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WOMEN IN THE LABOR FORCE

Examination of the U-shaped Hypothesis for South Korea

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Abstract:

This thesis addresses the relationship between economic development, captured by an increase in GDP per capita, and the rate of female labor force participation in South Korea the last 40 years. The basis of the analysis is "the U-shaped hypothesis"; a theoretical and empirical suggestion that female participation initially decreases then increases over the stages of economic development. Using time series data on the macro level for South Korea over the years of 1980 to 2019 from the World Bank and the OECD, an econometric model was estimated by vector autoregression. The empirical results do not find unambiguous and robust evidence of a U-shaped relationship between female labor force participation and economic growth in South Korea for the examined time period. However, the results suggest the presence of the discouraged worker effect. Contradictory to economic theory and previous empirical work, boosts in female education is associated with a decrease in female labor force participation.

An analysis of cross-sectional data of labor market conditions in the individual provinces pooled for the years of 2015, 2017 and 2019 is included in an attempt to further explore determinants of the labor supply decision for South Korean women today. The findings imply a negative effect of social stigma and traditional gender roles, as well as a suggestion for policy interventions in order to boost female participation in prevention of economic stagnation due to a predicted contraction of the labor force in a country in the face of low fertility rates and an aging population.

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1 Introduction

Although South Korea's rapid and successful economic development over the latter half of the 21st century has stood out in international comparison, so has the country's relatively low female economic participation. According to national estimates, about 53.5 % of the female population of working age was economically active in 2019 (KOSIS, 2022a). While a positive trend of the female labor force participation rate indicates that an increasing number of South Korean women are joining the labor force, women's participation is lower in South Korea compared to other economies with the same income and development level. For comparison, the average participation rate for women in the OECD was 61 % in 2019; for Japan, a country that is often highlighted in the context of low female participation, the rate was 62 % (OECD, 2022a).

The paradox of the low female participation in the otherwise advanced economy and society of South Korea is the subject of interest of this paper. Traditional economic theory predicts that as production and income in an economy increases, demand for labor and thus wage opportunities will rise, which one could imagine would lead to an influx of women to the labor force. The U-shaped hypothesis of female participation over the course of economic development proposes the existence of an initial trade-off between economic growth and economic equality between the genders, where the increased economic welfare and opportunities that come with initial economic growth benefit the male population to a greater extent than the female population – a feminized Kuznets curve of sorts. The U-shaped hypothesis would predict, based on the key indicators of the hypothesis such as the income level, educational attainment levels, sectoral composition and fertility rate, that the female labor force participation in South Korea would be higher. This suggests that there is likely to be more factors that contribute to the determination of a country's female participation rate.

Though other studies have addressed the issue of the country's low female participation rate (Nam, 1991; Choi, 2008), no previous study has done so in the light of the U-shaped hypothesis. Nam (1991) focuses on the determining factors of women's human capital and economic status and background in Seoul in 1970 and 1980, whereas Choi (2008) brings attention to the occupational distribution of female employment. Applying the U-shaped hypothesis in the account of South Korea's female participation is interesting because it could assist in a separation of its driving forces; how much can be explained merely as results of economic development and the economic and social structural changes that follows? Furthermore, the

literature hypothesizes that the U-shaped relationship suggested in cross-sectional analysis will hold as a time series dynamic for individual countries over the course of development; as one of the pioneers of the hypothesis, Claudia Goldin, states; "If all countries taken together trace out a U-shaped function, then each country's history probably did." (Goldin, 1995, p. 79). In order to investigate the empirical validity of the hypothesis and this claim, the objective of the present paper is to examine the degree to which economic growth can explain female labor force participation rate trends in South Korea from 1980 to today. As indicated by the variability in results in the literature, especially in the recent years, the empirical tests of the hypothesis have not been without shortcomings. It can be argued that the methodology choice of a large portion of the existing literature, in majority cross-sectional studies, is inadequate for the analysis of the phenomenon of female economic participation over time, because it would be a fallacy to investigate a dynamic time-series relationship by static cross-sectional methods. This makes the hypothesis and the methodological approach to it a matter of intrinsic interest per se. South Korea is a country of interest because of its history of astonishing, recent economic development and relatively low female labor force participation rate despite its high-income status. Additionally, I will explore what may remain unexplained in an attempt to shed more light on the factors that could give an explanation on why the country's female participation rate is lower than predicted by the U-shaped hypothesis and compared to other economies at the same development and income level.

The study is divided in eight sections. The next section discusses the theory and evidence behind the U-shaped hypothesis presented in the previous literature. Next follows a section of an account of South Korea's economic development as well as the female participation rate trends through descriptive statistics. In sections four and five, an econometric model for the analysis of the time series relationship is set up and estimated. Following the presentation of the results, I discuss limitations and conduct an additional cross-section analysis of possible determinants of the female labor supply in an attempt to gain a better understanding of the mechanisms that could be at work. The final section concludes.

2 Literature review and theoretical framework

The U-shaped hypothesis is a hypothesis stating that female labor force participation follows a U-shaped trend over the course of economic development, illustrated by the stylized graph below. Using cross-sectional data, it has been observed that female labor force participation is

typically high in low- and upper-income countries, while it is lower in middle income countries. The hypothesis was initially proposed by Sinha (1967) and has been studied and developed since then. Parametric and nonparametric methods in both static and dynamic models have been used by researchers, operating with a variation of control variables. The literature has provided documentation of the hypothesized relationship both in cross-sectional studies (Boserup, 1970; Goldin, 1995; Mammen & Paxson, 2000; Tsani et al., 2013, among others) and time-series studies of individual countries (Goldin, 1995; Mammen & Paxson, 2000; Fatima & Sultana, 2009). Recent papers have, however, questioned the robustness of the hypothesis (Gaddis & Klasen, 2013; Lechman, 2014; Verme, 2015), highlighting for instance the inadequate methodology, large variation in results across countries and the inadequate sensitivity analyses.

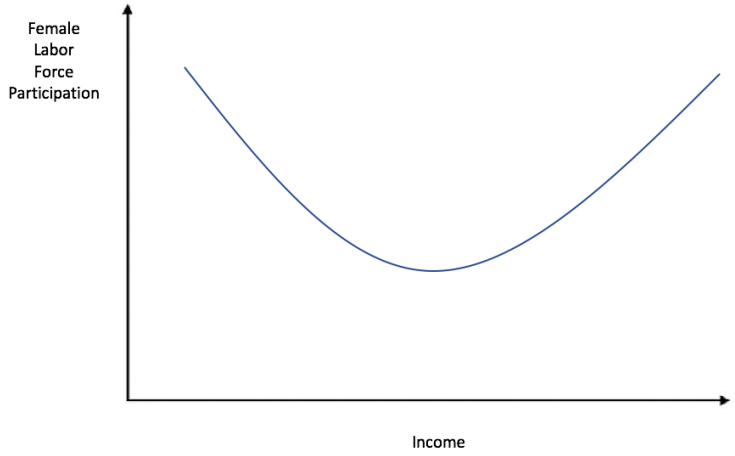

Figure 1: Stylized graph of the U-shaped hypothesis.

The literature highlights and explores different explanations of the hypothesized trend, and a substantial part of the discussion relates to the so-called "pillars" of the U-shaped women's labor supply hypothesis. The decline in women's labor supply following initial economic development is in large part attributed to a sectoral transformation from agriculture to manufacturing through industrialization and mechanization. In low-income countries, women participate to a higher degree, working predominately as unpaid family workers on the family farm. However, when a developing country moves from low to middle income one typically will see a growing industrial sector and the introduction of new technology which mechanizes agriculture, and the subsequent exit of women from the labor force. During the later stages of development, when the economy is more or less "developed", the tertiary sector provides women with wage opportunities and female labor force participation increases. However, there

is a common conception that the relationship depends on several factors reflecting both individual preferences and decisions, and the overall market conditions (Mammen & Paxson, 2000) that can accompany the ongoing development process. Many insinuate to independent and country-specific socio-cultural mechanisms at work.

Some of the most common explanations of the declining portion of the curve throughout the literature is that economic expansion and modernization improve employment opportunities and economic welfare for men at a faster rate than for women because mechanization of agriculture and the sectoral composition transformation through development decreases the demand for women's labor. Concurrent with the emergence of work opportunities primarily for men in the industrial sector, economic growth typically coincides with an accelerating urbanization process as the majority of these new jobs are situated in urban, rather than the rural areas where the shrinking agricultural sector dominates. Unable to take to wage labor in the industrial sector and geographically removed from agricultural areas, women find themselves without work opportunities and there will be an overall decline in female participation as the urban to rural population ratio increases (Mammen & Paxson, 2000).

Relative differences in educational levels is one key explanation that contributes to the alleged time lag of women's opportunities relative to men's in the development process. Women's education levels typically do not increase at the same rate as men's during early development (Mammen & Paxson, 2000), which hinders female participation as lower relative educational levels result in lower relative levels of human capital, productivity, and skills, making women less attractive in the labor market. Lower female productivity can also be reflected in and explain at least parts of the observed gender wage gap and subsequently the gender participation gap.

A microeconomic approach to the labor supply decision can be applied in this context. Economic development will involve higher overall economic productivity and income, which can affect labor supply decisions in two ways. As the standard labor supply model and the backward bending supply curve theory states, the effect can be decomposed in two; firstly, a positive substitution effect causing labor supply to increase as the opportunity cost of leisure is heightened, and secondly; a negative income effect where higher income causes the individual to desire more leisure relative to work and subsequently decrease labor supply. The ultimate decision to either engage in paid work or stay out of the labor force will be contingent on what effect dominates for the individual. Given the declining female portion of the U-curve, the

hypothesis would be consistent with a dominating negative income effect in the early stages of development. Lower and slower increases in women's productivity relative to men's, introduced in the previous paragraph, and as a result smaller growth in women's wages, could be one contributor to the negative income effect. Then, while women in low-income countries participate in economic activity driven by necessity and the need of two income sources, the income increase of the household with the general increase in male wages gives the economic leeway for women to respond to the negative income effect by retracting to the home. This could indicate that households tend to rely on the husband, who is often the highest earner, as the main provider. A household arrangement where the man works and the woman tends the home could be consistent with Becker's specialization theory of labor division between married men and women, explained by gender-specific comparative advantages in market work and home work respectively and thus unequal allocation of time and energy between the two, further exacerbating a productivity and wage gap (Becker, 1985). An intra-household inclination to divide responsibilities in this fashion could indicate that this is the optimal allocation, given that men have a comparative advantage in physical and wage-earning work, whereas women have a comparative advantage for childbearing. When men respond to increased wages and higher returns to human capital following economic advancement, they specialize in wage work by increasing labor supply and allocating less time to household responsibilities. In turn, women allocate less time to market work. Driven by comparative advantages, a gendered division of home work and market work arises. Empirical evidence from middle-income countries indicates that these tendencies could hold true at the household level, resulting in the aggregate trend; take for example the suggested inverse relationship between male wages and female labor force participation (Fatima & Sultana, 2009), a likewise negative relationship between the economic class of the household and the probability that the wife works (Mammen & Paxson, 2000), and a tendency for women to increase participation in response to increased male unemployment in order to compensate for negative income shocks to the household's overall income (Fatima & Sultana, 2009). The large entrance of women in the workforce in many countries during both world wars, also in activities traditionally deemed as masculine, (Welner, 1942; Goldin, 1991) presents a well-known historical example and can be attributed to labor shortage and the absence of spousal income. One could therefore question whether the tendency to drop out of the labor force when income growth occurs reflects women's true preferences regarding work (Mammen & Paxson, 2000), but this would not explain increasing labor force participation rates for women in later stages of development where income is even higher. It could, however, reveal women's preferences towards certain types of work that emerge with

economic advancement, such as factory work. The manufacturing industry's infamously poor working conditions and long hours (Mammen & Paxson, 2000; Savada & Shaw, 1992) could result in a preference of domestic duties over factory work. This preference could contribute to the dominance of the income effect over the substitution effect in women's labor supply decisions as the initial increase in general income allows for the option to opt out of wage labor.

The labor supply decision and the explicit and implicit costs of women's work should also be seen in the context of socio-cultural gender role attitudes. Traditional gender roles imply that the woman's role in the household is that of childbearing and other household responsibilities, while the husband's duty is to provide for the family. While childbearing and work can be reconcilable for the majority of women in low-income countries, where the workplace is typically the family farm, a decrease in home production due to economic development might cause a trade-off between motherhood and work. This could prevent women from taking wage work. Birth rates seem to drop over the course of economic development, but with a certain time lag: fertility rates typically remain relatively high for middle-income countries (World Bank, 2019), which could explain why women in middle-income countries are pushed to prioritize motherhood and housework rather than wage work out of the home. Furthermore, Goldin argues in her 1995 paper that there exists a widespread social stigma towards women taking blue-collar jobs in manufacturing, especially those involving heavy manual labor, as this is often considered men's work. This excludes women from benefitting from increased employment opportunities in manufacturing during industrialization. She argues that the stigma applies to married women to a larger degree than unmarried women, as the stigma relates to the husband through the traditional expectation of the male's obligation to provide for their family (Goldin, 1995). This could explain why we often observe young unmarried women participating in factory work (Mammen & Paxson, 2000). It also implies marital status, and implicitly economic dependence on a spouse, to be a determinant of labor supply decisions, as empirically suggested by Fatima & Sultana (2009). In many countries, one can observe a trend of economically active young women exiting the labor force when they reach the average marriage age (Verme, 2015). This can be explained by the woman taking to her "womanly" responsibilities in the home and becoming financially dependent on a spouse as opposed to her own income, or by the aforementioned social stigma "kicking in" as she enters marriage. Other possible costs contributing to a reduction in female labor supply can be explicit, for example due to underdeveloped social, economic or physical infrastructure materializing as high transport costs and absence of childcare alternatives, or even legal restrictions on women's

participation, as seen for example in Afghanistan. Relating to the standard labor market model, as long as the fixed costs of out-of-home work exceed the possible wage earnings, the woman will choose not to participate.

The upward portion of the curve, where female labor force participation rates increase with income, is commonly explained by rising female education levels, which causes women's human capital and productivity to catch up with that of the male population. Further economic development is associated with further sectoral transformation of the economy and especially the emergence of "white-collar" jobs in the tertiary sector, for example in services, sales and clerical work. These factors work together to increase employment opportunities and wages for women, which subsequently increases the opportunity cost of not working – causing the substitution effect to dominate and labor supply to increase as women shift away from household to market activities. It is argued that the stigma attached to women performing manual work does not apply to white-collar jobs (Goldin, 1995) and that gender norms and expectations often change to become more progressive in more developed economies (Chapman, 2015), lessening the social cost of taking work for women. A simultaneous factor is a large drop in fertility rates, which tend to be lower in higher income countries compared to low- and middle-income countries (World Bank, 2019).

Alas, there seems to be a multitude of factors with possible impacts on female labor force participation through economic development, and supporters of the U-shaped hypothesis do acknowledge the complexity of mechanisms at work. However, recent literature has criticized the alleged empirical evidence of the relationship. Gaddis & Klasen (2013), Verick (2014) and Verme (2015) emphasize the heterogeneity between countries, pointing out large variations in participation rates even for regions and countries with similar income levels. This would imply that country-specific cultural factors matter more for female participation than income. They also find results to be sensitive to the data sources used. Judging these inconsistencies too large, they argue that there is no robust evidence of an initial inverse relationship between GDP and female labor force participation for low- and middle-income countries. Although the hypothesis might fit the trends in female participation through early economic development for now modern economies, it might not explain female participation in developing countries today: a comparison of estimated regressions for OECD and non-OECD countries shows no support of an empirical U-relationship for the non-OECD countries (Gaddis & Klasen, 2013). The study does, however, find significant positive effects of both fertility and education on female labor

force participation, consistent with the U-hypothesis's explanation of the upward sloping portion of the curve.

3 Economic context and descriptive statistics

This two-part section provides a context of the economic conditions of South Korea throughout its economic development through descriptive statistics. The first part considers the economy as a whole, while the second part addresses specifically the role of South Korean women with a focus on their labor market conditions. The section relates descriptive statistics to the economic theory and empirical evidence introduced in the previous segment to formulate an account of the potential mechanisms that could explain the country's female labor force participation that will be explored in the econometric analysis in the next section.

Economic Development in South Korea: The Miracle on Han River

The South Korean economy underwent a rapid economic expansion during the last half of the 20th century, often referred to as the "Miracle on the Han River" (Kleiner, 2001). One of the Four Tigers, characterized by swift and successful growth (World Bank, 1993), the country transformed from a low-income, agrarian society devastated by war into an advanced and prosperous high-income economy over the course of a few decades (Kleiner, 2001). According to the World Bank 2017 indicators, GDP per capita increased from about US $1027 in 1960, to US $31,674 in 2019. Growth spurted following economic reforms carried out by the government of Park Chung-hee in the 60s, and has to a large degree been attributed to an expansion of an export-oriented industrial sector and large investments in human capital through universalization of education (Kleiner, 2001; World Bank, 1993).

The graph below shows the evolution of GDP per capita, in logarithmic terms, over the time period considered in this paper. The aggregated trend is an increase in income per capita: GDP per capita grew from $4055.791 in 1980 to $31,674.31 in 2019. The mean GDP per capita for the period was $17,001.81. According to the World Bank's definitions and price-adjusted thresholds of high-income economies (Prydz & Wadhwa, 2019), South Korea was classified as a middle-income country in the beginning of the examined period and transformed into the upper-income bracket in 1992. The plunge in the late 90s is attributed to the Asian Financial Crisis of 1997. The data indicate that the economy grew faster at the start of the period, as

illustrated by the steep slope in the first 10-15 years and the relatively flatter curve for the years towards the end of the period insinuate that growth might be slowing down.

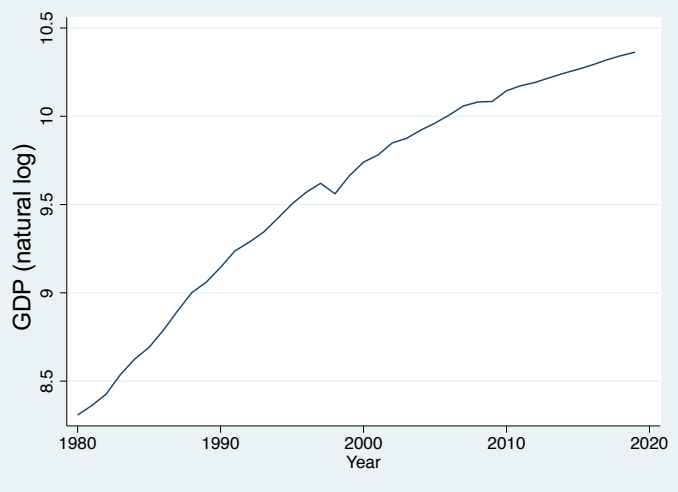

Figure 2: Economic development in South Korea, 1980-2019

Author's calculation based on GDP data from the World Bank

With development, the economy has undergone a structural transition similar to that of other developed countries, visible by the change in the sectoral composition of GDP and total employment: whereas the share of agriculture has decreased, the share of capital- and knowledge-intensive industries such as manufacturing and mining as well as the tertiary sector have grown. The country has, like the other Tigers, accomplished the transition into modernization faster than other developing countries (World Bank, 1993).

Simultaneous with economic development, South Korea has undergone a demographic transition with a sharp decline in fertility rates (World Bank, 1993). The fertility trend was declining over the whole considered period, from almost three children per woman in 1980 to just under one in 2019 (World Bank, 2019). South Korea has the lowest fertility rate of the OECD (Sustainable Governance Indicators, 2018).

Furthermore, with the rise of the industrial sector came rapid urbanization, as the industry was mainly concentrated in urban areas (Savada & Shaw, 1992). For the period of 1980 to 2019, the urban-to-total population ratio increased steadily, from 56.72 % in 1980 to 81.43 % in 2019, consistent with the empirical urbanization trends of developing countries. The growing industry sector increased demand for trained labor. Investment in education at all levels have resulted in large increases in human capital, as we can see from indicators such as a large increase in enrollment rates, real expenditures per pupil (World Bank, 1993) and resource investments in

vocational training (World Bank, 1993). Primary education was universalized in 1965, which resulted in a narrowing and in turn almost non-existent gender gap in enrollment (World Bank, 1993). The same trends apply for secondary and tertiary education (Savada & Shaw, 1992). The data used in this study display a large increase in the female education level over the series: female enrollment in tertiary education increased from just under 6 % in 1980 to about 88 % in 2019. Large increases in the enrollment rate in the late 90s and the 2000s affirm an observed influx of women in tertiary educational institutions. Statistics such as the university entrance rate for women which since 2009 has been higher than that of men (Statistics Korea, 2017) indicate a feminization of education and a slightly reversed gender gap in education. South Korea has thus become a country with a highly educated, both general and female, population.

Working women in Korea: Female Labor Force Participation through development

Pre-1960s, female labor force participation in South Korea was driven mainly by economic necessity, and women from lower classes participated as farm workers and some women generated income by producing and selling home-made objects (Savada & Shaw, 1992). With the start of the economic boom, factory work in manufacturing presented a wage opportunity for many women, the majority of whom were young, unmarried and unskilled (Yang, 2021). Factory work often involved long working hours under inhumane conditions to a low wage upon exit of the labor force when they married (Savada & Shaw, 1992). The female labor force participation rate in the country saw a sharp increase simultaneous with the industrial expansion: from 1960 to 1975 the rate of women participating in the workforce increased from 26.8 % to 46.7 % (Yang, 2021). The labor of these young women contributed to the initial stage of economic growth driven by the manufacturing industry, however the country saw a drop in the female participation rates entering the 80s. Yang (2021) links the drop in women's economic participation to a change in industrial and trade structure as industrialization; the next two decades of development from the mid-1970s and until the start of the 90s was characterized by a government-induced shift towards heavy and chemical industry mainly employing men. In 1984, the female labor force participation rate had declined to 40.67 % (OECD, 2022a). As development has continued, the emergence of the tertiary sector has provided women with work opportunities, especially in clerical and secretarial positions (Savada & Shaw, 1992).

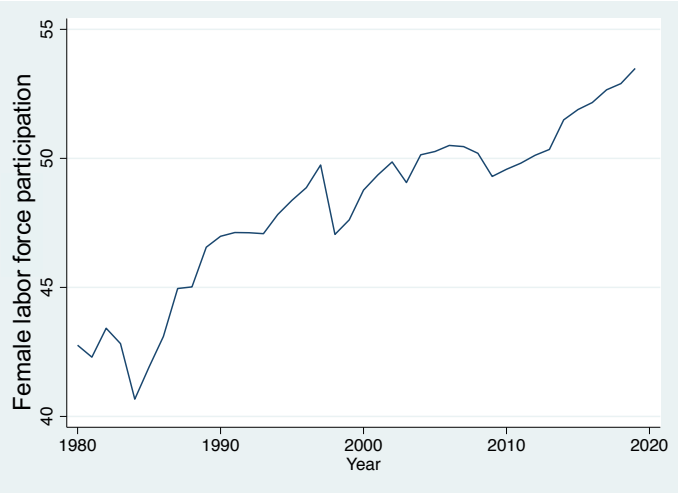

Figure 3: Female labor force participation (% of female population ages 15-64), South Korea 1980-2019.

Author's calculation based on data from OECD.

The figure above graphs the female labor force participation for the period of 1980 to 2019. The labor force participation rate for women was 42.76 % at the start of the time period, and 53.48 % at the end of the period. The average participation rate for women for the period was 48.09 %. After the lowest point in 1984, the overall trend is increasing, though the data exhibit variation and declines in certain time periods. It fell notably in the late 90s, a decline that might be associated with the 97 Financial Crisis.

We can still observe a tendency of South Korean women to work until marriage, when they leave the workforce to fulfill their duties at home, most importantly of raising the children and doing housework but often including administration of the family finances and the children's education: "Some Koreans still call a wife *Djip-saram*, which means a home person, while naming a husband *Bakat-Yangban*, a man outside, which signifies a stereotyped perception that women should stay home rearing children and doing unpaid work" (Yang, 2021), consistent with the ideals of the Confucian tradition which historically has been central in South Korean culture (Hoffman, 1995).

Comparison of the female versus male labor force participation, which in 2019 was 73.5 %, (OECD, 2022a), could suggest that the traditional distinction between the responsibilities of the sexes remains relevant in the South Korean society and economy. Statistics suggest an M-shaped employment curve for women (Cho & Jeon, 2008), illustrating a trade-off between work and family. The figure is a stylized presentation. Employment and labor force participation is typically high for women in their 20s, but falls for women in their 30s when they typically

marry and have children, before it increases for the 40-50 age group, and eventually falls again for the older age groups (OECD, 2019a, p. 3). This M-shape differs from the suggested inverted U of employment over the life-course of South Korean men as well as for both men and women in other advanced economies (OECD, 2019a).

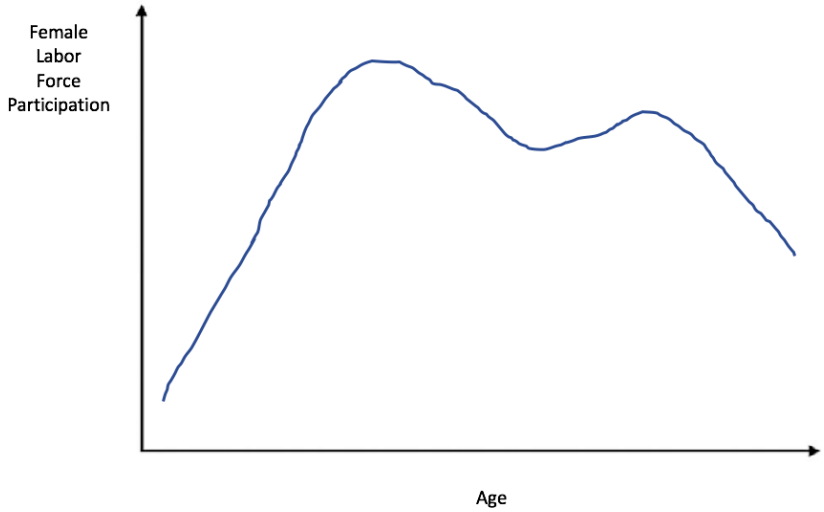

Figure 4: Stylized M-shape of female employment for age groups

This variation, and especially the dip in female employment in the years associated with the primary years of childbearing, could suggest a presence of structural cultural, social or economic barriers to women combining wage work with family and domestic responsibilities in South Korea. Career interruption is the highest for women with young children, and surveys show that the majority of economically inactive women ascribes their labor force exit to marriage, childbirth and childcare (Statistics Korea, 2020). Furthermore, South Korea is known for its long working-hours culture, with weekly working hours approaching or exceeding 40 hours for 90 % of male workers (OECD, 2007). Working hours are significantly higher for South Korean women, compared to women in other OECD countries (OECD, 2007). Long weekly working hours, as well as little access to part-time work or flexible hours contracts (OECD, 2019b), is less compatible with childbearing, especially if the woman is assumed to take on the majority of domestic duties; work and familial obligations might become impossible to fulfill at the same time.

4 Method and data

Appropriate to the underlying theory and existing literature on aspects of the female labor force participation rate, this study will examine the association between female labor force participation and economic growth over time and test the existence of a U-shaped relationship in the case of South Korea over the 40-year time period between 1980 to 2019. To this end, I employ time-series data on the macro level with an annual data frequency for South Korea for the relevant years and vector autoregressive econometric methods. In this section, I explain the establishment and estimation of the model, its components, mechanisms and underlying assumptions.

Econometric model

Due to the complexity of the relationship, additional explanatory control variables are included in the model in pursuance of empirical indications and a comprehensive grasp of the determining factors of women's economic participation. As established, the degree of female labor force participation in an economy will depend on several variables and can be written as a general function of these:

$$FLFPr_t = f(ED,LM,custom,u)$$

where $FLFPr_t$ is the female labor force participation rate in the economy at time t, which is a function of a vector of economic development variables (ED) including per capita income, urbanization and fertility rates; a vector of labor market condition determinants (LM) such as the unemployment rate, wages and education, and custom which is a vector of cultural gender attitudes and social custom. Lastly, u is the error term, assumed to have zero mean, which reflects disturbance in the relationship; omitted factors contributing to the female participation rate.

Based on this general function, the starting point of this analysis of the determinants of female labor force participation in South Korea is the following econometric model:

$$FLFPr_t = \beta_0 + \beta_1 \ln(GDPpc_t) + \beta_2 \ln(GDPpc_t)^2 + \beta_3 urbanization_t + \beta_4 fertility_t + \beta_5 femeducation_t + \beta_6 femunemployment_t + u_t$$

In the estimation of this model, this study employs data on all model variables collected annually in the time period between 1980 and 2019.

Female labor force participation is measured by the female labor force participation rate of a given economy, in its logarithmic form. This study employs the definition of the female labor force participation rate as the share of women in the workforce, relative to the economy's total female population of working age (15-64) (OECDa, 2022). The labor force is the economically active population and includes the employed, as well as all unemployed but actively job seeking individuals (OECDb, 2022). This gives a measure of an economy's female labor supply. The data on the female labor force participation for the years 1980-2019 are retrieved from the OECD database.

The model uses GDP per capita (GDPpc) as the proxy for economic growth. The data on GDP per capita are drawn from the 2017 World Bank Indicators. The study utilizes the World Bank's measure of GDP per capita as the economy's gross domestic product in constant 2015 $US divided by the population, and provides thus a measure of the average income per inhabitant. It is the natural logarithm of GDP per capita that is included in the model. The logarithmic transformation of economic variables is often preferred when describing relationships between variables (Hamilton, 2014). It allows for analyzing percentage changes, and is used to reduce volatility and cyclical fluctuations in the data in order to isolate the secular trend of the long-run such as long-run economic growth (Smith, 2006). The square of the logarithmic GDP variable is included in the model to test the hypothesized non-linear relationship between female participation and GDP per capita, as per the tradition of the existing literature. Non-linearity, as opposed to linearity, implies that returns and effects are not constant.

urbanization is the independent variable accounting for urbanization. It is the percentage of the total population that resides in urban areas. The data are extracted from the 2017 World Bank Indicators.

fertility is the fertility rate, measured as births per woman "if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year" (World Bank, 2019). The data are retrieved from the World Bank Indicators.

femeducation represents female educational attainment, proxied by the female school enrollment in tertiary education as the percentage of gross. The data are retrieved from the World Bank Indicators.

femunemployment represents the female unemployment rate. Data for the years 1980-1989 are retrieved from OECD, whereas the data for the rest of the series up until 2019 are obtained from the World Bank Indicators and are based on model International Labour Organization (ILO) estimates. Due to similarity in the data collection methods as well as a smooth and sensible

transition between the observed values in each respective dataset, I consider the combination of sources to be unproblematic to the analysis.
u is, as before, the error term, which encapsulates all other omitted and unobserved factors that affect the female participation rate.

The dynamic and complex nature of the data necessitates the use of an estimation method that sufficiently deals with the time dimension of the data, due to the possible and suspected time trends, correlation between variables, and non-stationary properties of the data. Estimating the model with Ordinary Least Squares would be a naïve and static approach to a model of an inherently dynamic relationship, and the estimated coefficients would likely be imprecise and, more importantly, biased and therefore unfit for inference. Contrary to cross-sectional data drawn from a random sample, observations in time series are non-random as the order in which data are collected and ordered is of importance and we cannot exclude the possibility of systematic patterns in the values of variables and errors over the time period.

A common issue with time-series data is serial correlation, which can cause serial correlation and thus unbiasedness (Studenmund, 2016) due to violation of the zero conditional mean assumption of the error term. Impure serial correlation, caused by misspecification of the model and omitted variables, causes bias in the estimated effects (Studenmund, 2016). Serial correlation can also lead to violation of the homoskedasticity assumption of constant variance of the estimates, as the estimates of the standard errors of the coefficients become biased (Studenmund, 2016). Though this does not cause biasedness (Wooldridge, 2019) in the coefficients, incorrect estimates of the coefficients' standard errors will make hypothesis test results unreliable (Studenmund, 2016). Typically, the consequence is a larger probability of making the type 1 error of wrongfully rejecting the null hypothesis (Studenmund, 2016). Serial correlation can be caused by both autocorrelation and multicollinearity between the modeled variables, as well as the error term.
With time series, serial correlation is often caused by the lagging effects of events, and time trends. Typically, the values of variables in one time period are dependent on past values, and effects might not be instantaneous but rather exhibit a time lag between cause and effect, where the lag is the time between the event and when you can measure the effect (Polich, 2021). For instance, the expansion of output in time *t* is likely to have lasting effects in succeeding periods, and research suggest slow adjustment of fertility rates in the initial stages of development, as mentioned in an earlier section. Lagging effects can cause biasedness if not accounted for as

there will be problematic correlation between the explanatory variables of other periods and the error term at time *t* if not included in the model.

Autocorrelation is often caused by time trends in the variables. The dataset is a multivariate time series, with several time-dependent variables that in furthermore are likely to be dependent on each other. The model variables; GDP, FLFPr, urbanization rate, fertility rate and education enrollments, are all variables that exhibit time tendencies. Consider for instance GDP at a time *t*: the value is likely not random, but most probably dependent on GDP in the previous year, *t - 1*. Figure 1 is a clear illustration; the data reveal an increasing trend in GDP over time; and while GDP can vary from year to year, the aggregated trend over time is positive.

The consequences of serial correlation of the errors in dynamic models including lags are especially grave, as the estimated effects of the lagged variables are likely to capture variation that is in actuality caused by the error term (Studenmund, 2016). Serial correlation of errors in time series analysis is common and occurs when the omitted factors captured by the error term are dependent on unobserved events of past periods (Studenmund, 2016, p. 275). It is for example not unlikely that the positive trend in female participation partly reflects effects of an omitted variable in the error term that is related to its own past values and thus is serially correlated. An example could be the role of a larger degree of economic openness, globalization and international trade. A serially correlated error term could be represented as the first-order Markov scheme (Studenmund, 2016, p. 275):

$$u_t = \rho u_{t-1} + u_t$$

Here u_t is the error term at time *t*. In the case of first order serial correlation as represented here, as long as $\rho \neq 0$, the error term is autocorrelated by depending on its value in the previous period. ρ, $-1 < \rho < +1$, is the first-order autocorrelation coefficient measuring the strength of the correlation (Studenmund, 2016, p. 275). When errors are serially correlated, we can observe systematic patterns of residuals as the error term typically will have the same sign as in the previous period (Studenmund, 2016, 277).

Furthermore, the variables of the model are likely to be correlated. For instance, the bidirectional positive relationship between the labor supply and output is an established fundament of traditional economic theory, and there are theoretical predictions as well as empirical evidence of relationships with similar mechanics of mutual reinforcement between GDP growth and urbanization, fertility rates and education; the U-shaped hypothesis as well as a literature of empirical work suggesting interdependency of especially female labor supply

decisions and fertility trends and female education. This means that the relationship between the dependent variable and the explanatory variables is compound, with a considerable number of intertwined possible mechanics at work between inherently endogenous variables. Thus, the methods of OLS regression are excluded.

Another issue with time-series data and macroeconomic data is the prospect of spurious correlation. Regression is spurious if variables demonstrate a strong, but non-causal relationship (Studenmund, 2016). The causal effect of variables that exhibit the same underlying trend as the dependent variable will be overestimated and incorrect, as it does not only include the isolated effect of the variable, but also the underlying trend and the fact that the variables are moving together (Studenmund, 2016). This is often the case for non-stationary variables, and correlation is believed to be spurious for the variables in this analysis as the data are assumed to be non-stationary. Non-stationarity implies that exogeneity assumption of time series data stating that the average value, variance and covariance of the variable should be constant and independent of time, is violated (Singh, 2018a). As previously stated, all variables exhibit clear time trends as opposed to constant variation around a constant mean, as one would observe with stationary data. With non-stationary data, variables are endogenous (Singh, 2018a) and regression will produce imprecise results as the results will not properly account for the role of time behind observational values and their systematic development over time. The error term can also be non-stationary.

Variables that are non-stationary in levels can be stationary in the first difference. The first difference is the difference between the variable's value in time *t* and its value in the previous period, *t - 1*. There are costs of using the first difference of variables, however. For instance, it reduces the sample size, as the first and last observations will not be included in the regression. Furthermore, Studenmund (2016) states: "(…) using first differences to correct for non-stationarity throws away information that economic theory can provide in the form of equilibrium relationships between the variables when they are expressed in their original units (X_t and Y_t)." (Studenmund, 2016, p. 383). It is further argued that if the variables are cointegrated, they can be separately nonstationary without yielding misleading regression results due to spuriousness, because the linear combination of the variables produces a stationary as opposed to serially correlated error term.

The model and estimation method must allow for us to account for these time dependent patterns, trends and endogeneities. In estimation of the econometric model set up of this paper,

I have opted for a vector autoregressive (VAR) model, as this method is more appropriate for multivariate time series data with the degree of interdependency suspected for the subject of analysis. Furthermore, the model accounts for the effects of previous periods and lagging effects by allowing for variables to depend on its own and other variables' past values (D'Amico, 2021). It is a dynamic and autoregressive model, which means that it allows for the dependent variable to also depend on its own past values (Studenmund, 2016). VAR models are widely used in macroeconomics due to superiority in the treatment of dynamic data and production of credible and reliable results (Stock & Watson, 2001).

Using the Augmented Dickey Fuller test for stationarity, I found the female labor force participation rate, the female unemployment rate and the female enrollment rate to be non-stationary at level. The natural logarithm of GDP per capita, its square and the urban-to-total population ratio and the fertility rate are found to be stationary at level. Executing the two-step Engle-Granger method test for cointegration between variables, I reject the null hypothesis of a random walk with no drift: there is no linear combination between the levelled variables that eliminate serial correlation of the errors. It could be argued that proceeding with an estimation in levels would give an indication of the long-run relationship between the variables (Allen & Fildes, 2004; Studenmund, 2016). However, I suspect that a regression in levels is likely to be spurious, and I exclude the option of specifying the model and conducting the analysis using the variables in their level values and opt for a VAR model in differences. Allen & Fildes (2004) argues that "differencing variables imparts robustness", which could give more reliable results. In addition to statistical benefits of the use of first differences, some hold that an analysis of relationships between differenced variables will uncover the real, underlying mechanisms of the interaction, whereas others will argue that differencing eliminates the economic relevancy. Mixed VAR models, using a combination of first differenced and level value variables is possible, however I opt for the method of differencing all model variables before inclusion in the model.

The appropriate lag-length will eliminate the problem of autocorrelation (D'Amico, 2021), where serial correlation of factors in the error term is caused by correlation between the dependent variable's value at time *t* and its values in previous periods (Hauser, 2004). In order to select the appropriate number of lags to include in the model, I assess the lag orders suggested according to the Akaike, Hannan-Quinn and Schwartz criteria. These are statistical measures of the quality of models (D'Amico, 2021), which test models, in this case with different number

of lags, against each other and reports which model is the best fit for the data. All criteria suggest one lag, which means that the variables' values in the previous period are included.

With all stationary variables exhibiting no pattern over time and the appropriate number of lags, I can formulate and estimate the model.

The restricted model, including the only the key explanatory variables of the first differences of the natural logarithms of GDP per capita and its square, can be formulated as a three variable VAR model with one lag. Each variable is treated as endogenous (Hyndman & Athanasopoulous, 2018), expressed as a linear function of the lagged values of all variables.

The linear reduced notation highlights the endogeneity of the variables, take for example the linear function for the dependent variable at time *t*:

$$\Delta FLFPr_t = a_0 + \phi_{11}\Delta lnFLFPr_{t-1} + \phi_{12}\Delta lnGDPpc_{t-1} + \phi_{13}\Delta lnGDPpc^2_{t-1} + u_t$$

Here ϕ_{11} is the coefficient associated with how the female labor force participation responds to its own value in the previous period, ϕ_{12} is the coefficient associated with the influence of the change in GDP per capita, in logarithmic form, from the previous period on the FLFP rate, and likewise ϕ_{13} is the coefficient associated with the quadratic term.

All variables can be expressed as above. Representing the model as a matrix simplifies the notation:

$$\begin{bmatrix} \Delta lnFLFPr_t \\ \Delta lnGDPpc_t \\ \Delta lnGDPpc^2_t \end{bmatrix} = \beta_0 + \phi \begin{bmatrix} \Delta lnFLFPr_{t-1} \\ \Delta lnGDPpc_{t-1} \\ \Delta lnGDPpc^2_{t-1} \end{bmatrix} + \begin{bmatrix} u_{1,t} \\ u_{2,t} \\ u_{3,t} \end{bmatrix}$$

a_0 is the vector of intercept coefficients, ϕ is the vector of the effects of the lagged values of the variables, $\begin{bmatrix} \phi_{11} & \phi_{12} & \phi_{13} \\ \phi_{21} & \phi_{22} & \phi_{23} \\ \phi_{31} & \phi_{32} & \phi_{33} \end{bmatrix}$, and u_t is the error term for each variable.

The unrestricted model, where the first differenced control variables of urbanization, fertility, female education and female unemployment rate are included, will be an extension of the model above, presented as a 7x7 matrix.

"An income increase" is defined by the model as a positive difference in per capita income from one year to the next, $\Delta lnGDPpc > 0$. Variation in the female labor force participation rate is given by the difference from the previous year; $\Delta lnFLFPr > 0$ constitutes an increase in the female labor force participation rate whereas $\Delta lnFLFPr < 0$ represents a negative labor supply

response. The logarithmic form allows for a percentage interpretation of the regression results and permits for analyzing small changes in percentages.

Finally, I conduct formal stability tests of both the restricted and unrestricted model in order to test whether the models are stable. According to the Eigenvalue stability condition, the estimated models is stable, indicating that the VAR process is stationary. Based on the result from the Lagrange-multiplier test of autocorrelation, I reject the null hypothesis of no autocorrelation at lag order 1 in both models at the 95 % confidence level. These tests imply that the model is accurately formulated, so that it appropriately deals with time dependent variance (Nymoen, 2014), autocorrelation and serially correlated errors (Gambetti, 2015). We assume the error term to have a constant mean of 0 and constant variance (Singh, 2018b). This means that the covariance between two observations in time depends only on the distance in time, all other factors partialed out. Thus, the error term should be "white noise" (Hyndman & Athanasopoulous, 2018); random variation that does not vary with the values of the explanatory variables and thus does not follow a systematic pattern or cause biasedness in estimations. The variation in the female participation rate is then explained by its past value, variation in the explanatory variables of the model and their respective past values, and random white noise.

5 Results and discussion

This study does not find consistent evidence of the relationship between the female labor force participation and per capita income. In this section, I present the regression results and discuss the estimated effects and possible mechanisms of the evaluated determinants of the female participation rate. Due to the nature of the relationship and the choice of estimation method, all estimated effects of the explanatory variables on the female labor force participation are understood as the lagged labor supply response – how the female labor force participation rate is expected to adjust in the next year based on last year's conditions. Furthermore, effects have to be interpreted as expected changes in the first difference; the change from one year to the next, also when not explicitly stated.

The results of the regression are displayed in the table below. The aim of this analysis is to attempt to grasp variation in the female participation rate and explore the possibility of a relationship between the female labor force participation rate and economic development in the time series data for the examined period. I am therefore predominantly interested in the directions of the relationships, illustrated by the signs of the coefficients.

Table 1:

Results of first differenced VAR(1) estimation

Dependent variable: Female LF Participation rate (natural log), first difference

Lags: 1

	Restricted model	**Unrestricted model**
Variable	**Coefficient (standard error)**	**Coefficient (standard error)**
Δ female LF participation rate	-0.069 *(0.188)*	-0.207 *(0.165)*
Δ GDP per capita, squared	0.092 *(0.941)*	-4.27** *(2.053)*
Δ GDP per capita, squared	-0.0038 *(0.054)*	0.223** *(0.109)*
Δ urbanization		0.026** *(0.011)*
Δ fertility rate		-0.008 *(0.035)*
Δ female education		-0.003*** *(0.001)*
Δ female unemployment		-0.007(*) *(0.005)*
constant	0.0054 *(0.007)*	0.002 *(0.009)*
	Observations: 38 $R^2 = 0.0050$	Observations: 38 $R^2 = 0.3494$

See text for variable explanations and definitions.

*** p < 0.01, ** p < 0.05, * p < 0.1, (*) p < 0.2

The focal point is on the coefficients associated with per capita income, in order to examine whether economic development has had a causal impact on the female labor force participation rate of South Korea the last 40 years. The U-shaped hypothesis supposes a convex relationship between female labor force participation and economic development, where the participation rate traces a U over the process of economic development by initially declining then, after reaching a threshold minimum point, increasing with development. We are therefore primarily interested in whether the effect on the explained variable for changes in the explanatory variable of economic development is believed to depend on the level of the explanatory variable in itself; the hypothesis resides in the assumption that changes in national income will have diametrically opposing effects on female labor force participation rates for different income levels. This is also the assumption that this thesis sets out to test. In order to find empirical evidence consistent with this theorized relationship dynamic, it must hold that the estimated coefficient of the linear

income term is negative and statistically significant indicating an initial negative effect of income increases tracing the downward slope of the U, while its square is positive and significant indicating a positive relationship when the economy reaches a threshold level of economic advancement.

The regression result of the restricted model indicates that the relationship between the female labor force participation and income per capita did not follow a U-shaped pattern in the examined period. It rather suggests that the relationship can be graphed as an inverted U, where income increases, given by the lagged effect of income increasing from one year to the next ($\Delta \ln GDP > 0$), increase female economic participation for small percentage increases between years, but with diminishing marginal returns so that the effect turns negative when the positive difference between two years is large. Figure 5a) to the left illustrates. However, ignoring the outliers and relating the result to the context, it could be argued that we are in fact looking at the upward slope of the U. This is not unlikely, as South Korea was classified as middle or upper income during the time period and therefore would be expected to be on the rising portion of the U. Moreover, one could also hypothesize that the relationship seems to trace an S, rather than a U. The diminishing marginals could be then viewed and explained a bottleneck effect in that there are limitations as to how large the response in the female labor force participation rate can be to an income increase from the previous period: the female labor supply is limited to the female working-age population and given the potential of other impeding factors such as the socio-cultural context of prevailing gender stereotypes or labor market frictions, the response in female labor supply will be muted or diminishing for large period-to-period income increases given by the differenced GDP per capita. This could indicate that the female labor force in South Korea is in the process of reaching its potential and adjusting to a long-run equilibrium.

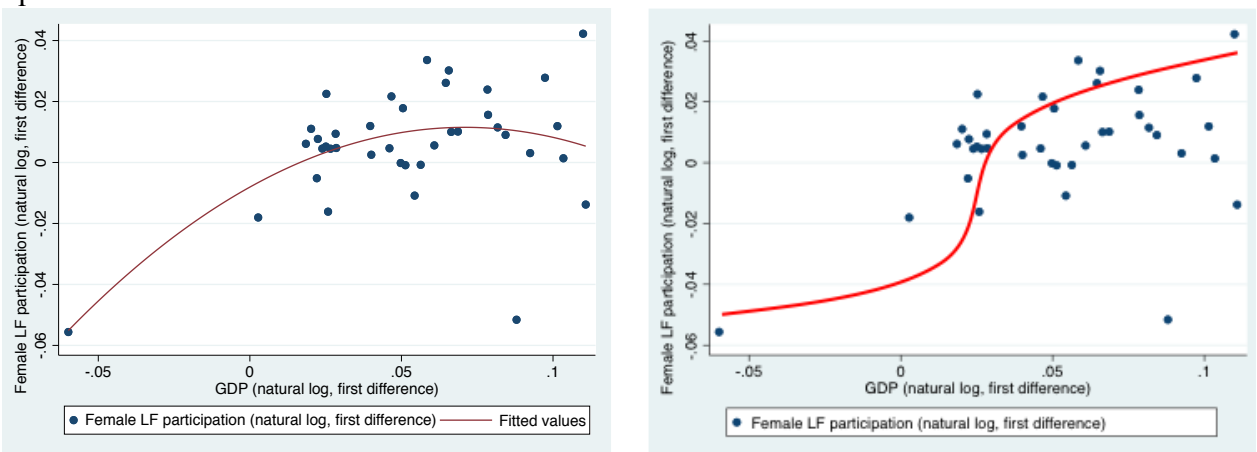

Figure 5: a) Fitted line vs. b) stylized fitted line (S-shape)

However, the result is not statistically significant nor robust; when controlling for the effects of urbanization, fertility, female education and female unemployment, the estimated effect of income increases turns negative. The estimated coefficient of its square is positive, which suggests the existence of a U-shaped relationship between the female labor force participation and income per capita for South Korea, as the coefficients of the unrestricted model fit the criteria of the hypothesis. The results are significant at the 5 % significance level. The per capita GDP turning point of the unrestricted model is $14,145.082. This is the expected income increase between two years where the effect on female labor supply switches from negative to positive. For economic expansion between two years beyond this level, the female labor force participation rate is expected increase, as displayed by an expected positive difference from the previous year to the next.

A test of the Granger causality, testing the unidirectional causality of variables in the unrestricted model, was conducted to investigate the direction of relationships. In VAR models, a variable X Granger causes Y if the preceding value of X (X_{t-1}) significantly affects the current value of Y (Y_t) (Sajwan & Chetty, 2018). The test indicates that income per capita, its square, urbanization, and female education Granger cause changes in the female labor force participation at the 5 % significance level. However, the high p-values of the female unemployment rate and fertility indicate that these factors are statistically insignificant to variation in the female labor supply.

As the estimated effect of economic development switches when controlling for the hypothesized determinants of the female participation rate indicates that the naïve model overestimates the causal effect of an income increase from one period to the next. The result of the Granger causality test could imply that the U-shape relationship did indeed appear for South Korea in the examined time period, when accounting for the control variables. The unrestricted model is an attempt of analyzing the relationship in a realistic context, whereas the restricted model considers the relationship between the variables in a vacuum. However, economic development does not occur in a vacuum in the real world, which could be an argument that the unrestricted model is a better fit for the data, providing a superior and more reliable evaluation of the relationship. The statistical significance of the results could also be a measure of its superiority.

Increased urbanization is expected to increase the female labor force participation. When the change in urban-to-total population from the previous period increases by one percentage point,

the estimated and statistically significant effect is an increase of the female participation rate of 2.6 % from the previous period. The positive effect can probably be attributed to the large increase in wage opportunities in urban areas relative to in rural areas; while urbanization can cause a decline in female labor force participation for middle-income countries, due to the lack of work opportunities available for women at this stage of development (Tsani et al, 2013), urbanization could positively impact participation rates as development continues, as urban cities typically constitute the epicenter of the service sector.

Though not significant, increased fertility is estimated to negatively impact female participation, as assumed by the U-shaped hypothesis. All else equal, if women have on average one child more compared to the previous period, the female participation rate is expected to fall by 0.8 %. South Korea has experienced a large decrease in fertility over the course of its economic development, which can be one of the possible factors behind the positive trend in the female participation rate. Decreasing fertility can be seen as both a driver and a consequence of economic growth. One can for example allude to possible income-specific and modernization effects on birth rates such as larger birth control availability and safer abortion opportunities as well as development of national social security and pension systems, or an increased female labor force participation rate in itself, which both increase the opportunity cost of a woman's time: women participate in wage-earning activities because they do not have children and they choose not to have children as they are in education or work. Correlation with the effects of fertility could be an explanation for why the restricted model underestimates the estimated isolated autoregressive effect of the female participation rate: the estimated coefficient changes from -0.069 to -0.207 when the additional variables are controlled for. Economic development can also make family and work compatible again through increased access to childcare services and often the option of working part time (Chapman, 2015).

The model predicts a negative effect of increased female unemployment, which is significant at the 80 % confidence level. If the difference in the female unemployment rate from the previous period is increased by one percentage point, the expected decrease in the female participation rate is 0.7 %, all else equal. This alludes to the presence of a discouraged worker effect for South Korean women over the time period. The discouraged worker effect is the tendency to drop out of the labor force discouraged by poor labor market outcomes due to barriers against employment (Ham, Mulder & Hooimeijer, 2001). The discussion of gender roles in the determination of the female labor force participation rate can be further related to

the gendered structure of the labor market and a socio-cultural gender role attitudes, which works as barriers to female participation, pushing them out of the labor force. A lack of labor market competitiveness due to gender discrimination and employer preference for men might reduce women's chances of employment, beyond observed differences such as different education levels and work experience. This can result in higher unemployment rates for women compared to men and the discouraged worker effect to cause women to drop out of the labor force rather than face the economic and psychological costs of seeking employment, assumed to be greater the higher unemployment is (Tsani et al, 2013).

The most surprising result of the analysis is the estimated negative effect of female education, which contradicts the estimated positive effects on female participation found in studies both on an international level in cross-sectional studies and in individual countries. The result challenges the assumptions of the U-shaped hypothesis and development economics of education to be one of the main drivers increased female participation. For the examined time period an increase in female educational attainment from the previous period was associated with a decrease female participation; when the first difference of percentage of university age women enrolled in university increases by one percentage point from the previous year, the female participation rate is expected to decrease by 0.3 %, all else equal. The estimated causal effect is significant at the 1 % significance level and indicates that the country's accomplishments in the education sector and human capital investment have not yet transferred to the labor market. The link between education and labor market outcomes is explored by traditional labor economic theory, as well as a plethora of empirical studies. Educational attainment is usually associated with increased human capital, productivity, skills and wage opportunities. Increased female education levels could through these elements attribute to improved labor market outcomes for women as it will increase women's ability to take advantage of the increased wage opportunities proposed in the growth-induced expansion of and shift towards the service sector when women to a larger degree satisfy the characteristics demanded in the labor market. Furthermore, the increased opportunity cost of her time may cause the labor supply decision to be bound by a larger positive substitution effect. The estimated effect based on the data is then inconsistent with traditional labor economics theory as well as empirical evidence. One explanation of the negative effect could merely be the effect of increased enrollment in itself: when women pursue a higher education and enroll in university to a larger degree, they withdraw from the labor market in their studying years, resulting in a decrease in the female labor force. The education system in South Korea is known

to be demanding, competitive and time-consuming (Mani & Trines, 2018), making studying and working incompatible. Assuming that higher university enrollment will eventually increase participation, as set out by economic theory, when the lagged effects become apparent, one would still expect to observe a positive effect of education for the considered time period, as the data reveal that the enrollment rates have been relatively high for a substantial portion of the considered years and the first differences of the variable were predominantly positive, which disclose a constant increase over time. However, statistics indicate low labor market attachment for highly educated women as South Korea, as the only OECD country, has a lower participation rate for women with tertiary education compared to women who have only completed compulsory education (OECD, 2007). Women remaining economically inactive despite high educational attainment could involve a substantial wasted investment and productive potential for the economy.

A possible explanation could be the large wage gap between the genders disclosed by statistics; a 2007 OECD review reports that the average median wage for South Korean women is 40 percentage points below that of men (OECD, 2007). This is the largest gender wage gap in the OECD (OECD, 2022e). The gender wage gap could indicate asymmetric returns to education conditional on gender, and lower returns to education could be one explanation for why South Korean women, despite high education attainment levels, participate to a lower degree. In the annual Global Gender Gap Report issued by the World Economic Forum, countries are evaluated with regards to female economic participation and opportunity, educational attainment, health and survival and political empowerment and given a score between 0 and 1 as a measure of the real gender gap, where 1 indicates full parity. In the 2021 report, South Korea was ranked 102nd out of 156 countries. Despite small gaps in education and health, the overall score of 0.687 is drawn down by low scores for economic participation and opportunity and political empowerment, attributed to factors like low wage equality for similar work (World Economic Forum, 2021). To explore the effect of a gender wage gap, I estimated a third model using data on the gender wage gap retrieved from OECD for the time period for which such data was available, between 1993 and 2019. Table 4 in the appendix shows the regression results for this time period and the effect of the inclusion of the wage gap. Particularly, the estimated coefficient of female education attainment remains negative and significant at the 99 % confidence level. Furthermore, the inverted U-shaped relationship between female labor force participation and GDP per capita estimated by the primary restricted model presented in table 1 materializes in the third estimation for the restricted time period, also when accounting

for wage differences between the genders. Having said that, it is not significant – possibly due to the smaller sample size. The results suggest a negative effect of the gender wage gap, which indicates that economic gender inequality can be a contributor to low female participation. Though statistically insignificant, one percentage point increase in the change in the gender wage gap from one period to the next is estimated to decrease the female labor force participation by 0.2 %, all else equal.

6 Limitations

The main limitation of this study was inaccessibility and unavailability of data, which restricted the time period investigated. This has two implications for the analysis; firstly, I could not properly test the existence of a U-shaped relationship between female labor force participation and GDP per capita over the course of its development. A consideration of the whole time period from 1960 to today would have been a superior and preferred approach to the hypothesis, as this would correspond to the entire development process from low to high income. This analysis instead relates to the transition from middle to upper income. Furthermore, the restricted time period resulted in a small data set with fewer observations. Small samples are suboptimal as they are more likely to produce less biased results and make hypothesis testing unreliable (Studenmund, 2016). With small samples, the probability of making the type 1 error of rejecting the null hypothesis when it is true is larger because the confidence intervals become narrower, subsequently the results might appear less significant than they are. This is why I include the 80 % confidence as an indication of statistical significance for some variables. The use of first differences further reduced the sample size: with 40 initial observations, the VAR model was estimated with a sample size of 38. This is still higher than the minimum of 30 observations for dynamic models as advised by Studenmund (2016).

Furthermore, the lack of robustness indicates violation of the zero conditional mean assumption of errors, and possible remaining serial correlation due to omitted variable bias cannot be ignored. The female labor force participation rate is likely a product of a plethora of factors and complex mechanisms at work, many of which it is likely that the model is likely to have omitted and thus does not properly account for. As the literature acknowledges, country specific cultural and structural factors seem to play a substantial role in the determination of the labor force participation rate of women. Qualitative research such as a survey by KOSIS on opinions on difficult factors for employment for women in South Korea indicates that social custom and

gender roles as well as problematic labor market conditions work as barriers to female employment in the country: the majority of respondents highlight the burden of childcare, social bias towards women, and unfair work conditions (KOSIS, 2022b). Due to the lack of data on social custom and gender roles for the whole time period considered in the time-series regression, these factors are not included in the model, and they will consequently fall within the error term. These could be meaningful to explore in the quest for a more profound understanding of female economic activity in today's South Korea, and I attempt to do so by OLS estimation on cross-sectional data in the next section. Furthermore, the error term could be heteroskedastic due to correlation with the model variables. It is for example not unreasonable to hypothesize that the effect of social stigma and gender stereotypes on the female labor supply can be correlated with economic advancement, in that they for instance could be more dominant in more traditional societies with lower income levels where the family is more important.

Some of the data series exhibit little variance. Combined with the omitted variable bias and a small sample, the estimated effects are likely to be biased. A measurement issue that could contribute to unreliable results could be that women often are engaged in the informal sector (Bonnet, Vanek & Chen, 2019) which is not registered and thus makes the observations of the female participation rate inaccurate. In sum, the estimates of the coefficients' standard errors are likely to be biased, which contributes to unreliability of inference conclusions.

The use of per capita income necessitates a justification. Although not a perfect measure of economic development, it is among the most commonly used. Despite its shortcomings, I have concluded that GDP per capita is the best fitting approach to model economic development in this regression. It is among the most reported and standardized measures of economic activity across countries and over time, which facilitates observation and descriptions of development, quantitative data comparisons, and income group classifications of economies. The measure is also consistent with the classification of the labor force as the population engaged in economic activities registered in the national accounts, so that it concurs with the definition of the independent variable. Furthermore, as the majority of studies on the U-shaped hypothesis uses per capita income as the proxy for economic development. By employing the same explanatory variable, the results of this examination will be more comparable to existing findings.

Another aspect that would have made the model perform better in the evaluation of the female labor force participation rate of South Korea over the course of economic development, would

be to include a dummy variable for the years of the Asian Financial Crisis of 1997, which could capture how the female participation rate responds to the negative shocks such as a financial crisis. This is a suggestion for future research.

7 Robustness

Quest for a deeper understanding: a static labor market approach to the female labor force participation rate

The previous analysis attempts to explain the variation in the female participation rate in South Korea from 1980 to 2019, and to what extent the patterns and trends can be explained by economic development, proxied by GDP per capita. The regression results trace a significant U-shape of the relationship between the female participation rate and per capita income in South Korea over the last four decades when controlling for the selection of hypothesized determinants of the female participation rate. This analysis can be used to outline possible patterns of aggregated responses in female labor supply decisions for South Korean women over time. Additionally, it might contribute in the identification of mechanisms that may have significantly contributed to the economic status of women throughout the country's economic history and transformation, and the factors that could play a pivotal role in the pursuit of economic gender equality as well as assist in the circumvention of a predicted economic stagnation as the one faced by South Korea, generated by labor shortages due to an aging and declining population.

An interesting consideration is the distinction between the evolution of female participation in absolute terms, and relative differences in participation *levels*. The present paper finds that the driving forces described by the U-shaped hypothesis may be at work in South Korea. This could mean that we can expect the female labor force participation to continue to increase in the coming years as economic growth continues, given that it continues. It could essentially be "just a matter of time" where the underlying mechanisms eventually will result in the economy reaching and adjusting to higher female participation rates on its own accord. Yet, the analysis does not allow for an adequate explanation of the female labor force participation level of South Korea, which is, as I have demonstrated in previous sections, lower than countries of the same income and advancement level and thus lower than the U-shaped hypothesis would predict. Furthermore, suspicion of omitted variable bias and the VAR estimated model's low R^2 measure of 0.3494 indicates that much remains unexplained. This alludes to a presence of other

determinants of female labor force participation that could be binding for labor supply decisions at the household level that could manifest and be of significant economic magnitude on the macro level, especially if they dominate the effect of economic growth. While the female labor force participation is an important macroeconomic variable, it is also a subject that necessitates a microeconomic approach as it is a result of decisions taken at the household level.

To reach this goal, I estimate a multiple linear regression model that uses the mechanisms of the U-shaped hypothesis as a point of departure for an analysis of the current situation for women in the temporary South Korean labor market to explore whether the data exhibit evidence of structural barriers to female labor force participation. The model is estimated by OLS on a pooled cross-section of the 17 administrative units of the country; the nine *do*s, provinces, (Gyeonggi-do, Gangwon-do, Chungcheongbuk-do, Chungcheongnam-do, Jeollabuk-do, Jeollanam-do, Gyeongsangbuk-do, Gyeongsangnam-do and Jeju Island), the "Special City" of Seoul, and the six metropolitan cities Busan, Daegu, Incheon, Gwangju, Daejeon, and Ulsan. The "special self-governing city" of Sejong was omitted due to data inaccessibility of several variables, possibly due to its late foundation. A geographical map of the subdivisions is available in the appendix. As the performance and precision of OLS increases with the number of observations, I pooled the cross-section for the years 2015, 2017 and 2019 so that the model is estimated with 48 observations. The years were selected to represent the current labor market conditions for South Korean women, in order to grasp the determinants of the female labor supply in the country today. 2019, as opposed to 2020, was selected in order to avoid noise related to the Covid-19 pandemic. Due to the use of some data that were collected at a biannual interval, the choice of the additional years in the pooled cross-section fell on 2017 and 2015. The time period between the years is judged to be small enough not to exhibit strong time trends that could bias the estimates. All data on the provincial level are retrieved from KOSIS, the Korean Statistical Information Service.

The population regression function which the estimated model is based on is expressed as follows:

$$\begin{aligned} FLFPr_i = \beta_0 + \beta_1 GDPpc_i + \beta_2 GDPpc_i + \beta_3 agriculture_i + \beta_4 servicesector_i + \beta_5 fertility_i + \\ \beta_6 femeducation_i + \beta_7 femeunemployment_i + \beta_8 marriageage_i + \beta_9 socialexpenditures_i + \\ \beta_{10} norms_i + u_i \end{aligned}$$

Here, i is the subscript designating the individual provinces. The dependent variable is, as before, the female labor force participation, expressed as a linear function of ten explanatory variables. The mean participation rate was 52.9 %, and it ranges from 43.6 % in Ulsan in 2015 to 66,1 % in Jeju in 2017.

GDP per capita is used as an approximation of the area's income level, measured in thousand won. The average value across the sample is 35,031 thousand won, which constitutes about 2015 US$ 24,900. It ranges from the minimum value of 20,991 thousand won for Daegu in 2015 to the maximum value of 65,370 thousand won for Ulsan in 2017. It is the natural logarithm of the variable that is included in the model. The justification for the use of the logarithmic form is stated in the specification of the VAR model.

Agriculture is the percentage of total employment in the area engaged in agricultural activities, agriculture, forestry and fishery. The data reveal a substantial difference in the role of the agricultural sector as a source of employment across provinces, from about 0.07 % in Seoul in 2015 to 27.03 % in Jeju in 2017.

Servicesector is similarly the percentage share of total employment of the province in the tertiary sector. The standard deviation of the percentage share of employment in the service sector is smaller as opposed to agriculture, which indicates less variation across the country.

Fertility captures the effect of fertility and childbirth. It is the total fertility rate; the number of children a woman is expected to have given that she lives to the end of her reproductive life (WHO, 2022).

Femeducation is used to measure the effect of female educational attainment. It is the female enrollment rate in tertiary education, and is measured by the percentage of women enrolled in university relative to the female population of "university age", judged to be the age interval of 20-29 years. This is the age interval where a woman is likely to be in higher education.

Femunemployment is the female unemployment rate.

Marriage age is included to capture how marriage affects the labor supply decision. It is the share of the female population that is in the average age interval of 25-34 years, which is the years associated with marriage and family formation in South Korea.

Social expenditures is the average per capita public spending on functions that could be relevant to labor supply decisions; family, unemployment and active labor market programs.

Norms is included to estimate the existence and possible effect of norms and opinions regarding family obligations and women in the work force. It is measured by the percentage of respondents in the Social Survey conducted by KOSIS, that in a question regarding whether women should get a job respond that women should "only devote to housework" (as opposed

to “Should always get a job”, “Should get a job before marriage”, “Should get a job before giving birth to the first child”, “Should get a job after raising the children”, “Should get a job both before and after raising the children”, and “Don’t know”). The responses vary from 3.9 % (Jeju, 2017) to 9.8 % (Ulsan, 2015), with an average of about 6.4 %.

u is the error term reflecting all other unobserved and omitted factors that determine the female labor force participation rate.

The model is estimated by OLS, the results of which are presented below. The second model includes an urban dummy variable using rural areas as the reference group to see whether the effects differ between urban and rural areas. The third model includes an interaction term between the urban dummy variable and income.

Table 2:

Results of OLS estimation

Dependent variable: Female LF participation rate (natural log)

	Model 1	**Model 2**	**Model 3**
Explanatory variable	**Coefficient (standard error)**	**Coefficient (standard error)**	**Coefficient (standard error)**
GDP per capita	3.590*** *(0.627)*	3.617*** *(0.653)*	3.954*** *(0.647)*
GDP per capita, squared	-0.501*** *(0.088)*	-0.505*** *(0.092)*	-0.562*** *(0.092)*
agriculture, %	-0.0007 *(0.006)*	-0.0007 (0.007)	-0.0005 *(0.0006)*
services, %	0.0002 *(0.001)*	0.001 *(0.001)*	0.0004(*) *(0.001)*
fertility	-0.005 *(0.048)*	-0.004 *(0.049)*	-0.004 *(0.047)*
female education	-0.0002 *(0.005)*	-0.0002 *(0.005)*	-0.0003 *(0.051)*
female unemployment rate	-0.008 *(0.013)*	-0.009 *(0.013)*	-0.012 *(0.013)*
marriage age, %	-0.001 *(0.006)*	0.002 *(0.006)*	0.0008 *(0.005)*
social expenditures	0.073*** *(0.015)*	0.075*** *(0.017)*	0.076*** *(0.016)*
norms	-0.004 *(0.007)*	-0.004 *(0.007)*	-0.004 *(0.007)*
urban		0.003 *(0.016)*	-0.353* *(0.174)*
GDP/capita*urban			0.101** *(0.049)*
constant	-2.508** *(1.147)*	-2.557* *(1.195)*	-3.084** *(1.174)*

	Observations: 48 $R^2 = 0.7140$	Observations: 48 $R^2 = 0.7142$	Observations: 48 $R^2 = 0.7447$
See text for variable explanations and definitions. *** p < 0.01, ** p < 0.05, * p < 0.1, (*) p < 0.2			

The U-shaped relationship between female participation and income per capita is not consistent with the cross-sectional data. The data suggest that the female labor force participation rate follows the inverted U indicated by the restricted VAR model estimated in the previous section. Female labor supply is consequently associated with a positive response to income increases in lower income regions and a negative response in the more affluent regions. Figure 6 illustrates the estimated relationship. With p-values of 0.00 for both the linear and quadratic income term, the result appears highly significant. It is also robust to the alternative model specifications including the urban dummy variable. The estimated turning point where the effect of income increases turns negative is 35,894 thousand won for the base model. In 2015 $US, this constitutes about $23,960. This could imply that the positive substitution effect dominates for women in regions with per capita income below 35,894 thousand won, while for women in regions with GDP per capita above 35,894 thousand the negative income effect is expected to dominate the labor supply decision. Consequently, the data suggest that as income increases on the household level, the economic necessity of multiple income sources lessens, allowing women the opportunity to leave the workforce for the home.

This effect could be strengthened by gender-conditional comparative advantages in home and market work, as per Becker's model of labor division introduced in the literature review. Men and women could have different abilities and physical endowments, resulting in an unequal, but economically optimal labor division for the household as a whole, where the man and woman specialize along the lines of their comparative advantage. Specialization further exacerbates the relative productivity levels in wage and housework, for example as women lose out on human capital gains through experience making them non-competitive on the labor market which in turn could disincentivize labor force participation via a discouraged worker effect. Due to distributional effects, the dynamic welfare effect could be that an arrangement that is individually optimal with regards to total household gains of efficiency in the static sense on a micro level rises economic inequality between men and women at the macro level, also in the long run. It would be interesting to include time allocation between housework and wage

work into the analysis to explore possible comparative advantage effects on the labor supply decision, as well as the wage gap to see how women's labor supply decisions depend on her own and the husband's income respectively, however data on female and male wages and time allocation are not available at the provincial level. This is a proposition for future academic work.

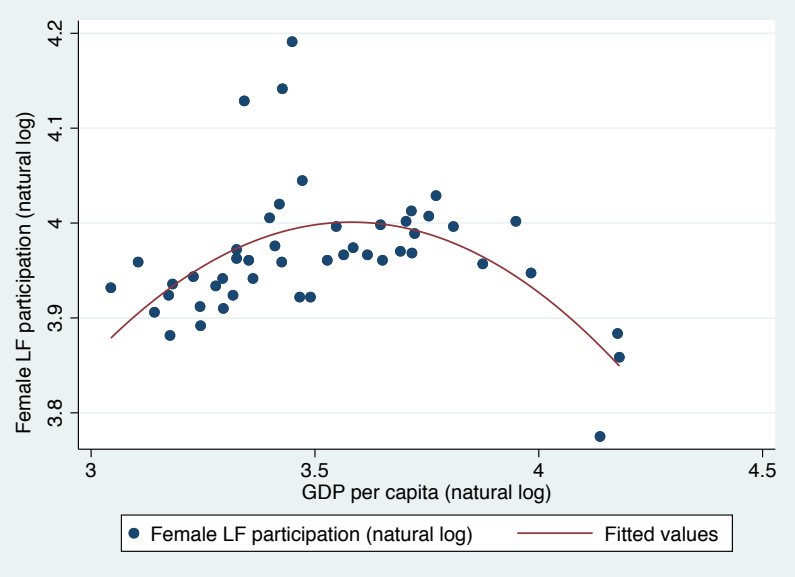

Figure 6: Inverted U-shaped relationship based on the data

Inclusion of the urban dummy variable reveals that urban areas are expected to have slightly higher rates of female participation, by 0,3 %, however the result is not significant. This is consistent with the positive effect of urbanization as indicated by the VAR regression results and could be associated with more wage opportunities in urban areas. To see whether female participation responds differently to income in rural and urban areas, the third model includes an interaction term between the two variables. The regression results, significant at the 90 % confidence level, suggest that urban female workers respond more to income increases, as indicated by the positive interaction term. This is unexpected, as one would presume women in rural areas to be less affluent and therefore be bound by the positive substitution effect as insinuated by the negative coefficient of the quadratic income term. However, the estimated isolated effect of the urban-rural classification switches when the interaction is included; in the third model the estimated effect of urbanization is negative. This indicates that the model overestimates the unique positive effect of residing in an urban area on the female labor supply, as some of the effect can be attributed to different levels of income. When the interaction between income and the urban dummy variable is controlled for, urban areas are associated

with lower levels of participation. This would be compatible with the U hypothesis' prediction of higher female participation in agrarian and less affluent areas. The result is significant at the 90 % confidence level.

The employment share in the agricultural and tertiary sectors are included in order to approach the effect of sectoral change over the course of economic development; one of the key explanations behind the U-shaped hypothesis as wage opportunities for women have historically resided in these two sectors. An increase in the employment share in agriculture is estimated to decrease the female labor force participation rate, whereas the opposite applies to the service sector. Neither sectors display significant relationship with the female labor force participation rate, except for in the third model where urbanization and its interaction with income is considered, where the tertiary sector has a significant effect on participation on the 80 % confidence level. The positive impact of an expansion and thus increased wage opportunities in the service sector is not surprising, as the service sector is the main employer of women in South Korea (Yang, 2021). Howbeit, correlation between the sectoral shares and GDP is likely and cannot be ignored as estimates could be spurious.

Consistent with the results of the VAR estimation and the expectations based on economic theory, the data suggest that increased fertility is associated with decreased participation. When the fertility rate increases by one child per woman, the female labor force participation is expected to decrease by 0.5 %, all else equal. The result is robust to the consideration of urbanization. The negative effect of female educational attainment shows up in the cross-sectional data as well, although it is no longer significant. A percentage point's increase in the female population of university appropriate age enrolled in university is associated with a 0.02 % decrease in the female participation rate. The estimated effect could be unreliable and, as the measure of the female enrollment rate as the share of women of university age enrolled in university is an approximate, rather than a direct measure of education. This excludes female students that fall within other age categories or are enrolled at other institutions of higher education such as technical college, cyber university, or polytechnic college.

Another predictor and measure of labor market outcomes is unemployment. The data insinuate, analogous with the VAR estimation, that the discouraged worker effect is relevant for women in the South Korean labor market today and could contribute to the low female participation rate in the country, though the effect is not significant. The estimated effect of an increase of

one percentage point in the female unemployment rate is a decrease in the female labor force participation rate of roughly 1 %, all else equal.

The main objective of this static analysis of the temporary labor market conditions for South Korean women was to explore the role of gender roles and the institution of marriage. The model attempts to capture these effects through the two variables of the percentage of the female population of "marriage age" and the percentage of the surveyed population that is of the opinion that women should not work, but rather devote herself to the home. According to the regression results, social stigma and gender expectations towards women are expected to negatively impact the female participation rate, however the results are not significant. All else equal, an increase in the percentage of the population that thinks that a woman should devote her time to housework and raising children by one percentage point is associated with a decline in the female labor force participation rate by 0.4 %. The result insinuates that some of the low economic participation of South Korean women could be attributed to entrenched traditional gender norms and a gendered division of familial duties and that social pressure based on prevailing gender norms and stereotypes, which could be binding for the individual woman's labor supply decision as well as structurally affect labor market outcomes in such a way that a woman judges herself better off outside the labor force than in it. As noted in a previous section, many South Korean women experience a trade-off between work and family life and a social expectation to prioritize family life, and descriptive statistics suggest an M-shaped employment curve over a woman's life. This can materialize as a barrier to employment and a source of disparity in employment conditions for men and women. If employers expect women to take parental leave, or exit the work force for good, during her 30s following marriage and childbearing, they could be less willing to offer permanent employment or promotions to women. Furthermore, South Korean wages are typically seniority-based as opposed to performance-based (OECD, 2018), which will result in lower wages for women that take a career hiatus to pursue spousal and motherly duties. The lower the female wage, the lower the opportunity cost of her time, which could result in a low substitution effect in the labor supply decision and thus a domination of the negative income as women reduce labor supply or drop completely out of the workforce. The social stigma can be analyzed as an additional implicit cost of female labor force participation, further reinforcing the effect.

The model approaches the aspect of marriage by the marriage age variable. The measure can also be interpreted as a measure of age composition of the female population. The effect of

being of “marriage age” is expected to have a negative effect on the labor supply decision in the base model; a one percentage point’s increase in the share of women of marriage age is expected to decrease participation by about 0.23 %, all else equal. However, the effect is not significant nor robust to the inclusion of the urban dummy variable; when accounting for the effect of urbanization, the effect is estimated to be positive. This could indicate that the primary model overestimates the negative effect of being of marriage age, and that some of the effect reflects differences between rural and urban areas. Additionally, the measure is likely not a direct determinant of female participation and could expose other effects correlated with the age distribution of an area that affect the female participation rate. We cannot exclude the possibility of correlation with the error term, which would indicate that the zero conditional mean assumption of errors is violated, causing biasedness in the coefficient. We could for example wrongfully pick up on an effect of local population growth or migration of young unmarried workers to certain regions and a subsequent increase in the labor force.

Certain characteristics of the South Korean labor market reveal an inflexible labor market with poor labor market conditions and outcomes for women that disincentivize female participation. This analysis indicates that familial duties and the discouraged worker effect might be contributors to the low female participation rate in South Korea today. Through allocation of social expenditures, poor labor market outcomes can be improved through correction of inflexible labor markets and a reduction of the implicit and explicit costs of having children. The Global Gender Gap Report reveals that South Korea has a low number of female legislators, senior officials and managers (World Economic Forum, 2021). Low female representation in political processes and supervisory posts could impact the prioritization of women’s labor conditions. This could be one possible explanation behind the country’s relatively low public spending on social infrastructure and parental support such as childcare facilities and paid parental leave. In 2019, social spending accounted for about 12 % of GDP, which is eight percentage points lower than the OECD average of 20 % and 13-16 percentage points below that of the Nordic countries, which are often celebrated for their social infrastructure (OECD, 2022d). According to the results, an increase in social expenditures designated for family support, unemployment and active labor market programs, in per capita terms to adjust for population size, is expected to increase the female labor force participation, all else equal. The causal effect is significant at the 99 % confidence level in the base model and robust to robustness checks. The economic magnitude of social public funding appears significant based

on the data: an increase of a million won in social expenditures relevant to female economic participation is expected to increase the female labor force participation by 7.3 %, all else equal. Increased family related social expenditures could decrease the trade-off between career and family formation, for example by increasing availability and cost of childcare and better parental leave conditions. Labor market and unemployment programs could reduce frictions in the labor market, which could potentially improve labor matching, ensure that women obtain work shortly upon graduation from tertiary education and decrease the discouraged worker effect.

8 Conclusion

This study has explored the relationship between the female labor force participation and economic development, measured by per capita income, in South Korea. The analysis comprised both of a dynamic and static approach: the time series analysis of the time period of 1980 to 2019 allowed for an investigation of female labor supply in the dynamic setting of economic development, whereas the static examination of the determinants of women's economic participation provided a depiction of the role of income, and additionally an exploration of other binding factors, in labor supply decisions of women in temporary South Korea.

As both U- and inverted U-shaped relationships are insinuated depending on the model specification and data, the results appear sensitive to estimation approaches and one must be careful in drawing conclusions on the relationship. The U-shape appears in the time series relationship when accounting for control variables such as urbanization, fertility, female education and the female unemployment rate, however the static model alludes to an inverted U.

A consistent and unexpected finding in the analysis is the negative impact of increased female educational attainment. In this regard, South Korea seems to differentiate from the international trends and predictions based on economic theory which identify education as a driving force of female labor force participation. The negative effect could reflect asymmetric returns to education based on gender, and rigid and gendered labor markets. Gender stereotypes and social stigma towards women in work may inhibit female labor supply in South Korea due to a trade-

off between family formation and career, as suggested by statistics and the empirical results of this study. A positive and significant effect of family- and labor market specific social expenditures could propose a course of action in the aim of encouraging female economic participation in South Korea. Yet, one could object that effects of increased social expenditures are likely to be restricted as long as prevailing gender stereotypes remain dominant and binding in the individual labor supply decision.

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Appendix

1 VAR Regression Results, 1993-2019

Table 4:

Results of first differenced VAR(1) estimation, 1993-2019

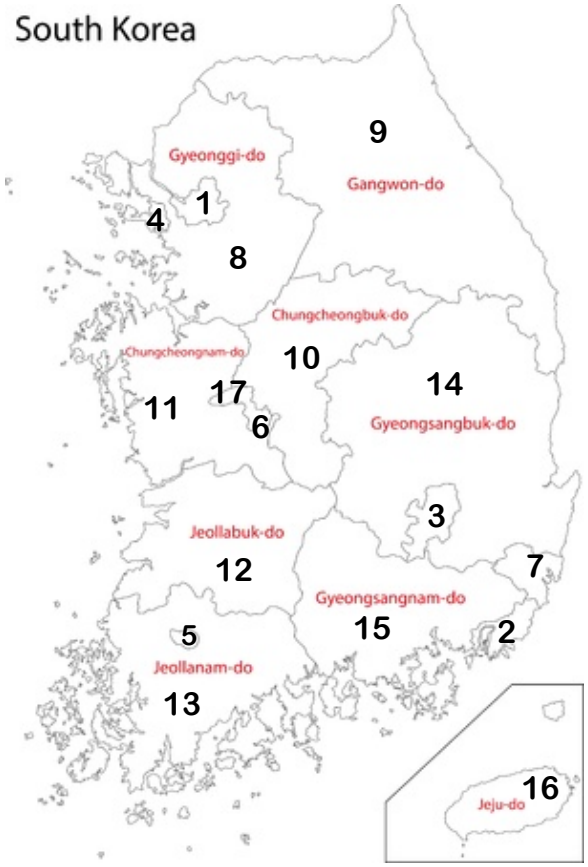
Dependent variable: Female LF Participation rate (natural log), first difference

	Unrestricted model	**Model 3**
Variable	**Coefficient (standard error)**	**Coefficient (standard error)**
Δ Female LF participation	-0.335(*) *(0.230)*	-0.337(*) *(0.232)*
Δ GDP per capita	2.908 *(2.853)*	2.86 *(2.904)*
Δ GDP per capita, squared	-0.138 *(0.147)*	-0.136 *(0.141)*
Δ urbanization	-0.005 *(0.016)*	-0.005 *(0.016)*
Δ fertility rate	-0.015 *(0.030)*	-0.016 *(0.021)*
Δ female education	-0.004*** *(0.0007)*	-0.004*** *(0.032)*
Δ female unemployment	-0.005 *(0.005)*	-0.005 *(0.005)*
Δ wage gap		-0.002 *(0.002)*
constant	0.007 *(0.007)*	0.007 *(0.007)*
	Observations: 26 $R^2 = 0.5890$	Observations: 26 $R^2 = 0.5891$

See text for variable explanations and definitions.

*** p < 0.01, ** p < 0.05, * p < 0.1, (*) p < 0.2

2 Map: Subdivisions of South Korea



17 subdivisions:

Special cities: Seoul (1), Busan (2), Daegu (3), Incheon (4), Gwangju (5), Daejeon (6), Ulsan (7), Sejong (17).

Provinces: Gyeonggi (8), Gangwon (9), Chungcheongbuk-do (10), Chungcheongnam-do (11), Jeollabuk-do (12), Jeollanam-do (13), Gyeongsangbuk-do (14), Gyeongsangnam-do (15), Jeju (16).

Source of base map: VectorStock (n.d.). Contour South Korea Map Vector Image [Map]. https://www.vectorstock.com/royalty-free-vector/contour-south-korea-map-vector-1606438

Numbering added by author.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