housing options affect child birth decision?: Evidence from Taiwan". *Urban Studies, 55(16): 3527-3546*

LeSage, J.P. and Pace, R.K. 2009. *Introduction to Spatial Econometrics.* Boca Raton, U.S.: CRC Press Taylorand Francis Group.

Mizutani, N. (2015). "The effects of housing wealth on fertility decisions: Evidence from Japan". *Economics Bulletin*, *35*(4): 2710-2724.

Mussa, A., Nwaogu, U.G. and PoZo, S. 2017. " Immigration and housing: A spatial econometric analysis." *Housing Economics* 35: 13-25.

Osland, L. and Thorsen, I. . 2013. "Spatial impacts, local labour market characteristics and housing prices." *Urban Studies* 50 (10): 2063–2083.

Ramos. 2018. "Introduction to ESDA and Spatial Econometric techniques using STATA." *Grup D'Analysis Quantitativa Regional, Universitat de Barcelona.*

Sabater, A. and Graham, E. . 2019. "International Migration and Fertility Variation in Spain during the Economic Recession: A Spatial Durbin Approach." *Applied Spatial Analysis and Policy* 12 (3): 515-546.

Simo-Kengne, B. ; Bittencourt, M. and Gupta, R. (*2012*). "House Prices and Economic Growth in South Africa: Evidence From Provincial-Level Data". *Journal of Real Estate Literature 20(1): 97-117*

Simo-Kengne, B.D. 2019. " Population aging, unemployment and house prices in South Africa ." *ournal of Housing and the Built Environment* 34 (1): 33-49.

Vitali, A. and Billari, F.C. 2015. "Changing Determinants of Low Fertility and Diffusion: a Spatial Analysis for Italy." *Population, Space and Place* (DOI: 10.1002/psp.1998). doi:10.1002/psp.1998.