

The Economic Role of Paid Child Care in the U.S.

A Report Series — Part 3: Economic Growth Modeling

May 2022



This report series was commissioned by the Committee for Economic Development of The Conference Board and produced by RegionTrack, Inc., an economic research firm, with generous support from the W.K. Kellogg Foundation. We also express special thanks to Grace Reef, President of Early Learning Policy Group, for her review and contributions. The report series provides an overview of the role of paid child care in the U.S. economy and across states. The series analyzes paid child care usage over the past two decades and its impact on workforce participation, including a focus on women and mothers.

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Executive Summary

This report is the third in a four-part series focused on the use of paid child care in the U.S.¹ The report provides extensive empirical analysis on a group of factors that potentially underlie differences in paid child care usage across the states and over time. These factors were introduced and discussed in the [first report in the series](#).

Time series tests of both short- and long-run statistical causality are used to examine the empirical relationships between these factors and paid child care usage. The report then develops a model of long-run economic growth and uses it to examine the potential effects of increased maternal and female labor force participation on real income growth and paid child care usage.

The results provide a helpful empirical view of the historical linkages between these factors and paid child care usage as well as the role of paid child care in economic growth. For policymakers, the results also inform the ongoing policy debate over the economic role of paid child care.

Factors Explaining Paid Child Care Usage

The empirical tests performed throughout the report examine two groups of potential factors driving paid child care usage. The first group includes economic and demographic factors that mostly address which parents need paid child care and are best able to afford it. Three additional factors capture the unique characteristics of the child care market in each state and focus on measuring the degree of accessibility and affordability of paid child care.

Economic and Demographic Factors. The report examines three economic and demographic factors:

- labor force attachment (particularly for mothers),
- household income, and
- educational attainment.

Historical time series survey data indicate that all three factors are associated with higher paid child care usage at the state level. Each factor also carries a sound theoretical basis for influencing paid child care usage.

Child Care Market Structure. The empirical tests also examine three characteristics of the child care market in each state:

- Child care expenditures as a share of income (or cost burden),
- Federal and state child care subsidies and cost offsets (such as tax credits) as a share of income, and
- The availability of alternative sources of publicly provided child care (primarily the share of preschool children ages 3 and 4 in public preschool).

These factors closely correspond to three areas of ongoing child care policy concern:

- the high cost of care,
- the degree of public funding of child care, and
- the role of public preschool provision.

50-State Panel Dataset

A key aspect of the empirical tests is the use of a 50-state panel dataset that captures the unique characteristics of paid care usage across the states. Panel techniques can provide for more robust estimates because they simultaneously utilize the information contained in the economic behavior of multiple regions and in the time dimension of the data.

The empirical tests use a balanced panel of data covering all six factors for the 50 states. Paid child care usage and the economic and demographic factors are available for 2000 to 2020. A balanced panel for child care market characteristics extends from 2009 to 2019. Hence, a combined panel using all six factors is available for the 2009 to 2019 period.

Unit root tests of stationarity are applied to the panel dataset and provide strong evidence that all the data series used in the empirical tests are nonstationary in levels or possess a unit root. Subsequent unit root tests on first differences of each series indicate that all the data series are stationary in differences for a strong majority of cross sections (states). The stationarity characteristics of the panel dataset are used to inform the application of the time series techniques used in the remainder of the report.

Empirical Causality Tests

Both short- and long-run tests of statistical causality are used to address the key question of whether economic, demographic, and child care-related characteristics of each state can be used to inform the future use of paid child care. The tests also shed light on the reverse question of whether changes in paid child care usage influence the future value of the economic, demographic, and child care market factors across the states.

The initial empirical tests use Granger causality tests of short-run lead-lag relationships. Granger causality is a statistical notion of causality that tests for increased predictability of the future path of one variable, X, using another variable, Y. While not addressing the issue of economic causality in the traditional sense, the tests provide an empirical measure of the historical responses and timing embodied in the relationships among the data. When coupled with a theoretical basis for inclusion in a model, Granger causality tests provide valuable observational evidence on the historical relations among a set of time series variables.

Long-run cointegration tests are subsequently used to examine potential long-run relationships present among the variables over time. The concept of cointegration is closely tied to the notion of Granger causality but focuses on the long-run dimension of the relationship among a group of variables over time. A set of cointegrated variables maintain a long-run equilibrium relationship over time. The linkages between cointegrated variables can be quantified as long-run elasticities.

Finally, cointegration results are used to construct a 50-state model of long-run income growth. The model is used to estimate the size of potential economic growth effects and changes in paid child care usage that may result from changes in labor force participation.

Short-Run Causality Tests – Paid Care and Labor Force Attachment

The Granger causality tests provide considerable evidence on the short-run linkages between paid child care usage and labor force attachment. Four overall findings emerge from the tests:

1. **Evidence of bi-directional Granger causality is found between the share of children in paid care and the female labor force participation rate.** The implication of bi-directional causality is that paid care evolves jointly over time as women move in and out of the labor force, with each series forecasting the future movement of the other. This is consistent with expectations that a dynamic relationship with feedback exists between the share of women in the labor force and the share of children in paid care.

2. All other remaining significant Granger causal relationships are present in only one direction, from the share of children in paid care to labor force attachment. **In other words, greater use of paid care leads to increased future labor force attachment.** For policymakers, this indicates that changes in the availability of paid care are far more likely to result in increased labor force attachment than increased attachment is to precede more paid care usage. As anticipated, any increase in paid care is most likely to come from the increased attachment of mothers.
3. **An increase in the share of children in paid care is likely to precede an increase in overall labor force attachment, with both male and female attachment responding to increased paid care usage.** This evidence points toward a broader labor force attachment effect for both males and females rather than simply increased female participation as a greater share of paid care is used.
4. **Future paid child care usage is far more closely associated with the labor force participation rate than the employment ratio.** The implication is that workers who are unemployed but remain in the labor force play a role in explaining paid care usage.

Additional tests of maternal participation for various groups of mothers by age of the child in care are performed. Three groups of mothers are examined: those with all children ages 0 to 4, those with a youngest child ages 0 to 4, and those with a youngest child ages 0 to 14. The expectation is that mothers with younger children generate a greater causal response relative to paid care usage. The findings suggest that:

1. The presence of younger children is far more closely associated with the use of paid care across the states than the presence of older children.
2. There are two distinct components to the finding on mothers and the age of the child.
 - a. First, the share of children in paid care is significantly Granger caused only by the participation of mothers with all children between the ages of 0 and 4.
 - b. Second, the causal linkages are most significant for explaining the future share of children ages 0 to 4 in paid care versus those ages 0 to 14.
3. The relationship for mothers with all children ages 0 to 4 has an estimated elasticity that is more than twice as large as that for children ages 0 to 14 in paid care.
4. None of the maternal measures of labor force attachment are statistically significant for future paid care usage when examining the broader group of children ages 0 to 14 in paid care. Only overall female labor force attachment is significant for ages 0 to 14 in paid care. This finding may be proxying for the effect of improved overall economic conditions on the use of paid child care by all households, including those formerly using unpaid care.

Short-Run Causality Tests – Paid Care and Other Economic Factors

Additional tests add the remaining two economic and demographic factors – education and income – to labor force attachment in a system Granger causality test of the relationship between paid care usage and the three economic and demographic factors.

Based on prior findings, we use paid care usage for children ages 0 to 4 and the labor force participation rate for mothers with all children ages 0 to 4. Education is defined as average years of schooling and income is measured initially as real personal income per capita. The estimates are formed using a balanced panel in the 2000 to 2019 period.

The findings provide an expanded backdrop for evaluating the role of economic factors in determining paid care usage:

1. Consistent with earlier evidence, the results continue to find bi-directional Granger causality between the share of children in paid care and maternal participation.
2. The short-run link from education to paid care usage is found significant but has a seemingly counterintuitive negative sign. While surveys consistently find a positive relationship between the *level* of education and paid care usage, the Granger causality test instead measures the *change* in education relative to paid care usage. The negative sign may be highlighting underlying behavior where higher income households are using a lower share of paid care as their incomes rise, but still have a far higher use of paid care than lower income households, as seen in survey data.
3. The level of real personal income per capita is not found Granger causal for paid care in the short run. This indicates limited evidence of a near-term effect on paid care usage where short-run fluctuations in income lead to greater use of paid child care, but does not rule out causality in the long-run. **However, in testing the sensitivity of this finding to the variable definition used for income, both nominal personal income per capita and median household income are found Granger causal for paid child care.** The significance of the two nominal measures suggests the presence of a macroeconomic effect and may simply reflect diminished concerns over inflation during the extended period of low and stable inflation covering most of the sample period used for the model. **On balance, the short-run tests are consistent with the notion that increased income leads to increased future use of paid child care.**

Short-Run Causality Tests – Paid Care and Market Characteristics

Two variables reflecting child care market characteristics at the state level are added to the model. The first is the measure of the net cost burden of child care (*cccosthnet*) to families with a child in paid care and is calculated from two of the market characteristics. The variable is calculated as the difference between the child care cost burden (cost per child as a share of household income) and federal and state subsidy and cost offsets as a share of household income, both as detailed in the report. The new variable provides a measure of net child care costs as a share of household income faced by families with children ages 0 to 14 in paid care. The second child care market variable added is the share of children ages 3 and 4 in various forms of publicly funded preschool.

The findings provide mixed evidence on the short-run role played by market characteristics in explaining paid care usage:

1. Bi-directional short-run Granger causality is still found between the share of children in paid care and maternal participation when the market characteristic variables are included in the model. Maternal labor force participation (*lfprfc04*) is the only explanatory variable found individually Granger causal in the short run for paid care usage. The estimated elasticity from maternal labor force participation to paid care remains highly stable when market characteristics are included in the equation.
2. Tests of a link from the net cost burden for paid care to paid care usage provide little evidence that changes in the cost burden for child care precedes changes in paid care usage for younger children. These findings do not suggest the absence of a relationship between the cost of care and the use of paid care but merely identify no short-run lead-lag relationship between the two in either direction. Alternative modeling approaches may be better suited for examining the response of child care usage to cost.
3. The share of children in public preschool is found inversely related to the share of children in paid care, as expected, but is marginally insignificant. Nevertheless, the estimated coefficient (-0.1635) suggests that a 1 percent rise in the share of children in public preschool would reduce the share of children in paid care by 0.16 percent.
4. The relatively small sample size for the market characteristics limits our confidence in the findings on market characteristics.

Panel Cointegration Tests and Model Estimates

Testing for cointegration among child care variables is promising because it tests for the presence of stable long-run statistical relationships among the set of factors believed to influence paid child care. Much like short-run Granger causality tests, they inform the joint behavior of the group of variables as they evolve over time.

Panel cointegration techniques are used to test for the presence of long-run cointegrating relationships between paid child care usage and the economic and demographic factors. Child care market characteristics are excluded from the tests due to the short sample period for which these data series are available.

The findings on the presence of cointegrating relationships shed considerable additional light on the statistical long-run relations present between paid child care and the other variables:

1. **The share of children in paid care (for both age groups) has a significant long-run cointegrating relationship with the full group of economic variables in the period tested.**
2. **Most importantly, maternal labor force participation has a highly significant long-run relationship with paid care across the states.** For children ages 0 to 4, a 1 percent increase in the maternal participation rate (*lfprfc04*) is associated with a 1.6 percent long-run change in the share of children in paid care. Paid care and maternal labor force participation were similarly found to have a significant bi-directional short-run relationship in earlier Granger causality tests.
3. **Real personal income per capita is found to have a stable long-run relationship with paid care usage.** The cointegration model estimates suggest that a 1 percent increase in real personal income per capita is associated with a 0.30 percent long-run increase in the share of children in paid care. This relationship was marginally insignificant in the short-run causality tests but suggests an economically significant long-run relationship.
4. **Educational attainment is statistically significant** in the cointegration relation but has an estimated negative sign as found in the Granger causality tests. This likely reflects the persistent uptrend in educational attainment in the period. It may also reflect some redundancy with income.

As with the Granger causality tests, the cointegration results are tested for sensitivity to the age of children in care and the measure of labor force attachment. The base case cointegrating equation is re-estimated using children in paid care in two groups – ages 0 to 4 and ages 0 to 14 – and

both the labor force participation rate and the employment ratio for various groups of the population ages 18-54. Labor force groupings include the overall population, males, females, females with all children ages 0 to 4, females with a youngest child ages 0 to 4, and females with a youngest child ages 0 to 14.

The findings strongly confirm the presence of a stable long-run relationship between multiple measures of labor force attachment and the share of children in paid care.

1. **Importantly, a significant long-run relationship is found between paid care usage and labor force attachment for mothers with both younger and older children in paid care.** The relationship is significant for nearly every measure of labor force attachment. Only the male employment ratio is not cointegrated with the share of older children ages 0 to 14 in paid care. This suggests that increased labor force attachment of nearly all demographic groups is expected to be accompanied by a rising share of children in paid care.
2. **The estimated long-run elasticities are generally larger for younger children ages 0 to 4 relative to the older group of children ages 0 to 14 for a given demographic group.** This too is consistent with short-run findings from the Granger causality tests. For the overall female participation rate, the elasticity of 1.22 for younger children is roughly 20 percent higher than the estimate of 1.03 for older children.
3. **The estimated response of paid care to maternal labor force attachment is greater as the definition used for mothers widens.** For mothers with all children ages 0 to 4, the estimated elasticity with respect to children ages 0 to 4 in paid care is 0.493. However, mothers with a youngest child ages 0 to 4 have an estimated elasticity of 0.837, while mothers with a youngest child ages 0 to 14 have an estimated elasticity of 1.21. One potential implication of this result suggested by the data is that mothers with younger children are simply less likely to change their use of paid child care as their labor force status changes.
4. Consistent with the findings of Granger causality tests, **elasticities with respect to children in paid care measured using the labor force participation rate are generally higher than those measured with the employment ratio.** Again, this suggests inclusion of the unemployed by using the participation rate when modeling paid care usage.
5. Overall and male labor force attachment rates are also found cointegrated with the share of children in paid care. This is additional evidence of a broader and more general relationship between labor force participation and paid child care use over the long run.

Labor Force Attachment and Economic Growth

State level economic development efforts often focus on increasing labor force attachment or enhancing the size of the labor force within a region. Research findings continue to point toward increased labor force participation as an underlying source of added economic growth. Economic theory suggests that higher utilization and more efficient employment of existing labor resources directly increases the potential output of a region.

Widely used approaches to increasing labor force attachment include subsidized job training following mass layoffs, high-school completion programs, targeted employment tax credits, and expanded child care availability. All these approaches are viewed as offering some potential to increase labor force attachment and economic growth.

State Income Growth Modeling

Three potential growth scenarios are examined based on increased U.S. labor force attachment through higher female and maternal labor force participation. Panel cointegration methods are used to model the co-movement of real personal income per capita across the states over time.

Along with the overall labor force participation rate, we model the contribution of three other well-known factors affecting regional economic growth: educational attainment, capital investment, and traded activity (or openness). These three factors receive considerable attention in the research literature on economic growth and have long been recognized by policymakers as viable targets for regional economic development.

A panel cointegration model is constructed with five data series:

PIPCR = real personal income per capita (dollars)
 LFPR = labor force participation rate (percent)
 AVGSCH = average years of schooling (years)
 CAPPW = net private fixed capital per worker (dollars)
 EXPPW = earnings from traded activity, or exports,
 per worker (dollars)

Each series is included in a balanced panel dataset for the 50 states in the 1990 to 2019 period. The initial cointegration results indicate that the five factors have a stable cointegrating relationship in the test period. Panel cointegration techniques are then used to derive empirical estimates of the effect of each growth factor on real personal income per capita across the states over time. The estimated model allows us to evaluate the expected long-run effect on state real income growth per capita given alternative scenarios for each factor.

Estimated Growth Effects

The estimation results suggest a robust long-run response in real personal income per capita to changes in the labor force participation rate. A 1 percent increase in participation is associated with an estimated 0.87 percent long-run increase in real personal income per capita across the states. Based on 2020 U.S. real income per capita of \$53,701, a 1 percent change in the participation rate (from 65.6 percent to 66.3 percent) implies a \$467 average increase in real income per capita across the states in the long run.

Based on U.S. population of 331.5 million in 2021, the expected increase in total real personal income is \$154.9 billion. The estimated total real income gain is equal to 0.79 percent of current nominal U.S. personal income totaling \$19.61 trillion in 2020. In other words, a 0.7 percentage point increase in the U.S. labor force participation rate is expected to produce a nearly 0.8 percent increase in total real personal income in the long run. The predicted effects of rising participation are sizeable and similarly reflect the expected reduction in real income growth traced to falling participation rates in recent years.



Potential Long-Run Growth Effects from Higher Participation

The estimated growth model can be used to derive estimates of the long-run expected change in real personal income per capita that results from changes in labor force participation. The estimate of a 0.87 percent increase in real personal income per capita for a 1 percent increase in labor force participation can be viewed as an average long-run effect across all states and all segments of the labor force.

Paid child care usage is also expected to change along with labor force participation as captured in prior cointegration test results. Hence, scenarios of changing labor force participation rates can thus be used to estimate both changes in real personal income and changes in paid child care usage.



We examine three scenarios evaluating the long-run growth effects of increased labor force participation of women ages 18-54 on real personal income per capita:

1. **A 1 percent increase in the overall female participation rate.** This is the case of a broad effort to attract women of all maternal and marital statuses into the labor force. Using 2020 as a comparative base year, the participation rate for females would rise from 72.9 percent to 73.6 percent, or an additional 569,100 females in the labor force holding population constant. Average real personal income per capita is estimated to increase by 0.41 percent, or a \$221 average increase in real personal income per capita across the states in the long run. The expected increase in total real personal income is \$72.8 billion, or 0.4 percent of current nominal U.S. personal income in 2020.

The increase in the labor force participation of females is also accompanied by an expected long-run increase in the use of paid child care. The estimated long run cointegration coefficient for the female participation rate is 1.216 for children in paid care ages 0 to 4 and 1.027 for children in paid care ages 0 to 14. The share of children in paid care is expected to rise from 29.4 percent to 29.8 percent for those ages 0 to 4 and from 16.0 percent to 16.24 percent for those ages 0 to 14. Based on 5.71 million children ages 0 to 4 in paid care in 2019, the increased participation rate would produce an expected gain of 69,500 children ages 0 to 4; the current 12.29 million children ages 0 to 14 in paid care would increase by an estimated 126,200. Each female entrant into the labor force would place an average of 0.22 children in paid care.

2. **A 1 percent increase in the participation rate for mothers with a youngest child ages 0 to 14.** This is a narrower case of focusing only on mothers with children. The 2020 participation rate for these mothers would require an increase from 70.7 percent to 71.4 percent, or an additional 210,700 mothers in the labor force. Average real personal income per capita is estimated to increase by 0.18 percent, or an \$81 average increase in real personal income per capita across the states in the long run. The expected increase in total real personal income is \$26.9 billion, or 0.14 percent of current nominal U.S. personal income in 2020.

The increase in labor force participation for mothers with a youngest child ages 0 to 14 is expected to produce a long-run increase in the use of paid child care. The estimated long run cointegration coefficient for the participation rate for these mothers is 1.212 for children ages 0 to 4 and 0.991 for children ages 0 to 14. The share of children in paid care is expected to

rise from 29.4 percent to 29.8 percent for those ages 0 to 4 and from 16.0 percent to 16.24 percent for those ages 0 to 14. These changes roughly match the expected responses for the overall female participation rate in Scenario 1 due to nearly equal estimated elasticities for both groups. Based on 5.71 million children ages 0 to 4 in paid care in 2019, the increased participation rate would produce an expected gain of 69,300 children ages 0 to 4; the current 12.29 million children ages 0 to 14 in paid care would increase by an estimated 121,800. Each mother entering the labor force would place an average of 0.58 children in paid care.

3. **A 1 percent increase in the participation rate for women with all children ages 0 to 4.** This is a far narrower scenario of focusing only on mothers with very young children. The 2020 participation rate for this group of mothers would rise from 69.3 percent to 70.0 percent, or an additional 44,900 mothers of children ages 0 to 4 in the labor force. The expected increase in total real personal income is only about \$17 in real personal income per capita across the states in the long run, a negligible contribution to economic growth. The expected increase in total real personal income is \$5.7 billion, or 0.03 percent of current nominal U.S. personal income in 2020. Any efforts to produce economic gains from the small group of mothers with all children ages 0 to 4 is unlikely to produce any meaningful economic growth effects.

The increase in labor force participation for mothers with all children ages 0 to 4 is similarly expected to produce a long-run increase in the use of paid child care. The estimated long-run cointegration coefficient for the participation rate for these mothers is 0.493 for children ages 0 to 4 and 0.390 for children ages 0 to 14. The share of children in paid care is expected to rise from 29.4 percent to 29.56 percent for those ages 0 to 4 and from 16.0 percent to 16.13 percent for those ages 0 to 14. These changes are proportionately smaller than the responses in the first two scenarios because of smaller estimated elasticities. Based on 5.71 million children ages 0 to 4 in paid care in 2019, the increased participation rate would produce an expected gain of 28,200 children ages 0 to 4; the current 12.29 million children ages 0 to 14 in paid care would increase by an estimated 47,900. Mothers entering the labor force would place an average of slightly more than one (1.07) child in paid care. The higher share of children in paid care reflects the greater share of children under the age of 5 in the analysis. There is also typically more than one child per household in paid care. In 2019, there were 1.56 children in paid care per household among those with children in paid care

The three economic growth scenarios highlight some important conclusions for policymakers pursuing efforts to increase the labor force participation of women and mothers:

1. The modeling results provide evidence that changes in maternal labor force participation rates produce expected changes in both real income and paid child care usage.
2. While participation rate changes are believed to be a direct factor in both income growth and paid care usage, changes in paid child care use accompany economic growth only indirectly through its relationship with changes in participation.
3. The size of the pool of potential workers determines in large part the size of any potential economic gains to increased participation. The pool of mothers is declining in size over time and offers far less potential for economic growth than the broader group of women with no children. Mothers with children ages 0 to 4 are far fewer in number than women with either older children or no children and offer less potential to affect overall U.S. income trends by increasing their workforce participation.
4. The expected long-run elasticity between labor force attachment and real personal income growth plays a key role in determining the size of any potential income gain as labor force attachment increases. The estimated elasticity of 0.87 measured across the full labor force suggests a slightly less than proportional gain in real personal income per capita as participation rates increase.
5. The long-run response of paid child care use to changes in labor force participation vary greatly by both the age of the child in care and the age of children in the household. The elasticities range from just above a one-to-one response to less than a 0.5 percent response. However, the ratio of new children in paid care per new entrant in the labor force is highest for mothers, particularly those with young children at home.
6. The total potential income gains from increased labor force participation are quite large when spread across large groups of potential workers. A 1 percent increase in the participation rate for females (from 72.9 percent to 73.6 percent) is associated with an expected \$72.8 billion long-run increase in total personal income in the U.S. This increase in labor force participation would represent only a modest rebound in the participation rate relative to losses in recent years. Potential income gains are far lower from increasing the labor force participation rates among smaller groups of mothers.

Time Series Modeling of Paid Child Care Usage

This report is the third in a four-part series focused on the use of paid child care in the U.S.² The report provides extensive empirical analysis of factors that are believed to underlie differences in paid child care usage across the states and over time. A range of time series techniques are used to examine the empirical relationships between these factors and the use of paid child care.

Empirical tests are performed using a 50-state panel dataset that captures the unique characteristics of paid care usage across the states. Panel techniques simultaneously utilize the information contained in the economic behavior of multiple regions and the time dimension of the data. The use of a panel of states rather than national data can provide for more robust estimates of the fundamental factors driving paid child care usage.

The report examines six key factors believed to influence paid child care usage. Time series tests of both short- and long-run statistical causality are used to examine the empirical relationships between these factors and paid child care usage. The report then develops a model of long-run economic growth and uses it to examine the potential effects of increased maternal and female labor force participation on real income growth and paid child care usage.

Explaining Paid Child Care Usage

The first report in this series examined six key factors believed to be closely intertwined with the use of paid child care at the state level. These six factors were selected for evaluation based on findings from existing research on child care, economic theory, and analysis of historical child care data at the state level.

The six factors fall into two categories. The first group is comprised of three economic and demographic factors, which mostly address which parents are in need of paid child care and best able to afford it. The second category captures three unique characteristics of the child care market in each state that focus on measuring the degree of accessibility and affordability of child care.

Economic and Demographic Factors. Three economic and demographic factors are viewed as having a fundamental influence on paid child care usage:

1. labor force attachment (particularly for mothers),
2. household income, and
3. educational attainment.

Each factor is supported by historical data and has a solid theoretical basis for influencing paid child care usage.

Three economic and demographic factors are viewed as having a fundamental influence on paid child care usage:

- 1. labor force attachment (particularly for mothers),*
- 2. household income, and*
- 3. educational attainment.*

Labor Force Attachment. One of the primary roles of child care, both paid and unpaid, is its role in facilitating a parent's participation in the workforce. Specifically, it is the labor force participation of mothers that is believed to be most closely tied to paid child care. The second report in this series examined trends in labor force participation in the U.S., particularly for mothers, and the implications for paid care usage. The findings indicate that a 1 percentage point higher labor force

participation rate for mothers is associated with a nearly 1 percentage point higher share of children in paid care across the states in 2019.

Household Income. National surveys of child care usage continue to show that households with higher income are far more likely to have a child in paid care, particularly younger children under age 5. Among all households with children ages 0 to 14, those with children in paid care reported household income of \$149,926 in 2020 versus \$110,877 for those not using paid care for their children, a 35 percent income gap.

At the state level, the share of children in paid child care is highly sensitive to income differences. Each additional \$1,000 of real income per capita is associated with a 0.7 percent higher share of children in paid care. In other words, an additional \$10,000 in real income per capita in a state is associated with a 7 percent average higher share of children in paid care. This is approximately the income gap between the highest and lowest income states. The lowest income states with real per capita income of about \$45,000 annually typically have about 17 percent of children in paid care. The highest income states with real per capita income of approximately \$55,000 typically have about a 24 percent share of children in paid care.

Educational Attainment. The greatest use of paid care is generally found where the primary householder has attained education beyond high school. States with the highest education level tend to have a share of children in paid care that is roughly double the share in states with the

lowest education level. Across the states, an additional 0.1 years of schooling is associated with a 1.4 percent higher share of children ages 0 to 4 in paid care. Many of the highest education states have a full year of additional schooling on average relative to the lowest education states. This difference from highest to lowest educational attainment is associated with an additional 14 percent share of children ages 0 to 4 and an 11 percent share of children ages 0 to 14 in paid care, on average, across the states.

Child Care Market Structure. The structure of the child care market in each state is also believed to influence the level of paid child care usage. Three important characteristics of state child care markets believed to influence the use of paid care include:

1. Child care expenditures as a share of income (or cost burden),
2. Federal and state child care subsidies and cost offsets (such as tax credits) as a share of income, and
3. The availability of alternative sources of publicly provided child care (primarily preschool for 3- and 4-year-olds).

These three factors closely correspond to three areas of ongoing child care policy concern: the high cost of care, public funding of child care, and the role of public preschool provision.

Child Care Expenditure Share of Income. Child care costs have long been viewed as the greatest obstacle to wider use of paid child care services. The child care expenditure share of income in each state is defined as the average per child expenditure for paid child care as a share of household income of those households with a child ages 0 to 14. In other words, it measures the share of income expended each year, on average, per child in paid care in each state and then scales it by income in the state among households with a child of child care age. The child care cost share of income provides a measure of the relative burden of child care expenditures, a more comparative measure than simple expenditures per child or per family (Herbst 2015).

In 2019, Current Population Survey (CPS) estimates suggest that U.S. households with children ages 0 to 14 in paid care spent an average of \$4,880 per child, or 3.4 percent of household income, on child care. The share varied widely across the states, from 1.9 percent in Arizona to 6.3 percent in Maryland. The child care ex-

penditure share per household remained in a narrow range from 5.0 percent to 5.4 percent between 2009 and 2019, before falling to 4.7 percent in 2020. All other factors held constant, a higher share of income spent on paid care is expected to result in reduced usage of paid child care across the states.

Child Care Subsidies and Cost Offsets. The net cost of child care to U.S. households is often determined by the receipt of a range of federal and state subsidies and other cost offsets. These subsidies and offsets are viewed as a potential key determinant of the share of paid child care usage across the states. The expectation is that greater funding as a share of household income produces an increased share of children in paid care nationally and at the state level.

Public child care funding comes primarily from shared federal and state expenditures through the Child Care and Development Fund (CCDF) and Temporary Assistance for Needy Families (TANF) programs along with the federal Child and Dependent Care tax credit.

Funding from the three primary sources totaled approximately \$19.3 billion nationally in fiscal year 2019 – CCDF \$10.3 billion, TANF \$5.1 billion, and the federal Child and Dependent Care tax credit \$3.8 billion. For perspective, the \$19.3 billion in fiscal year 2019 support is equal to approximately 37 percent of total child care expenditures reported by U.S. households in CPS data in 2019.

Three important characteristics of state child care markets believed to influence the use of paid care include: Child care expenditures; Federal and state child care subsidies and cost offsets; Alternative sources of publicly provided child care.

Subsidies and offsets from these sources totaled approximately \$320 per child ages 0 to 14 in 2019, or 0.46 percent of U.S. median household income. This equates to 6.6 percent of the average expenditure per child of \$4,880 on paid care in 2019. The dollar amount of child care subsidies and offsets per child in paid care varied widely across the states in 2019 (\$149 in Tennessee to \$828 in the District of Columbia), as did subsidy spending per child as a share of median household income (0.23 percent in Arizona and Utah to 0.97 percent in Delaware).

There is also a link between the child care expenditure share of income and the measure of subsidy and cost offset share of income. Subtracting subsidies

and offsets from the child care expenditure share of income produces a measure of the net child care expenditure share of income. In 2019, the net child care expenditure share of income equaled 2.91 percent of household income at the national level.

The measure of subsidies and cost offsets includes the major federal and state programs but does not capture all child care aid received by U.S. households. Child care funding and cost offsets can also be provided by employers and other state and local programs not tracked in this analysis.

Public Child Care Options (Preschool). The availability of other publicly funded child care options can influence the demand for paid child care within a given state. In many states, a growing alternative to paid care for 3- and 4-year-olds is publicly funded preschool. Greater availability of public preschool options in a state implicitly provides a fully subsidized option for care (for at least some hours of the day). The share of children in preschool is expected to be inversely related to the use of paid care.

Measured by the National Institute for Early Education Research (NIEER) as the share of all children ages 3 and

4 in preschool, 30.4 percent were reported as enrolled in preschool in academic year 2020.³ Public preschool options serve about 44 percent of 4-year-old children and 17 percent of 3-year-old children.

The number of children in preschool increased steadily from a recent low of 2.21 million in academic year 2013 to 2.45 million in academic years 2019 and 2020. The share varied widely across the states in academic year 2020, with the District of Columbia and Vermont serving about 84 percent of 4-year-olds and Vermont far surpassing all other states serving 64.9 percent of 3-year-old children. Idaho had the smallest share of children in public preschool programs, serving 12.5 percent of 4-year-old children and 8.4 percent of 3-year-old children. States without a public preschool program and relying instead on Head Start tended to serve the smallest percentage of either 3- or 4-year-old children.

Figure 1. Time Series Properties of Child Care-Related Variables

Variable Description	Variable Name	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Panel Observations
Share of children in paid child care (ages 0-4)	SHRPAID014	0.2792	0.2720	0.5800	0.0510	0.0767	0.5050	3.2900	1050
Share of children in paid child care (ages 0-14)	LFPR	0.1957	0.1890	0.3830	0.0380	0.0506	0.5800	3.3825	1050
Labor force participation rate - total	LFPRF	0.8033	0.8033	0.8993	0.6872	0.0380	-0.1795	2.9564	1050
Labor force participation rate - female	LFPRFC04	0.7510	0.7500	0.8848	0.6113	0.0472	0.0633	2.7385	1050
Labor force participation rate - female all children <5	LFPRFYC04	0.6770	0.6758	0.9375	0.3941	0.0808	0.0183	3.0064	1050
Labor force participation rate - female with youngest child <5	LFPRFYC014	0.6592	0.6568	0.8827	0.4593	0.0688	0.1681	2.7915	1050
Labor force participation rate - female with youngest child <15	LFPRM	0.7260	0.7240	0.8923	0.5770	0.0552	0.1441	2.6675	1050
Labor force participation rate - male	EMPOP	0.8569	0.8592	0.9423	0.7096	0.0362	-0.4446	3.1881	1050
Employment-population ratio - total	EMPOPF	0.7546	0.7547	0.8743	0.6110	0.0458	-0.1216	2.7061	1050
Employment-population ratio - female	EMPOPF04	0.7111	0.7075	0.8692	0.5618	0.0526	0.1353	2.6613	1050
Employment-population ratio - female all children <5	EMPOPFYC04	0.6312	0.6273	0.9133	0.3610	0.0852	0.2077	3.1202	1050
Employment-population ratio - female with youngest child <5	EMPOPFYC014	0.6158	0.6081	0.8827	0.4351	0.0728	0.3691	2.8705	1050
Employment-population ratio - female with youngest child <14	EMPOPM	0.6854	0.6823	0.8790	0.5440	0.0603	0.2624	2.6189	1050
Employment-population ratio - male	AVGSCH	0.7993	0.8020	0.9105	0.6256	0.0468	-0.3268	2.8091	1050
Average years of schooling	BACHDEG	13.17	13.20	14.40	12.02	0.3792	-0.3111	3.0304	1000
Share of population with bachelor's degree	PCPI	0.2815	0.2740	0.6041	0.1483	0.0624	1.1439	6.1072	1000
Personal income per capita	PCPIR	41921.2	40372.0	87064.0	21640.0		0.8007	3.6898	1050
Real personal income per capita	MEDHHINC	44519.6	43754.5	68294.0	30617.0	6480.14	0.6305	3.4492	1050
Median household income	CCEXPshr	52484.2	50713.5	95572.0	29359.0	11596.0	0.7368	3.4025	1050
Child care expenditures per child as share of household income	FEDSTCCSHR	0.0347	0.0342	0.0626	0.0177	0.0067	0.5634	3.8160	600
Fed/state CC spending per child as share of household income	PREKSHR	0.0054	0.0048	0.0238	0.0019	0.0025	2.0168	11.6765	550
Share of children ages 3 or 4 in preschool, special edu., or Head Start	FEDSTCCSHR	0.2630	0.2290	0.9780	0.0000	0.1362	1.5183	6.9150	700
Share of children ages 3 or 4 in preschool, special edu., or Head Start	PREKSHR	0.2596	0.2390	0.7440	0.0830	0.1171	0.9084	3.8708	600



Dataset and Summary Statistics

A 50-state panel dataset is assembled for use in the empirical tests discussed in the remainder of the section. The dataset includes multiple measures of the share of paid child care along with measures of the six economic, demographic, and child care market factors underlying paid care usage.

All data used in the analysis are collected on an annual basis. The analysis generally excludes 2020 data to avoid both concerns over data reliability due to Census Bureau surveying challenges during the pandemic and the potential effects from outliers.⁴ The District of Columbia is excluded from most of the empirical analysis because of the significant amount of cross-state border activity that influences much of the available data describing the region.

Summary Statistics. Figure 1 provides general descriptive statistics for each data series. The reported statistics are for the unadjusted form of each series and include the full available sample period for each series. The resulting groups and individual data series include the following:

- The *share of children in paid care* is examined for three age groups: ages 0 to 4 (shrpaio4) and ages 0 to 14 (shrpaid014).
- *Labor force attachment* is evaluated using both the labor force participation rate and employment ratio for six labor force groups: total (lfpr and empop), female (lfprf and empopf), female with all children under age 5 (lfprfco4 and empopfco4), female with young-

est child under age 5 (lfprfyc04 and empopfyc04), female with youngest child under age 15 (lfprfyc014 and empopfyc014), and male (lfprm and empopm). The measures of labor force attachment represent all civilian persons ages 18 to 54.

- Two measures of *educational attainment* are tested: average years of schooling (avgsch) and share of population with a bachelor's degree or higher (bachdeg).
- Three income measures are used: both nominal (pipe) and real (rpipe) measures of personal income per capita along with median household income (medhhinc).
- Three *child care industry-specific* measures are evaluated: child care expenditures per child as share of household income (cchhincshr), federal and state child care spending per child as share of median household income (fedstcchhincshr), and the share of children ages 3 or 4 enrolled in publicly funded preschool, special education, or Head Start (prekshr).

Panel Sample Size. A balanced panel of data is available for the 50 states from 2000 to 2020 for both paid child care usage and the economic and demographic factors. A balanced panel for child care market characteristics extends only from 2009 to 2019. The combined panel using all factors is available only for the 2009 to 2019 period.

Panel Unit Root Tests

The initial step in evaluating the statistical properties of each data series is testing for stationarity, an important property of time series data. A stationary data series will have a mean, variance, and autocorrelation structure that is stable over time. Visually, stationary series tend to be mean reverting and do not trend strongly upward or downward. They also do not have periodic patterns such as seasonality.⁵

The practical reason for stationarity testing is to determine whether a data series is used most appropriately in levels or in differences in empirical models. This testing addresses a common concern over the creation of spurious regressions when using time series data that are nonstationary. The process also lends important insight into selecting the appropriate approach when modeling short- and long-run empirical relationships among a group of data series of interest.

A nonstationary data series, or one with a unit root, may have to be differenced one or more times to achieve stationarity. The level of integration, denoted as $I(i)$, is used to describe the number of times (i) a data series must be differenced to achieve stationarity. Unit root tests are used to establish the degree of integration of each series. $I(0)$ variables are stationary in levels (no unit root) and require no differencing, while $I(1)$ variables have a unit root and must be differenced once to achieve stationarity. An $I(2)$ series is one that must be differenced twice to achieve stationarity. Most nonstationary series are $I(1)$ and become stationary after differencing once. Few data series require differencing twice (or more) to achieve stationarity.

Unit Root Test Methodology

A concern in testing for unit roots in panel data is that cross-sectional independence can be difficult to establish, as state level economic measures are often influenced by common factors. This dependency between cross sections (states) reduces the power of traditional first-generation unit root tests. To address potential cross-section dependency, each data series described in Figure 1 is tested for stationarity using the panel unit root test of Bai and Ng (2004). The test is a second-generation approach to unit root testing within panel data that allows for the presence of some dependency between the cross sections in the panel.⁶

The estimation results do not provide a binary test of the presence or absence of a unit root. Instead, they provide evidence on the number of states within the panel that may have a unit root. The null hypothesis assumes that each individual cross section has a unit root (or is nonstationary). Having a preponderance of the states with a similar degree of stationarity provides useful evidence concerning the behavior of the overall group. A high p-value for a test suggests the presence of a unit root in the level of the vari-

able and that it must be differenced to achieve stationarity. Rejection of the null of a unit root indicates that most of the cross sections (states) are stationary in levels. If the weight of the evidence suggests a series is not stationary, or has a unit root, the first difference of the series is subsequently tested for stationarity.

Unit Root Test Results

Unit root test results for each data series in Figure 1 are summarized in Figure 2. Each series is first tested for a unit root in levels and then tested in differences if a unit root is present. Either an intercept or intercept and time trend is included in each test where indicated in the results. The autocorrelation correction lag length used in each unit root test is chosen automatically using the Schwarz Information Criterion.

In summary, the unit root test results provide strong evidence that all the data series are nonstationary in levels and possess a unit root. Using both an intercept and an intercept and time trend, tests for nearly all data series find a unit root in levels for approximately 40 or more of the 51 state cross sections.

The economic variables generally produce the strongest evidence of a unit root in levels. Nearly all 50 states and the District of Columbia have individual unit roots when using either an intercept or intercept and time trend. The evidence of unit roots is slightly weaker for the three child care market characteristics, but all three indicate that approximately 40 or more states possess an individual unit root in levels.

The only evidence of stationarity in levels is found for male labor force attachment. For tests with an intercept only, the participation rate suggests a unit root in levels for 41 states; however, the employment ratio suggests only 23 states possess a unit root in levels. For tests with both an intercept and time trend, both the participation rate and the employment ratio for men suggest that fewer than half of the states have a unit root in levels. While the initial evidence on male participation is mixed, the full breadth of the tests suggests that male labor force attachment most likely has a unit root in levels along with the other definitions of labor force attachment. Evidence also suggests that the finding may be influenced by the period examined. Tests for male attachment using approximately half the sample in the 2000 to 2020 period indicate that 39 of 51 cross sections have a unit root in levels.

Some concerns also remain surrounding the results for the child care market characteristics. The sample sizes are far smaller than those used for the remaining variables. The power of unit root tests is well known to diminish in small samples.⁷ Nevertheless, the results consistently suggest the presence of a unit root in levels using either an intercept or an intercept and time trend.

Figure 2. Panel Unit Root Tests - BAI & NG Method

Data Series	Number of Balanced Observations	Maximum Lag Length	Bai & Ng Common Factors ($p > .05$)	Cross Sections With Unit Root ($p > .05$)
Intercept Only				
SHRPAID014	20	8	6	32
SHRPAID04	20	8	7	36
SHRPAID514	20	8	8	41
LFPR	43	9	5	46
LFPRF	43	9	5	38
LFPRFC04	43	9	5	39
LFPRYC04	43	9	5	45
LFPRYC014	43	9	5	40
LFPRM	43	9	5	41
EMPOP	43	9	5	34
EMPOPF	43	9	5	36
EMPOPF04	43	9	5	43
EMPOPYC04	43	9	5	43
EMPOPYC014	43	9	5	39
EMPOPM	43	9	5	23
AVGSCH	49	10	10	42
BACHDEG	49	10	10	39
PIPCR	30	8	7	47
PIPC	51	10	10	47
CCHHINCSHR	11	3	6	38
FEDSTCCHHINCSHR	10	3	6	44
PREKSHR	13	3	7	48
Intercept and Trend				
SHRPAID014	20	8	6	39
SHRPAID04	20	8	7	37
SHRPAID514	20	8	8	44
LFPR	43	9	5	43
LFPRF	43	9	5	34
LFPRFC04	43	9	5	31
LFPRYC04	43	9	5	37
LFPRYC014	43	9	5	34
LFPRM	43	9	5	20
EMPOP	43	9	5	28
EMPOPF	43	9	5	38
EMPOPF04	43	9	5	28
EMPOPYC04	43	9	5	36
EMPOPYC014	43	9	5	32
EMPOPM	43	9	5	18
AVGSCH	49	10	10	45
BACHDEG	49	10	10	50
PIPCR	30	8	7	48
PIPC	51	10	10	51
CCHHINCSHR	11	3	6	38
FEDSTCCHHINCSHR	10	3	6	40
PREKSHR	13	3	7	41

Note: All panel unit root tests utilize the method of Bai & Ng (2004) which allows for dependency across cross sections. The Schwarz Information Criterion is used with automatic lag length selection. Cross sections include all 50 states and the District of Columbia.

Based on the full weight of the evidence, all data series tested are believed to have a unit root in levels, or are non-stationary. Subsequent unit root tests on first differences of each series indicate that all the data series are $I(1)$ based on findings of stationarity for a strong majority of cross sections. Hence, the empirical tests applied in the remainder of the report assume that all variables tested have a unit root in level and are stationary in first difference.

Short-Run Causality Tests

Empirical tests in this section address the key question of whether economic, demographic, and child care-related characteristics of each state can be used to inform the future use of paid child care. The tests also shed light on the reverse question of whether changes in paid child care usage influence the future value of the economic, demographic, and child care market factors across the states. Existing research findings provide few clear prior beliefs concerning the statistical linkages between paid care usage and the other six factors.

Granger (1969) causality tests are used throughout the section to examine the short-run lead-lag relationships that are present among the data series. The tests are performed using the 50-state panel dataset and focus on two primary questions:

1) How are changes in paid child care usage and labor force attachment related in the short run?

These two factors are the most closely intertwined with the fundamental decision to work and use paid child care. A key concern for policymakers is whether historical data suggest that greater usage of paid care leads to higher labor force participation, and vice versa.

2) Do historical data support a role for the other economic factors and the three child care market characteristics in determining the share of paid care usage across the states?

The initial model tested focuses on the link between paid care and labor force attachment. The remaining economic and demographic variables are then added to the model to evaluate the overall role of these factors in paid care usage. Finally, the three market characteristic variables are added to the model in a comprehensive test of all the factors.

Panel Granger Causality Tests

Granger causality tests are used to examine whether there is evidence to support a statistical short-run causal relation

between the share of children in paid child care and the six key variables examined in the prior section.

In simplest terms, Granger causality is a test of the usefulness of one variable in forecasting future values of another. Granger causality is present between two variables if future forecasts of variable X are improved by using variable Y in its prediction, above the level present when using only information about the history of X .

Granger causality can be present in a single direction from either X to Y or Y to X , in both directions (bi-directional), or may not be present at all. If there is no Granger causal relation found from Y to X , Y is deemed strictly exogenous to X in providing useful forecasting information.

Granger causality is a statistical notion of causality that tests for increased predictability of the future path of one variable, X , using another variable, Y . While not addressing the issue of economic causality in the traditional sense, the tests provide an empirical measure of the historical responses and timing embodied in the relationships among the data.

When coupled with a theoretical basis for inclusion in a model, Granger causality tests provide valuable observational evidence on the historical relations among a set of time series variables. Thus, the approach provides empirical evidence on the effects between a group of variables over time, not the mechanism at work. Granger causality tests also provide empirical estimates of the magnitude and sign

of the coefficients underlying the relationship. These estimates can be derived from either the underlying model used to perform the causality test or with other empirical modeling methods.

Granger causality focuses on lead-lag relationships and does not provide information on the presence of contemporaneous changes in two variables. The presence of a Granger causal relation suggests predictability in a forecasting sense but provides no evidence on whether two time series have a statistical linkage in concurrent time periods.

Bi-directional Granger causality, where causality between two data series is present in both directions, is the closest analog to contemporaneous changes in the variables. In some modeling contexts, contemporaneous changes may represent a more important finding than significant lead-lag relationships.

Granger causality also differs greatly from measuring the correlation between two time series. Correlation simply measures the linear dependence between two series over a specified period. If X and Y are correlated, the calculated correlation is the same for both series in each direction in

A key concern for policymakers is whether historical data suggest that greater usage of paid care leads to higher labor force participation, and vice versa.



the period. Granger causality, however, measures statistical predictability in both directions and in the time dimension. Because economic causality also operates in the time dimension, basic causal relations are often informed using Granger-type methods, particularly in forecasting applications.

Test Methodology. All Granger causality tests are implemented within a Vector Autoregressive (VAR) model using the method of Todo and Yamamoto (1995), hereafter referred to as TY. The TY approach allows for causality testing among a group of data series within a system framework. The system includes an equation for each data series with the series as the dependent variable and the remaining variables as explanatory (independent or right-hand side or) variables. Each equation in the VAR model includes only each variable's lagged (or past) values, lagged values of the other variables in the model, and an error term. The VAR model imposes no structural assumptions on the data but instead treats all data in the model as endogenous to the system.

Granger causality tests require careful application to produce reliable estimates, and the results can be sensitive to the statistical properties of the data used and the methodology used to implement the tests.⁸ The TY method is

noteworthy in that it is robust to the presence of unit roots, or the order of integration of the time series, and addresses any concern over the stationarity of the variables used in the Granger causality tests. Evidence from unit root tests performed in the prior section suggests some uncertainty over the stationarity of male labor force attachment and the three child care market characteristics.

The VAR is estimated using a common lag length (or order) denoting the number of lags used for the right-hand side variables in each equation. The optimum order of the VAR is selected automatically using the minimum Schwarz Information Criteria (SIC) with a maximum lag length of three years. All VARs estimated in this section are ultimately fit with an optimal lag length of one year based on the SIC. Consistent with the TY approach, the base VAR is then augmented, or overfit, by including an additional lag of the level of each variable as an additional exogenous variable in each equation of the VAR. The additional lags used to overfit the VAR are at year 2.

Hypothesis tests performed on the estimated coefficients for lag 1 of each equation in the VAR provide evidence on the causal linkages present from one or multiple variables to each dependent variable. The statistical test consists of

a block exogeneity Wald test of zero restrictions on each of the lagged dependent variables up to the optimal order of the fitted model (year 1) but excluding the additional lagged period (year 2).

The null hypothesis for each test is that a Granger causal relationship is not present between the variables in the VAR. A significance level (p-value) of 0.10 is used to identify potential Granger causal linkages. This higher significance level reflects the relatively short time period covered by the panel dataset, particularly for the market characteristic variables. If the reported p value is less than 0.10, then we reject the null hypothesis and conclude that a Granger causal link is present. Test significance is noted in the results at both the 5 percent and 10 percent levels. In other words, a low p value suggests the presence of a Granger causal relationship between two time series.

Paid Care and Labor Force Attachment

The initial Granger causality tests focus on the short-run historical linkages between the share of children ages 0 to 4 in paid child care and various measures of labor force attachment. Among the three economic variables examined, labor force attachment is believed to be the most important given the fundamental relationship between work and paid care.

The expectation is that paid care usage at the state level is positively associated with greater labor force attachment. What is not clear in existing research is whether there is a tendency for one measure to lead the other, or for both series to evolve jointly over time.

The initial tests address three additional aspects of the relationship between paid care usage and labor force attachment:

1. Which demographic measures of labor force attachment (i.e., total, female, male, maternal, etc.) are most closely associated with paid child care usage?
2. Is paid care more closely associated with the labor force participation rate (which accounts for unemployed workers in the labor force) or the employment ratio (which focuses solely on employed workers)?
3. Does the relationship between paid care usage and labor force attachment differ for younger versus older children?

Granger Causality Results – Paid Care Usage and Labor Force Attachment

Child care usage is examined for two age groups of children (0 to 4 and 0 to 14) while labor force attachment is measured using both the participation rate and the employment ratio. These initial tests focus on the broad categories of labor force attachment by examining total (both male and female) attachment and the male and female components individually. Tests are performed using a balanced panel in the 2000 to 2019 period.

Each data series enters the VAR using the natural logarithm of the level. Because all variables are in natural logarithms, the estimated coefficients on the explanatory variables represent short-term elasticities with respect to the dependent variable. The elasticities are interpreted as the expected percentage change in the dependent variable for a 1 percent change in the explanatory variable. Test statistics are provided for the individual estimated coefficients and each Granger causality test.

Among the three economic variables examined, labor force attachment is believed to be the most important given the fundamental relationship between work and paid care.

Results: Labor Force Attachment to Paid Care Usage. The results for linkages between paid care usage and labor force attachment are summarized in Figure 3. The top half of the figure examines Granger causality running from labor force attachment to paid child care usage while the bottom half examines the reverse direction from paid care usage to labor force attachment. The results provide considerable evidence on the linkages from labor force attachment to paid care.

1. Most importantly, the share of children in paid care is found Granger caused only by female labor force attachment. The share in paid care is not significantly related to either overall attachment or male attachment. This finding is consistent with our expectation for females given their traditional role as the primary caretaker of children but provides additional evidence of an insignificant link from overall attachment and male attachment to paid care.
2. The Granger causal relationship from female attachment to paid care usage is significant using the participation rate (lfprf) but not the employment ratio (empopf). In fact, none of the measures of paid child care usage are Granger caused by any of the employment ratio measures tested. In labor market terms, paid child care usage is found more closely related to a broader measure of the labor force that captures both employed and unemployed workers than to a narrower measure including only employed workers.

Figure 3. Granger Causality Tests - Paid Care And Labor Force Attachment

Dependent Variable	Explanatory Variable	Estimated Coefficient (t-1)	T-stat	Granger Wald Test Chi-Sq	p-value
Granger causality tests: labor force attachment --> paid care usage					
LOG(SHRPAID014)	LOG(LFPR)	0.0559	0.20	0.04	0.8443
LOG(SHRPAID014)	LOG(LFPRF)	0.3440	1.75 *	3.05	0.0805 *
LOG(SHRPAID014)	LOG(LFPRM)	-0.1876	-0.77	0.60	0.4389
LOG(SHRPAID014)	LOG(EMPOP)	-0.1171	-0.55	0.30	0.5839
LOG(SHRPAID014)	LOG(EMPOPF)	0.0928	0.54	0.29	0.5893
LOG(SHRPAID014)	LOG(EMPOPM)	-0.1919	-1.10	1.22	0.2697
Granger causality tests: paid care usage --> labor force attachment					
LOG(LFPR)	LOG(SHRPAID014)	0.0242	6.52 **	42.50	0.0000 **
LOG(LFPRF)	LOG(SHRPAID014)	0.0433	7.97 **	63.59	0.0000 **
LOG(LFPRM)	LOG(SHRPAID014)	0.0115	2.67 **	7.13	0.0076 **
LOG(EMPOP)	LOG(SHRPAID014)	0.0366	7.15 **	51.08	0.0000 **
LOG(EMPOPF)	LOG(SHRPAID014)	0.0535	8.47 **	71.67	0.0000 **
LOG(EMPOPM)	LOG(SHRPAID014)	0.0239	3.81 **	14.53	0.0001 **
LOG(LFPR)	LOG(SHRPAID04)	0.0190	6.12 **	37.51	0.0000 **
LOG(LFPRF)	LOG(SHRPAID04)	0.0397	8.79 **	77.30	0.0000 **
LOG(LFPRM)	LOG(SHRPAID04)	0.0042	1.16	1.34	0.2468
LOG(EMPOP)	LOG(SHRPAID04)	0.0279	6.50 **	42.25	0.0000 **
LOG(EMPOPF)	LOG(SHRPAID04)	0.0468	8.87 **	78.66	0.0000 **
LOG(EMPOPM)	LOG(SHRPAID04)	0.0126	2.40 **	5.76	0.0164 **

Note: ** indicates significance at the 5% level; * indicates significance at the 10% level.

3. The estimated elasticity of female labor force participation (lfprf) for paid care usage is larger for the share of children ages 0 to 4 in paid care (0.495) than for the broader group of children ages 0 to 14 (0.344). The estimated elasticities indicate that a 1 percent change in the female participation rate produces a 0.495 percent change in the share of children ages 0 to 4 in paid care but only a 0.34 percent change in the share of children ages 0 to 14 in paid care. The smaller response when older children are considered likely reflects the more optional nature of paid care for older children as parents work.
4. Estimated coefficients for male attachment are negative for both the employment ratio and the participation rate and for both age groupings. While this finding is counterintuitive, both the estimated coefficient and Granger causality test are statistically insignificant. The negative sign is likely a statistical anomaly traced to the consistent decline in male participation rates coupled with an uptrend in paid child care usage in recent decades. Similarly, estimated coefficients for employment ratios for the overall population have a negative estimated coefficient for paid care but are not statistically significant. The negative coefficient for the overall relationship is capturing the recent decline in both male and female attachment as paid care usage trended upward in recent decades.

Granger Causality Results: Paid Care Usage to Labor Force Attachment. The results examining the reverse case of Granger causality from paid care usage to labor force attachment suggest additional evidence on the short-run linkages examined. The share of children in paid care is found strongly Granger causal for labor force attachment. All coefficient signs are uniformly positive as expected, whereby higher paid child care usage indicates greater labor force attachment in the next period. The findings are consistent for both age groups of children in paid care.

Most important, the findings indicate that paid care usage Granger causes almost all measures of labor force attachment – the overall labor force, both males and females, and mothers with children of both age groupings. This suggests a broad stimulative effect on labor force attachment from changes in paid care usage. The only insignificant finding is that the share of younger children ages 0 to 4 in paid care is not Granger causal for the male labor force participation rate.

The highest elasticities for labor force attachment are, again, found for females across both age groupings of children in paid care. However, opposite the case with paid care usage, the elasticity response of labor force attachment for women is higher measured using the employment ratio than the participation rate. **This implies that a rising**

share of children in paid care is expected to have a relatively greater influence on the number of employed females than on the combined number who are either employed or unemployed. That is, a rising share of children in paid care is more likely to precede actual hiring rather than efforts to search for a job.

Discussion. The overall short-run findings on paid child care usage and labor force attachment provide evidence of bi-directional Granger causality only between the share of children in paid care and the female labor force participation rate. The implication of bi-directional causality is that paid care evolves jointly over time as women move in and out of the labor force, with each series forecasting the future movement of the other. This is consistent with expectations that a dynamic relationship with feedback exists between the share of women in the labor force and the share of children in paid care across the states.

All other remaining significant Granger causal relationships are present in only one direction, from the share of children in paid care to labor force attachment. For policymakers, this indicates that changes in the availability of paid care are far more likely to result in increased labor force attachment than increased attachment is to precede more paid care usage. Any increase in paid care is most likely to come from increased attachment of mothers.

The findings also indicate that an increase in the share of children in paid care is likely to precede a unidirectional increase in overall labor force attachment, with both males and females responding to increased paid care usage. While a rise in paid care can be associated with either a voluntary use of paid care or added paid care supplemented through external sources, the evidence points toward a broader response in labor force attachment by both males and females rather than simply increased female participation as a greater share of paid care is used.

Granger Causality Results: Maternal Labor Force Attachment to Paid Care Usage. Based on evidence that female attachment is the key predictor of future paid child care usage, we next focus on the specific role played by maternal labor force attachment. Of key concern is which mothers by age of child are the most relevant in explaining paid care usage. Three groups of mothers are examined: those with all children ages 0 to 4, those with a youngest child ages 0 to 4, and those with a youngest child ages 0 to 14. The expectation is that mothers with younger children generate a greater causal response relative to paid care usage.

Granger causality tests of a predictive link from the three measures of maternal labor force attachment to paid care using both the participation rate and employment ratio are detailed in Figure 4. The results confirm that, much like

overall female attachment, maternal labor force attachment is significantly related to future paid child care usage. However, the findings are highly dependent upon the age of the child in care and the age of children at home with mothers.

The overarching result is that the presence of younger children matters most in determining the use of paid care across the states. There are two distinct components to the finding on mothers and the age of the child.

First, the share of children in paid care is significantly Granger caused only by mothers with all children between the ages of 0 and 4. In contrast, the Granger causal link is found insignificant for the two broader groups of mothers with a youngest child ages 0 to 4 and with a youngest child ages 0 to 14.

Second, the result is most significant for explaining the share of children ages 0 to 4 in paid care versus those ages 0 to 14 in paid care. The relationship for mothers with all children ages 0 to 4 has an estimated elasticity (0.2453) that is more than twice as large as that for children ages 0 to 14 in paid care (0.0901).

For the share of children ages 0 to 14 in paid care, none of the maternal measures of attachment are significant for future paid care usage. Only overall female labor force attachment is significant for ages 0 to 14 in paid care. Overall female labor force attachment is also significant for ages 0 to 4 in paid care. This surprising finding of female rather than maternal attachment Granger causing paid care usage may be proxying for the effect of improved overall economic conditions on the use of paid child care by all households, including those formerly using unpaid care. Our expectation is that other economic variables account for some of this effect.

The results provide further evidence that future paid child care usage is far more closely associated with the labor force participation rate than the employment ratio. Estimated elasticities, those both statistically significant and insignificant, are uniformly higher for measures of labor force participation than the employment ratio for both age groups of children in paid care. Again, the results suggest that workers who are unemployed but remain in the labor force matter when determining the share of paid care usage across the states.

The estimated elasticities for maternal labor force attachment Granger causing paid care usage are found insignificant in many tests but the estimated size of the elasticities for mothers are uniformly smaller than those for the broader

group of all females for both age groups. Specifically, the estimated response for paid care usage is smaller in percentage terms when maternal participation rates change than when overall female participation rates change. For children ages 0 to 14, the estimated percent change in the share of children in paid care resulting from a 1 percent change in attachment is more than three times larger (0.344) for all females than for mothers with all children ages 0 to 4.

For younger children ages 0 to 4 in paid care, the elasticity is roughly twice as large for all females (0.4946) versus mothers with all children 0 to 4 (0.2453). This result may be further evidence of a role played by labor force attachment in signaling changes in overall economic conditions. The rate of

overall female attachment is likely more closely related to overall changes in economic conditions than the narrower measure of maternal attachment. We examine this possibility further in the next section of the report.

Additional tests not included in Figure 4 examine the reverse causal linkage running from the share of children in paid care to labor force attachment. Much like the results in the bottom half of Figure 3, the findings indicate a significant Granger causal link is uniformly present from both age groups of children in paid care to nearly all measures of labor force attachment. Again, this suggests that increased usage of paid care has a broad labor market effect that extends beyond just mothers.

Paid Care and Economic Factors

Other economic factors beyond labor force attachment are believed to explain paid child care usage across the states. The earlier finding that overall female labor force attachment significantly Granger causes the share of children in paid care suggests that paid care responds to changes in both maternal employment and overall economic conditions.

In this section we add the remaining two economic and demographic factors – education and income – to labor force attachment in a 4-variable system Granger causality test of the relationship between paid care usage and the three economic and demographic factors. Based on earlier findings, we use paid care usage for children ages 0 to 4 and the labor force participation rate for mothers with all children ages 0 to 4. Education is defined as average years of schooling and income is measured as real personal income per capita. The estimates are formed using a balanced panel in the 2000 to 2019 period.

This suggests that increased usage of paid care has a broad labor market effect that extends beyond just mothers.

Figure 4. Granger Causality Tests - Female And Maternal Labor Force Attachment

Dependent Variable	Explanatory Variable	Estimated Coefficient (t-1)	T-stat	Granger Wald Test Chi-Sq	p-value
Granger causality tests: female labor force attachment --> paid child care usage ages 0 to 14					
LOG(SHRPAID014)	LOG(LFPRF)	0.3440	1.75 *	3.05	0.0805 *
LOG(SHRPAID014)	LOG(LFPRFC04)	0.0901	1.49	2.23	0.1357
LOG(SHRPAID014)	LOG(LFPRFYC04)	0.0145	0.17	0.03	0.8647
LOG(SHRPAID014)	LOG(LFPRFYC014)	0.0827	0.58	0.33	0.5645
LOG(SHRPAID014)	LOG(EMPOPF)	0.0928	0.54	0.29	0.5893
LOG(SHRPAID014)	LOG(EMPOPFC04)	-0.0139	-0.26	0.07	0.7966
LOG(SHRPAID014)	LOG(EMPOPFYC04)	-0.0821	-1.07	1.15	0.2846
LOG(SHRPAID014)	LOG(EMPOPFYC014)	-0.0768	-0.60	0.36	0.5468
Granger causality tests: female labor force attachment --> paid child care usage ages 0 to 4					
LOG(SHRPAID04)	LOG(LFPRF)	0.4946	2.07 **	4.28	0.0386 **
LOG(SHRPAID04)	LOG(LFPRFC04)	0.2453	3.27 **	10.72	0.0011 **
LOG(SHRPAID04)	LOG(LFPRFYC04)	0.1472	1.38	1.89	0.1689
LOG(SHRPAID04)	LOG(LFPRFYC014)	0.2765	1.59	2.52	0.1123
LOG(SHRPAID04)	LOG(EMPOPF)	0.2128	1.02	1.04	0.3067
LOG(SHRPAID04)	LOG(EMPOPFC04)	0.1039	1.55	2.40	0.1210
LOG(SHRPAID04)	LOG(EMPOPFYC04)	0.0250	0.26	0.07	0.7946
LOG(SHRPAID04)	LOG(EMPOPFYC014)	0.1006	0.65	0.42	0.5147
Notes: Null hypothesis is no Granger causality present. Sample is a balanced 50-state panel in the 2009 to 2019 period. ** Significant at the 5% level; * Significant at the 10% level..					

Results – Paid Care and Economic/Demographic Factors.

The results of Granger causality tests of the short-run lead-lag relationships between paid care and the economic and demographic variables are summarized in Figure 5. Results are presented for estimated equations for each of the four dependent variables. The coefficients for each of the explanatory variables lagged one period represent an approximate elasticity for changes in the dependent variable with respect to each explanatory variable. The Granger causality test statistic is included along with its significance level (p-value).

Our primary interest is on tests of Granger causal factors driving the share of children ages 0 to 4 in paid care. Importantly, the estimated elasticity coefficient for Granger causality from labor force participation for mothers with children ages 0 to 4 (*lfprfc04*) to the use of paid care (*shrpaid04*) remains highly significant ($p=0.0025$). The size of the coefficient declines only slightly in the presence of the added variables, from 0.2453 in the prior estimates using maternal attachment in Figure 4 to 0.2143.

In the reverse case, the share of children in paid care also remains strongly causal for maternal labor force participation (*lfprfc04*). This remains consistent with earlier evidence of bi-directional Granger causality between the share of children in paid care and maternal participation.

The causal link from education to paid care usage is found significant but has a seemingly counterintuitive negative sign. While surveys consistently find a positive relationship between the levels of education and paid care usage, the Granger causality test instead measures the change in education relative to paid care usage. The negative sign may be highlighting underlying behavior where higher income households are using a lower share of paid care as their incomes rise, but still have a far higher use of paid care than lower income households as seen in survey data.

The level of real personal income per capita is also not Granger causal for paid care, with a p-value of 0.1751. This suggests no general short-run macroeconomic effect on paid care usage where stronger overall real income growth

leads to greater use of paid child care. However, in testing the sensitivity of this finding to the variable definition used for income, both nominal personal income per capita and median household income are subsequently tested and found significant as Granger causal factors for paid care use. This provides far stronger evidence of a short-run macro-economic effect pushing paid care usage higher as incomes rise but is most evident in nominal rather than real terms.

In the reverse case, the model results do not suggest a Granger causal link from paid care to real income. This is evidence that paid child care usage is not a direct driver of real economic growth. Tests of sensitivity using both nominal personal income per capita and median household income confirm the finding. While this result casts doubt on

the role of paid child care as a direct cause of higher real economic growth, it does not eliminate the indirect path already established to income through increased labor force participation.

Other relationships in the model suggest that the share of children in paid care is not Granger causal for education. We have no expectation that the overall level of education across the states is driven by changes in the share of children in care due to the small number of parents enrolled in college and the inability of the group to influence overall education levels. CPS survey data suggest that paid care usage is above average for householders attending college either part- or full-time, but that fewer than 2 percent of householders with children ages 14 and under are enrolled in college.

Figure 5. System Granger Causality Tests – Economic Factors

Dependent variable: LOG(SHRPAID04)			
Explanatory Variable	Estimated Coefficient (t-1)	Granger Wald Test Chi-Sq	p-value
LOG(LFPRFC04)	0.2143	9.14	0.0025 **
LOG(AVGSCH)	-5.8038	4.13	0.0422 **
LOG(PCPIR)	0.3580	1.84	0.1751
All		14.48	0.0023 **
Dependent variable: LOG(LFPRFC04)			
Explanatory Variable	Estimated Coefficient (t-1)	Granger Wald Test Chi-Sq	p-value
LOG(SHRPAID04)	0.1634	109.72	0.0000 **
LOG(AVGSCH)	0.8534	0.40	0.5283
LOG(PCPIR)	-0.1355	1.17	0.2784
All		110.90	0.0000 **
Dependent variable: LOG(AVGSCH)			
Explanatory Variable	Estimated Coefficient (t-1)	Granger Wald Test Chi-Sq	p-value
LOG(SHRPAID04)	0.0003	0.51	0.4753
LOG(LFPRFC04)	0.0012	2.25	0.1339
LOG(PCPIR)	0.0138	21.39	0.0000 **
All		25.01	0.0000 **
Dependent variable: LOG(PCPIR)			
Explanatory Variable	Estimated Coefficient (t-1)	Granger Wald Test Chi-Sq	p-value
LOG(SHRPAID04)	0.0033	0.66	0.4153
LOG(LFPRFC04)	0.0174	3.97	0.0463 **
LOG(AVGSCH)	-1.8045	26.25	0.0000 **
All		30.65	0.0000 **

Notes: Null hypothesis is no Granger causality present. Sample is a balanced 50-state panel in the 2009 to 2019 period.
 ** Significant at the 5% level; * Significant at the 10% level..

Paid Care and Child Care Market Characteristics

This section of the report extends the child care model in the prior section by including state-level child care market characteristics. The model continues to examine paid child care usage for children ages 0 to 4 and labor force participation for mothers with all children ages 0 to 4. Income is measured using nominal personal income per capita based on findings in the prior section.

Two variables reflecting child care market characteristics at the state level are added to the model. The first is the measure of the net cost burden of child care (*cccosthnet*) to families with a child in paid care. The variable is calculated as the difference between the child care cost burden (cost per child as a share of household income) and federal and state subsidy and cost offsets as a share of household income, both as discussed earlier in the report. The new variable provides a measure of net child care costs as a share of household income faced by families with children ages 0 to 14 in paid care. Families with children in paid care currently spend just less than 3 percent of their household income per child after subsidies and offsets. Our expectation is that a higher cost burden will result in less paid care usage across the states.

The second child care market variable added to the model is the share of children ages 3 and 4 in various forms of publicly funded preschool. In 2019, 30.4 percent of U.S. children ages 3 and 4 were enrolled in public preschool. The variable is expected to have an inverse relationship with paid child care usage. Again, publicly funded preschool functions as a fully subsidized form of child care for enrolled children. Greater enrollment in public preschool is expected to substitute for paid market care for these children and reduce the share of children in paid care.

Tests are performed using a balanced panel in the 2009 to 2019 period, a far smaller test sample. The power of the Granger causality tests is expected to be diminished in the smaller sample.

Results – Paid Care, Economic/Demographic Factors, and Market Characteristics. Results for tests of whether both economic and demographic factors and child care market characteristics Granger cause the share of children ages 0 to 4 in paid care are detailed in Figure 6. A VAR model with six equations is estimated, with each variable serving as the dependent variable in an equation.

For the equation examining children in paid care (*shrpaido4*), the overall group of variables is found Granger causal ($p=0.0283$) in the period. In other words, there is an overall predictive relationship found from the group of factors to the share of children in paid care. However, maternal labor force participation (*lfprfc04*) is the only explanatory variable found individually Granger causal. This finding continues to support the basic result that maternal labor force participation is Granger causal ($p=0.0073$) for paid care, especially for younger children. The estimated elasticity (0.2678) from maternal labor force participation to paid care remains highly stable when market characteristics are included in the equation.

The reverse case also remains Granger causal ($p=0.0000$), with the share of children in paid care preceding changes in maternal labor force participation. This is, again, consistent with a bi-directional link between the two measures.

Among the child care market characteristics, the share of children in public preschool is found inversely related to the share of children in paid care, as expected, but is marginally insignificant ($p=0.1135$). Nevertheless, the estimated coefficient (-0.1635) suggests that a 1 percent rise in the share of children in public preschool would reduce the share of children in paid care by 0.16 percent. The degree to which reduced power of the test in the smaller sample is affecting the significance of the estimate is unknown.

The estimates do contribute to our expectation that policy efforts to broaden access to public preschool may weigh heavily on paid child care usage.

Tests of a link from the net cost burden for paid care to paid care usage provide little evidence that changes in the cost burden for child care precedes changes in paid care usage for younger children. The estimated coefficient has an unexpected positive sign but is near zero and highly insignificant ($p=0.6694$). The reverse case of a causal link from paid care to the cost burden is similarly insignificant ($p=0.5791$). These findings do not suggest the absence of a relationship between the cost of care and the use of paid care but merely identify no short-run

lead-lag relationship between the two in either direction. Alternative modeling tools may be better suited for examining the response of child care usage to cost. Increased data coverage may also be needed to model the link between the net cost of care and paid care usage.

Some evidence is found for an inverse relationship between the share of 3- and 4-year-olds in preschool and the share of children ages 0 to 4 in paid care, but it is marginally insignificant. The estimates do contribute to our expectation that policy efforts to broaden access to public preschool may weigh heavily on paid child care usage. A larger sample size for evaluating child care market characteristics could shed additional needed empirical light on the linkage.

Figure 6. System Granger Causality Tests – Child Care Market Characteristics

Dependent variable: LOG(SHRPAID04)							
Explanatory Variable	Estimated Coefficient (t-1)	Granger Wald Test Chi-Sq	p-value	Explanatory Variable	Estimated Coefficient (t-1)	Granger Wald Test Chi-Sq	p-value
LOG(LFPRFC04)	0.2678	7.19	0.0073 **	LOG(SHRPAID04)	0.1568	52.30	0.0000 **
LOG(AVGSCCH)	-2.3362	0.41	0.5195	LOG(AVGSCCH)	1.5734	0.83	0.3635
LOG(PCPI)	0.5817	1.91	0.1666	LOG(PCPI)	0.0153	0.01	0.9392
LOG(CCCOSTHHNET)	0.0191	0.18	0.6694	LOG(CCCOSTHHNET)	-0.0194	0.83	0.3636
LOG(PREKSHR1)	-0.1635	2.51	0.1135	LOG(PREKSHR1)	-0.0821	2.77	0.0958 *
All		12.52	0.0283	All		57.36	0.0000
Dependent variable: LOG(LFPRFC04)							
Explanatory Variable	Estimated Coefficient (t-1)	Granger Wald Test Chi-Sq	p-value	Explanatory Variable	Estimated Coefficient (t-1)	Granger Wald Test Chi-Sq	p-value
LOG(SHRPAID04)	-0.0003	0.36	0.5505	LOG(SHRPAID04)	-0.0027	0.30	0.5869
LOG(LFPRFC04)	0.0009	0.49	0.4835	LOG(LFPRFC04)	0.0002	0.00	0.9837
LOG(PCPI)	0.0105	4.22	0.0400 **	LOG(AVGSCCH)	-0.5579	1.96	0.1616
LOG(CCCOSTHHNET)	-0.0001	0.05	0.8257	LOG(CCCOSTHHNET)	-0.0020	0.17	0.6794
LOG(PREKSHR1)	-0.0020	2.66	0.1031	LOG(PREKSHR1)	0.0064	0.32	0.5728
All		7.20	0.2063	All		2.55	0.7694
Dependent variable: LOG(AVGSCCH)							
Explanatory Variable	Estimated Coefficient (t-1)	Granger Wald Test Chi-Sq	p-value	Explanatory Variable	Estimated Coefficient (t-1)	Granger Wald Test Chi-Sq	p-value
LOG(SHRPAID04)	-0.0276	0.31	0.5791	LOG(SHRPAID04)	0.0367	2.95	0.0860 *
LOG(LFPRFC04)	-0.2301	4.42	0.0356 **	LOG(LFPRFC04)	0.1014	4.65	0.0310 **
LOG(AVGSCCH)	8.9821	5.11	0.0238 **	LOG(AVGSCCH)	-2.8464	2.78	0.0955 *
LOG(PCPI)	0.2225	0.23	0.6293	LOG(PCPI)	-0.0387	0.04	0.8449
LOG(PREKSHR1)	0.0159	0.02	0.8884	LOG(CCCOSTHHNET)	-0.0045	0.05	0.8299
All		11.17	0.0481	All		11.79	0.0378

Notes: Null hypothesis is no Granger causality present. Sample is a balanced 50-state panel in the 2009 to 2019 period.
 ** Significant at the 5% level; * Significant at the 10% level.

Cointegration Tests

The concept of cointegration is closely tied to the notion of Granger causality but focuses on the long-run dimension of the relationship among a group of variables over time. A set of cointegrated variables maintain a long-run equilibrium relationship over time, with any short-run deviations from the long-run relationship corrected over time through an error-correction process. In fact, two cointegrated variables are expected to have short-run Granger causality present in at least one direction.

Testing for cointegration among child care variables is promising because it may identify any long-run statistical relationships present among the set of factors believed to influence paid child care. Much like short-run Granger causality tests, they inform the joint behavior of variables as they evolve over time. Panel cointegration techniques are used in the remainder of this section to test for the presence of long-run cointegrating relationships between paid child care usage and the economic and demographic factors. Child care market characteristics are excluded from the tests due to the short sample period for which these data series are available.

Panel Cointegration

Ongoing advances in economic growth theory and related advances in economic model construction now provide a much richer backdrop for analyzing questions of long-run statistical causality. One of these advances is panel cointegration, a time series modeling technique that offers the potential to capture long-run movements in economic activity. Panel refers to the simultaneous use of data across multiple regions and time periods. Cointegration refers to the co-movement of multiple data series over time (Engle and Granger 1987).

Unit root tests performed earlier provide necessary information for the implementation of cointegration tests. Given a common order of integration among the share of children in paid care and the other explanatory factors, cointegration tests provide a convenient means for testing for the presence of long-run equilibrium relationships among the variables. If variables are found to be cointegrated, estimates can then be made of the long-run elasticity between two cointegrated factors over time.

For any two cointegrated variables, an error correction term describes the difference between their current relationship and the expected long-run linear relationship predicted by the cointegration model. The farther the two variables are from their predicted relationship, the larger is the error correction term in a given period. The size of the error correction term contains useful information for long-run forecasting (Duy and Thoma (1998)).

Panel Cointegration Tests and Model Estimates

The base model includes children ages 0 to 4 in paid care as the dependent variable in the estimated equation. The economic variables include the labor force participation of mothers with all children ages 0 to 4, education measured as years of schooling, and real personal income per capita.

Cointegration tests are performed using both the Pedroni (1999, 2004) and Kao (1999) panel fully modified ordinary least squares (FMOLS) techniques. The Pedroni method provides 11 individual significance tests for the presence of a cointegrating relationship. Eight tests examine whether there is a common relationship across all states or the relationship differs by state. The null hypothesis of no cointegration can be rejected for either all or some of the individual tests. Cointegration is assumed present if a preponderance of the tests reject the null at either the 5 percent or 10 percent significance levels. The Kao test provides a single test statistic with reported probability levels. Both techniques have a null hypothesis of no cointegration. A small p-value suggests the presence of cointegration among the group of variables.

Panel cointegration test results for the base model are reported in Figure 7. Results indicate that the share of children in paid care (for both age groups) has a significant long-run cointegrating relationship with the group of economic variables. Nine of the test statistics for the Pedroni test reject the null hypothesis of no cointegration at the 5 percent level for both age groups. The Kao ADF statistic similarly finds a cointegrating relationship is present between paid child care (both age groups) and the economic and demographic measures. The cointegrating relationship is present both with and without a time trend in the model. The follow-up step is estimating the magnitude and direction of the long-run relationships.

Figure 7. Panel Cointegration Tests Of Base Model

Dependent Variable	Ages 0 to 4		Ages 0 to 14	
	Statistic	p-value	Statistic	p-value
H0= There is no cointegration				
<i>H1= common AR coefficients (within-dimension)</i>				
Unweighted:				
Panel v	0.878	0.1899	1.010	0.1563
Panel ρ	-5.177	0.0000	-4.173	0.0000
Panel PP	-16.215	0.0000	-13.600	0.0000
Panel ADF	-7.426	0.0000	-6.278	0.0000
Weighted:				
Panel v	-1.249	0.8942	-2.097	0.9820
Panel ρ	-4.894	0.0000	-3.704	0.0001
Panel PP	-17.328	0.0000	-15.946	0.0000
Panel ADF	-9.004	0.0000	-9.917	0.0000
<i>H1= individual AR coefficients (between-dimension)</i>				
Group ρ	-2.622	0.0044	-1.547	0.0609
Group PP	-20.957	0.0000	-19.306	0.0000
Group ADF	-7.701	0.0000	-7.360	0.0000
Kao ADF				
	-6.734	0.0000	-4.710	0.0000
Notes: Null hypothesis is no Granger causality present. Sample is a balanced 50-state panel in the 2009 to 2019 period. ** Significant at the 5% level; * Significant at the 10% level..				

Cointegration Estimates. Given evidence of long-run cointegrating relationships, the Pedroni (2004) fully modified ordinary least squares panel (FMOLS) method is used to estimate the long-run coefficients for the cointegrating relationship between the share of children in paid care and the economic and demographic factors.

The estimated coefficients for each independent variable can be interpreted as a long-run elasticity with respect to the share of children in paid care. The numerical value of each coefficient is interpreted as the expected long-run percent change in the share of children in paid care for a 1 percent change in the explanatory variable.

Cointegration Results. The base case model in Figure 8 indicates that each of the three economic and demographic factors has a stable long-run relationship with paid child care across the states in the test period.

Most important, maternal labor force participation has a highly significant long-run relationship with paid care across the states ($p=0.0000$). For children ages 0 to 4, a 1 percent increase in the maternal participation rate ($lfrpc04$) is associated with a 1.6 percent long-run increase in the share of children in paid care. The estimated elasticity is greater than unity, indicating a greater than proportional response from labor force attachment to paid care usage. Paid care and maternal labor force participation were similarly found to have a significant bi-directional short-run relationship in the earlier Granger causality tests.

Most important, maternal labor force participation has a highly significant long-run relationship with paid care across the states

Figure 8. Cointegration Model Of Paid Care And Economic Factors

Dependent Variable: SHRPAID04				
Explanatory Variable:	Estimated Coefficient	Std. Error	t-Statistic	p-value
LOG(LFPRFC04)	1.6018	0.077	20.87	0.0000 **
LOG(AVGSCH)	-1.5222	0.381	-3.99	0.0001 **
LOG(PCPIR)	0.3049	0.092	3.33	0.0009 **
R-squared	0.2309	Mean dependent var		-1.3143
Adjusted R-squared	0.2293	S.D. dependent var		0.2721
S.E. of regression	0.2389	Sum squared resid.		56.8914

Notes: Base case model estimated using the Pedroni fully modified ordinary least squares panel (FMOLS) procedure. Sample is a balanced 50-state panel in the 2000 to 2019 period. ** Significant at the 5% level; * Significant at the 10% level.

Given the 2020 participation rate of 69.9 percent for mothers ages 18 to 54, a 1 percent increase is equivalent to a rise of 0.7 percent in the rate, to 70.6 percent. The estimated 1.6 percent long-run change in children ages 0 to 4 in paid care is equivalent to approximately 160,500 additional children in paid care based on 2020 enrollment of 10.03 million children in paid care.

Similarly, real personal income per capita is found to have a stable long-run relationship with paid care usage ($p=0.0009$). The cointegration model estimates suggest that a 1 percent increase in real personal income per capita is associated with a 0.30 percent long-run increase in the share of children in paid care. This relationship was marginally insignificant in the short-run causality tests but suggests an economically significant long-run relationship. A 1 percent increase in real personal income per capita is associated with a long-run increase of 30,100 children in paid care.

The education variable is statistically significant but has an estimated negative sign as found in the Granger causality tests. Again, this reflects the persistent uptrend in educational attainment in the period. It may also reflect some redundancy with income.

A significant long-run relationship is found between labor force attachment and both younger and older children in paid care.

Results - Labor Force Attachment and Paid Care Usage. The key aspect of the cointegration findings is the cointegrated relationship between maternal labor force attachment and the share of paid care usage. In this section, alternative measures of labor force attachment are included in the cointegration model to better understand which measures of labor force attachment are most closely related to paid care in the long-term.

As with the Granger causality tests, the cointegration results are tested for sensitivity to the age of children in care and the measure of labor force attachment. The base case cointegrating equation is re-estimated using children in paid care in two groups – ages 0 to 4 and ages 0 to 14 – and both the labor force participation and the employment ratio for various groups of the population ages 18-54. Labor force groupings include the overall population, males, females, females with all children ages 0 to 4, females with a youngest child ages 0 to 4, and females with a youngest child ages 0 to 14.

Additional cointegration test results using the alternative labor force measures are summarized in Figure 9. Again, because the focus of this section is on labor force attachment, estimates are provided only for those linkages from the various labor force attachment measures to the share of children in paid care.

The findings strongly confirm the presence of a stable long-run relationship between multiple measures of labor force attachment and the share of children in paid care.

1. Importantly, a significant long-run relationship is found between labor force attachment and both younger and older children in paid care. The relationship is also significant for nearly every measure of

labor force attachment. Only the male employment ratio is not cointegrated with the share of older children ages 0 to 14 in paid care. This suggests that increased labor force attachment of nearly all demographic groups is expected to be accompanied by a rising share of children in paid care.

2. The estimated long-run elasticities are generally larger for younger children ages 0 to 4 relative to the older group of children ages 0 to 14 for a given demographic group. This is consistent with short-run findings from the Granger causality tests. For the overall female participation rate, the elasticity of 1.22 for younger children is roughly 20 percent higher than the estimate of 1.03 for older children. This is true for all measures of maternal labor force attachment and provides further evidence of larger relative changes in paid child care usage by mothers of younger children relative to those with older children. The same relationship is present for the overall labor force and for males.
3. The estimated response of paid care to maternal labor force attachment is greater as the definition used for mothers widens. For mothers with all children ages 0 to 4, the estimated elasticity with respect to children ages 0 to 4 in paid care is 0.493. However, mothers with a youngest child ages 0 to 4 have an estimated elasticity 0.837 while mothers with a youngest child ages 0 to 14 have an estimated elasticity of 1.21. A similar pattern is present for mothers with respect to children ages 0 to 14 in paid care. These relationships

Increased labor force attachment of nearly all demographic groups is expected to be accompanied by a rising share of children in paid care.

are consistent for both the participation rate and the employment ratio. Thus, the broader definitions of maternal attachment have higher estimated long-run elasticities with respect to paid care. One potential implication of this result suggested by the data is that mothers with younger children are simply less likely to change their use of paid child care as their labor force status changes. One possible interpretation is the difficulty often reported in finding care for younger children, particularly infants. The desire to maintain a care arrangement through a period outside the labor force may outweigh the cost of care while out of work for many parents. For mothers with older children, substitutes for a care arrangement are found more easily.

4. Elasticities measured using the labor force participation rate are generally higher than those measured with the employment ratio. This is believed to be capturing the presence of some mothers using paid child care who are in the labor force but unemployed. These mothers will not be captured when analyzing labor force data using only the employment ratio.

5. Overall and male labor force attachment rates are also found cointegrated with the share of children in paid care. This is additional evidence of a broader and more general relationship between labor force participation and paid child care use over the long run. Most measures of labor force participation suggest a cointegrating relationship for paid child care with both younger and older children in paid care.



Figure 9. Cointegration Coefficients - Share Of Children In Paid Care

Dependent Variable	Explanatory Variable	Panel FMOLS Estimates			
		Estimated Coefficient	Standard Error	t-Statistic	p-value
Children Ages 0 to 4 in Paid Care					
<i>Alternative RHS Measures:</i>					
LOG(SHRPAID04)	LOG(LFPR)	1.406	0.3300	4.26	0.0000 **
LOG(SHRPAID04)	LOG(LFPRF)	1.216	0.2304	5.28	0.0000 **
LOG(SHRPAID04)	LOG(LFPRFC04)	0.493	0.0721	6.84	0.0000 **
LOG(SHRPAID04)	LOG(LFPRFYC04)	0.837	0.0957	8.75	0.0000 **
LOG(SHRPAID04)	LOG(LFPRFYC014)	1.212	0.1608	7.54	0.0000 **
LOG(SHRPAID04)	LOG(LFPRM)	0.616	0.3122	1.97	0.0487 **
LOG(SHRPAID04)	LOG(EMPOP)	0.665	0.2069	3.22	0.0013 **
LOG(SHRPAID04)	LOG(EMPOPF)	0.720	0.1791	4.02	0.0001 **
LOG(SHRPAID04)	LOG(EMPOPFC04)	0.416	0.0636	6.53	0.0000 **
LOG(SHRPAID04)	LOG(EMPOPFYC04)	0.666	0.0839	7.94	0.0000 **
LOG(SHRPAID04)	LOG(EMPOPFYC014)	0.856	0.1352	6.33	0.0000 **
LOG(SHRPAID04)	LOG(EMPOPM)	0.425	0.1856	2.29	0.0224 **
Children Ages 0 to 14 in Paid Care					
<i>Alternative RHS Measures:</i>					
LOG(SHRPAID014)	LOG(LFPR)	1.287	0.3047	4.22	0.0000 **
LOG(SHRPAID014)	LOG(LFPRF)	1.027	0.2140	4.80	0.0000 **
LOG(SHRPAID014)	LOG(LFPRFC04)	0.390	0.0672	5.81	0.0000 **
LOG(SHRPAID014)	LOG(LFPRFYC04)	0.640	0.0906	7.06	0.0000 **
LOG(SHRPAID014)	LOG(LFPRFYC014)	0.991	0.1498	6.61	0.0000 **
LOG(SHRPAID014)	LOG(LFPRM)	0.689	0.2866	2.40	0.0164 **
LOG(SHRPAID014)	LOG(EMPOP)	0.408	0.1918	2.13	0.0336 **
LOG(SHRPAID014)	LOG(EMPOPF)	0.468	0.1669	2.80	0.0051 **
LOG(SHRPAID014)	LOG(EMPOPFC04)	0.303	0.0595	5.09	0.0000 **
LOG(SHRPAID014)	LOG(EMPOPFYC04)	0.455	0.0797	5.71	0.0000 **
LOG(SHRPAID014)	LOG(EMPOPFYC014)	0.566	0.1267	4.47	0.0000 **
LOG(SHRPAID014)	LOG(EMPOPM)	0.250	0.1710	1.46	0.1440
Note: Table shows coefficients from a multi-variate panel cointegration models estimated using fully modified ordinary least squares (FMOLS). The null hypothesis is no cointegration. Balanced panel of 50 states with sample of 2009-2019.					

Economic Growth Effects

Labor force attachment has long received considerable attention from policymakers striving to spur economic growth. Research findings continue to point toward increased labor force attachment as an underlying source of added economic growth (Aaronson et al. 2014). Economic theory suggests that higher utilization and more efficient employment of existing labor resources directly increases the potential output of a region.

This growth view of the role of increased labor force attachment was substantiated by the long-run influx of women into the U.S. labor force during much of the Post-World War II period (Goldin 1986). More recently, falling labor force attachment for both men and women likely acted as a meaningful drag on real household income growth in the U.S. the past two decades. The steep decline in participation for all groups during the Covid 19-driven recessionary period raised further concerns over the nation's shrinking participation rate.

Multiple Economic Growth Factors

The question addressed in this section of the report concerns the size of any expected economic growth effects from increased labor force attachment. Gauging the size of the potential economic gains from increased labor force attachment is complicated by the fact that it is just one of many factors believed to drive the level of income within a state or region. The set of fundamental factors driving economic growth can vary widely across the states and is often influenced by the industry mix in place within a given state.

The presence of multiple growth factors presents a challenge to policymakers who must choose among alternative strategies but may have only limited empirical evidence on the probable effect each might have on their region's economy. Many potential growth factors are also interrelated with labor force participation. Ultimately, a group of factors jointly determine income growth in a region. As a result, evaluations of the expected income gains from increased labor force participation at the state level must be undertaken within the context of a model including multiple economic growth factors.

The objectives of the remainder of the report are three-fold:

1. To describe recent advances in long-run economic growth modeling that can help explain the empirical link between labor force attachment and income growth at the national and state levels;

2. To provide empirical estimates of the expected long-run effect of increased participation on future income growth; and
3. To use empirical results from earlier in the report to form estimates of the resulting change in the use of paid child care as labor force participation changes.

Labor Force Attachment and Economic Growth

State level economic development strategies often focus on labor force-based efforts to increase both labor force attachment and educational attainment. Labor force attachment focuses on enhancing the size of the labor force within a region while educational attainment is concerned with the quality of the labor force.

Labor force attachment becomes increasingly relevant when examined jointly within a framework that includes education. Workers with higher educational attainment are more likely to participate in the labor force and are less likely to experience unemployment during economic downturns.

In addition to increased education, other widely used approaches to increasing labor force attachment include subsidized job training following mass layoffs, high-school completion programs, targeted employment tax credits, and expanded child care availability. All these approaches are viewed as offering some potential to

increase labor force attachment and economic growth.

Historical Link Between Income and Labor Force Involvement

The current policy focus of raising labor force attachment in the U.S. is largely derived from the long-run relationship observed between income and labor force attachment over time and across the states.

Figure 10 illustrates the recent state level relationship between the per capita personal income and labor force participation in 2019. Income is defined as real personal income per capita, consistent with measures used earlier in the report. The participation rate is measured for the civilian noninstitutional population ages 16 and over. The relationship underlies the notion that income is higher in states where overall rates of labor force participation are higher.

Participation in most states falls within a range of 55 to 70 percent, or approximately 7-8 percent above and below the U.S. ratio of 61.4 percent in 2019. Income per capita has greater relative variation than participation across the

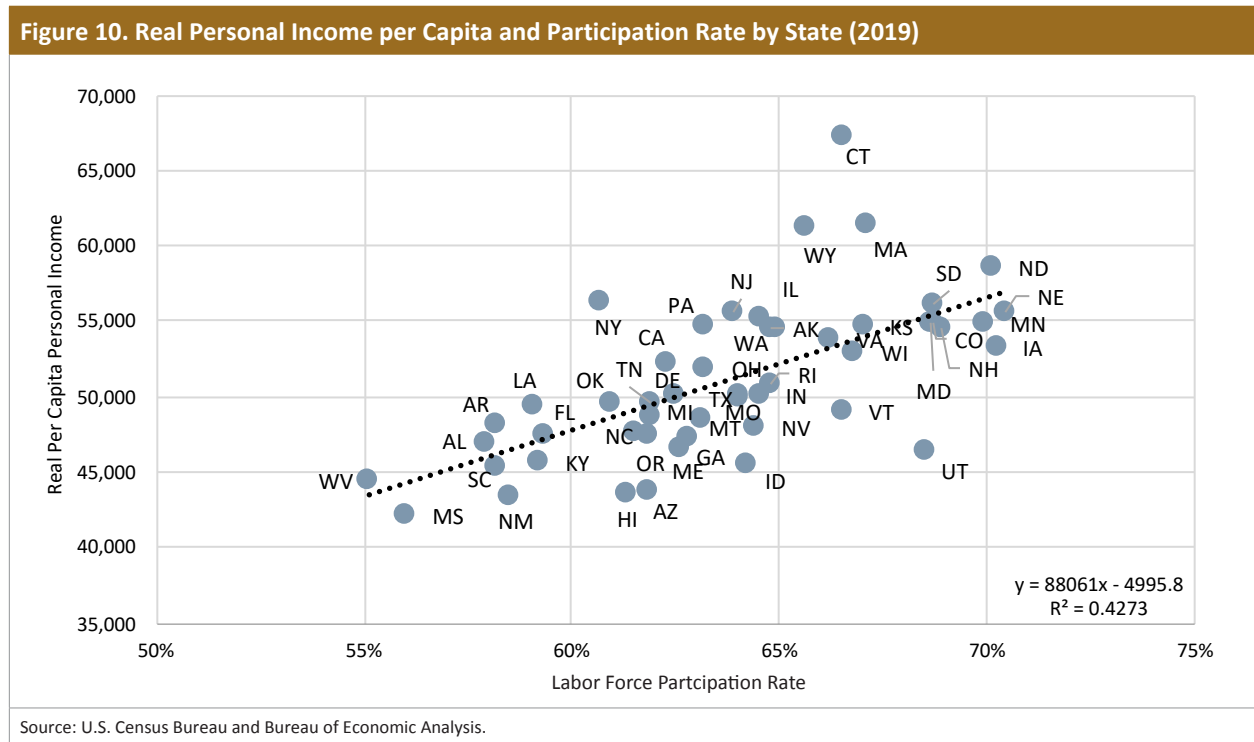
Evaluations of the expected income gains from increased labor force participation at the state level must be undertaken within the context of a model including multiple economic growth factors.

states, and ranges from about \$42,000 to about \$58,000 for most states. Three states – Connecticut, Wyoming, and Massachusetts – have far higher real income than the remaining states, exceeding \$60,000 per capita.

The estimated best-fit line in Figure 10 illustrates the strength of the overall relationship across states. On average, the equation indicates that one additional percentage point in participation rate is associated with approximately \$881 in higher annual personal income per capita on average across the states. States above (below) the best-fit line have a

level of state per capita income in 2019 that is higher (lower) than expected based solely on the state’s participation rate.

The approximately 15 percent difference in the participation rate between the highest (Nebraska) and lowest (West Virginia) ratio states produces an expected \$13,215 difference in real personal income per capita. This simple relationship has remained remarkably stable for several decades and is frequently cited as underlying support for economic development initiatives that encourage greater labor force involvement.



State Income Growth Modeling

Panel cointegration methods are used in this section to model the co-movement of labor force participation and income across the states over time. Cointegration methods do not explicitly seek to explain causal linkages among the various factors driving income growth but instead capture stable long-run relationships that tend to hold between income and other economic growth factors over time. Hence the growth estimates measure the expected long-run change in real personal income per capita given a change in overall labor force attachment.

Key Economic Growth Factors

Other growth factors beyond labor force participation are required for the construction of a robust state-level growth model. This requires the identification and inclusion of

other key economic factors that reliably predict economic growth across regions. Ideally, these growth factors should have:

- a strong theoretical relationship to the economic growth process;
- a reliable statistical relationship with regional economic growth over time; and
- meaningful policy applications within common economic development strategies.

Along with the participation rate, we model the contribution of three other well-known factors affecting regional economic growth:

1. educational attainment,
2. capital investment, and
3. traded activity, or openness.

These three factors receive considerable attention in the research literature on economic growth and have long been recognized by policymakers as viable targets for regional economic development. These growth variables are also broadly consistent with evidence at the country level in both Bergheim (2008) and Casadio et al. (2012) that trade openness, human capital, and investment in physical capital drive growth across a range of countries. Dall'erba and Llamosas-Rosas (2015) provide an overview of research examining the returns to schooling at the state and regional level within the context of multiple growth factors.

Educational Attainment. Early works by Holtz-Eakin (1993), Vohra (1996), Garofalo and Yamarik (2002), Bauer et al. (2006), and Yamarik (2006) find that attainment of higher education leads to higher average incomes at the state level. More recently, Yamarik (2011) examines the relationship between schooling and state-level growth and finds that 20-25 percent of the growth in income across states is traced to increased education. These findings reinforce the existence of a systematic relationship between income and economic activity at the state level.

However, not all observers agree that higher education and regional economic growth are obvious or necessary partners. Again, education is only one of many factors believed to stimulate regional economic growth.⁹ Questions also surround the direction of causality between education and earnings. Research by In and Doucouliagos (1997) first suggested evidence of bi-directional causality, whereby education and economic growth are determined jointly over the long run.¹⁰ Despite these issues, ongoing research continues to confirm a strong empirical link between educational attainment and economic growth at the state level.

Capital. The second factor, capital investment, has long been viewed as a critical ingredient to economic growth, especially in the capital-intensive sectors of the economy (Garofalo and Yamarik 2002 and Yamarik 2011). Several theoretical frameworks are available to describe the process by which capital formation takes place and influences regional economic growth. There is only limited agreement on the exact process, including the degree of endogeneity of capital spending (Bergheim 2008). Economic development strategies designed to stimulate capital spending include investment tax credits, subsidized lending programs, accelerated depreciation schedules for equipment, sales and use

The use of these factors condenses the broad range of potential economic development strategies into four basic foundational policy actions that can be taken with respect to a regional economy: greater labor force participation, higher levels of education, increased capital formation, and increased traded activity.

tax exemptions on equipment purchases, and ad valorem tax exemptions and rebates.

Traded Activity, or Openness. And, finally, production for trade outside a region, or a region's degree of openness, traces its origins to the notion of enhancing the "basic" industries located within a region. Basic industries produce goods and services that are exported for sale outside the local market. This includes trade with other states as well as internationally. States with large manufacturing, mining, and federal government sectors (including military) tend to have the most traded activity with outside regions.

Traded activity captures spending from outside the region which in turn helps support the development of the region's "nonbasic" sectors. Nonbasic industries are believed to merely recirculate existing purchasing power, which exerts less influence on overall regional growth than an equivalent injection of spending from outside the region. Theory also suggests that the cross-border exchange of goods, services, technologies, factors of production, and ideas have a beneficial impact on incomes as scarce resources are utilized more efficiently (Hausmann, Pritchett, and Rodrik 2005). Economic development strategies that attempt to boost traded activity include trade zones, manufacturers' exemptions, as well as various tax exemptions, deductions, and rebates targeted at exporters.

Interrelationships. The four growth factors in the model rarely work in isolation but are instead highly interrelated. As described earlier, labor force attachment and education are closely related, with higher levels of education generally associated with increased participation rates across the states. Capital investment acts as a complement to the labor force in jointly determining overall rates of worker productivity. As a result, efforts to produce better-educated workers for industries which have no capital base in place to thrive within the region are likely to produce lower returns to increased education. Similarly, many basic industries that produce traded activity outside the region tend to be the heaviest users of capital, particularly the mining and manufacturing sectors.

Economic Development Strategies. All four growth factors are also believed to play a key role in the fundamental process of economic growth over time across all regions and are not simply transient contributors to the growth process. The use of these factors condenses the broad range of

potential economic development strategies into four basic foundational policy actions that can be taken with respect to a regional economy: greater labor force participation, higher levels of education, increased capital formation, and increased traded activity. This basic model results in a set of four fundamental economic development strategies that are identified as relevant in the research literature, consistent with historical trends in data, and time-tested in practice.

Other Potential Growth Factors. There are certainly other potential economic factors that underlie the regional economic growth process. One such factor is population. We exclude population from the model based on extended findings in the research literature that suggest population is largely determined by, or endogenous to, the overall economic growth process rather than a key determinant of economic growth in most regions (Becker, Glaeser, and Murphy 1999; Easterly 2001). There is also little statistical relationship between population growth and economic growth over time and across regions (Bergheim 2008).

Similarly excluded are measures of innovation such as patents and R&D spending. Additionally, elements postulated to enhance a region's economic dynamism such as entrepreneurship training, depth and breadth of capital markets, levels of business taxes, mobility of labor and capital, and the regulatory environment (Bauer et al. 2006) are also omitted. While all these factors are all possible candidates for explaining economic growth in a regional growth forecasting model, there remains significant disagreement concerning the role played by these factors in fostering long-run economic growth at the regional level (Bartik 2009).

Data. A panel cointegration model is constructed with five data series defined as follows:

PIPCR = real personal income per capita (dollars)
 LFPR = overall labor force participation rate (percent)
 AVGSCH = average years of schooling (years)
 CAPPW = net private fixed capital per worker (dollars)
 EXPPW = earnings from traded activity, or exports, per worker (dollars)

All five series are measured annually over the 1990-2019 period. Data series names include the log operator, L(), when used in natural logarithms. A log series used in differenced form to compute percentage changes over time is denoted by the log-difference operator, DL().

Real personal income per capita and educational attainment (average years of schooling for the population ages 25 and over) remain as defined earlier in the report.

Data on the stock of fixed capital are generally not available at the sub-national level and must be estimated from U.S. data produced by the Bureau of Economic Analysis (BEA) on fixed capital stocks. State-level estimates are formed in

the 1990 to 2019 period by partitioning national data on net private fixed assets at the industry level based on a region's share of national earnings at the industry level (Yamarik 2013).¹¹ The estimated measure of capital is net of depreciation and includes the broad asset categories of equipment, structures, and intellectual property. Public sector assets are excluded from the analysis.

Industry-level estimates of net private fixed assets are formed for each state at approximately the 3-digit North American Industrial Classification System (NAICS) as defined by BEA. The industry level estimates are then aggregated to derive total net private fixed assets at the state level. Net investment is measured as the year-to-year change in net private fixed assets.

Capital is defined in the model as net private fixed assets per worker (using the BEA definition of employment including both wage and salary employees and self-employed proprietors). Capital per worker at the national level totaled \$244,543 in 2019.

Exports of goods and services is the most common measure of traded activity at the national level. However, there is no equivalent measure of regional external trade at the sub-national level. Measures of international exports from the states and metro areas are available, but they do not capture the full notion of traded activity at the sub-national level. Goods and services that are sold outside a state or region but within the U.S. are excluded here.

We construct a proxy of traded activity for each state by estimating the amount of earnings derived within industry sectors that produce goods and services considered mostly or fully for sale outside the local market. Using BEA industry definitions at approximately the 3-digit NAICS level, the following goods-producing sectors are considered basic sectors: farming; forestry, fishing, and related activities; mining; and manufacturing.

The following service-providing sectors are viewed as basic sectors producing services largely for external trade: air transportation; rail transportation; water transportation; truck transportation; transit and ground passenger transportation; pipeline transportation; scenic and sightseeing transportation; telecommunications; ISPs, search portals, and data processing; securities, commodity contracts, and investments; arts, entertainment, and recreation; accommodation; and federal government - civilian and military.

Traded activity is defined as total household earnings derived from these basic sectors that primarily produce activity for consumption outside the state divided by total state employment (using the BEA definition of employment including both wage and salary employees and self-employed proprietors).¹² Traded activity per worker totaled \$15,274 nationally in 2015.

Figure 11. Sample Correlation Matrix – Levels (50 States)

Data Series	L(PCPIR)	L(LFPR)	L(AVGSCH)	L(CAPPW)	L(TRADEPW)
L(PCPIR)	1.00	0.57	0.77	0.85	0.76
L(LFPR)	0.57	1.00	0.65	0.32	0.40
L(AVGSCH)	0.77	0.65	1.00	0.66	0.52
L(CAPPW)	0.85	0.32	0.66	1.00	0.71
L(TRADEPW)	0.76	0.40	0.52	0.71	1.00

Notes: Sample is 1990-2019 for all data series. All correlations are significantly different from zero based on a t-test. All variables are in log levels.

Correlation Analysis. Figure 11 summarizes the long-run correlation of each factor with personal income per capita across the 50 states. Examining the simple historical correlations of income with the four growth factors provides a basic illustration of the various long-run interrelationships over time.

All four growth factors are highly positively correlated with the level of real personal income per capita (see the first column of Figure 10) and are all significantly different from zero based on a t-test. The correlations of each growth factor with income range from a high of 0.85 for capital per worker to a low of 0.57 for the participation rate. Years of schooling has the second highest correlation with income at 0.77. Traded activity is only slightly lower at 0.76.

Years of schooling is most closely correlated with income (0.77) but has a strong correlation with the participation rate (0.65) as expected. The correlation is also highly consistent across the states.

Figure 12 extends the correlation analysis to annual changes (log first differences) in personal income per capita and the four growth factors in log-difference form in the 1990 to 2019 period. Annual changes in all four growth factors are positively correlated with changes in income (see the first column of Figure 11), and all but educational attainment are significantly different from zero based on a t-test.

Log differences in the participation rate have the highest year-to-year correlation with income per capita (0.62). However, the correlation between income and education is much lower in differences (0.08) than in levels (0.77). This is consistent with intuition that the level of education in a region may contain more information about future income growth than small, incremental year-to-year changes in education. It also suggests that volatile year-to-year cyclical changes in income are less likely to be correlated with a relatively smooth measure such as the change in educational attainment.

The correlation between capital and traded activity remains relatively high (0.34) in differences, but the correlation between schooling and the participation rate becomes quite weak (0.06) over time when measured in differences. This finding was present in Granger causality tests conducted earlier in the report. This suggests that year-to-year changes in the participation rate are tied to other factors beyond simply ongoing steady gains in educational attainment.

Figure 12. Sample Correlation Matrix – Differences (50 States)

Data Series	DL(PCPIR)	DL(LFPR)	DL(AVGSCH)	DL(CAPPW)	DL(TRADEPW)
DL(PCPIR)	1.00	0.62	0.08	0.27	0.50
DL(LFPR)	0.62	1.00	0.06	0.01	0.11
DL(AVGSCH)	0.08	0.06	1.00	0.03	0.06
DL(CAPPW)	0.27	0.01	0.03	1.00	0.33
DL(TRADEPW)	0.50	0.11	0.06	0.33	1.00

Notes: Sample is 1991-2019 for log first differences. All correlations except average schooling with both capital per worker and traded activity, are significantly different from zero based on a t-test. DL() denotes a log difference.

Estimating the Growth Model

Panel cointegration techniques are used to derive empirical estimates of the effect of each growth factor on personal income per capita across the states over time. A 50-state panel model linking labor force participation to real income growth is constructed to provide long-run empirical estimates of the underlying relationships. Our primary interest remains the relationship between labor force participation and real income growth per capita.

Each data series is first tested to determine whether it has suitable statistical properties for inclusion in the model, primarily stationarity. Panel unit root tests indicate that all five variables (income and the four growth factors) are found to have a unit root in levels and are stationary in first differences, or are I(1). This satisfies the stationarity requirements for inclusion in the model.

Estimation of Long-run Cointegrating Relationships

The Pedroni (2004) fully modified ordinary least squares panel (FMOLS) method is applied to the panel dataset to determine whether there is a reliable long-run relationship between income and each of the growth factors. The model is estimated using a balanced panel in the 1990 to 2019 period. Figure 13 contains the estimated coefficients for each growth factor in the state panel cointegration model.

The estimated model allows us to evaluate the expected long-run effect on state income growth given alternative scenarios for each growth factor in the model. The coefficient for each factor represents a long-run elasticity with respect to real personal income per capita. Because the model is estimated in natural logarithms, the numerical

value of each coefficient can be interpreted as the expected long-run percent change in real personal income per capita for a 1 percent change in the growth factor.

Estimated Growth Effects

For the labor force participation rate, a 1 percent increase is associated with an estimated 0.87 percent long-run increase in real personal income per capita across the states. Based on 2020 U.S. real income per capita of \$53,701, a 1 percent change in the participation rate (from 65.6 percent

to 66.3 percent) implies a \$467 average increase in real income per capita across the states in the long run. Based on U.S. population of 331.5 million in 2020, the expected increase in total real personal income is \$154.9 billion.¹³

The estimated total income gain is equal to 0.79 percent of current nominal U.S. personal income totaling \$19.61 trillion in 2020. In other words, a 0.7 percentage point increase in the U.S. labor force participation rate is expected to

produce a nearly 0.8 percent increase in total real personal income in the long run.

The estimated cointegration coefficients for the other long-run growth factors in Figure 13 are interpreted in a similar manner. For education, or average years of schooling, a 1 percent increase in attainment is associated with an estimated 1.76 percent increase in long-run real personal income per capita across the states.¹⁴ A 1 percent increase in the amount of capital per worker is associated with an additional 0.19 percent in added real income per capita across the states. For traded activity per worker, each 1 percent increase in the amount of earnings from traded activity produces an expected long-run increase of 0.17 percent in personal income per capita on average across the states.

A 1 percent increase in the labor force participation rate would increase total real personal income by \$154.9 billion.

Figure 13. Long-Run Cointegration Coefficients (50 States)

Dependent Variable: Real Personal Income per Capita

Explanatory Variable	Panel FMOLS Results			
	Coefficient	Std. Error	t-Statistic	P-Value
LFPR	0.868	0.0459	18.90	0.0000
AVGSCH	1.761	0.1587	11.10	0.0000
CAPPW	0.190	0.0163	11.66	0.0000
TRADEPW	0.165	0.0183	9.03	0.0000

Notes: Table shows coefficients from bi-variate panel cointegration tests using fully modified ordinary least squares (FMOLS). Null hypothesis is no cointegration. Sample is 1970-2019 for real personal income per capita (PIPCR), years of schooling (AVGSCH), and employment-population ratio (EMPOPR). Capital per worker (CAPPW) and traded activity per worker (TRADEPW) are measured over the 1990-2019 period.

Potential Growth Effects From Increased Participation

The estimated long-run growth model estimated in the prior section illustrates for policymakers the potential long-run payoff from raising the nation's current participation rate. It also illustrates the potential loss of income resulting from declining labor force participation rates in recent decades.

Specifically, the estimated growth model can be used to derive estimates of the long-run expected change in real personal income per capita that results from changes in labor force participation. The estimate of a 0.87 percent increase in real personal income per capita for a 1 percent increase in labor force participation can be viewed as an average long-run effect across all states and all segments of the labor force.

Role of Paid Child Care in Economic Growth. Prior empirical results suggest that paid child care usage is also expected to change along with labor force participation. Paid child care usage is characterized as having significant short- and long-run empirical relationships with labor force attachment. **Short run causality tests suggest a significant Granger causal link from labor force participation to paid child care usage, but primarily for women with younger children.** The reverse short-run link from the share of children in paid care to labor force participation is significant for most measures of labor force attachment, including overall measures.

Long-run cointegration tests also suggest a long-run relationship between paid care and labor force participation. Estimated long-run elasticities for a change in the share of children in paid care range from 0.4 percent to 1.2 percent for a 1 percent change in various female and maternal participation rates.

Paid child care usage is not believed to be fundamental factor driving the level of real income in the U.S. Most importantly, there is little evidence of any short-run Granger causal relationship running from paid child care usage to real personal income per capita. This suggests that paid care usage is only indirectly related to real income growth through its relationship with labor force participation. As labor force participation rises, the expectation is that both paid child care usage and real income rise. This is also consistent with the long-run cointegrating relationship between paid child care usage and labor force participation and between paid child care usage and real income growth.

Growth Scenarios

We examine three scenarios evaluating the long-run growth effects of increased labor force participation of women ages 18-54:

1. **A 1 percent increase in the overall female participation rate in 2020.** This is the case of a broad effort to attract women of all maternal and marital statuses into the labor force. The overall 2020 participation rate for females would rise from 72.9 percent to 73.6 percent, or an additional 569,100 females in the labor force holding population constant. Approximately 78.1 million women are in the category, with 3.44 million unemployed and 21.16 million not in the labor force in 2020. The required 569,100 workers represent 16.5 percent of unemployed workers and 2.7 percent of those not in the labor force. Of the women in this group, about 37 percent (210,700) would be females with children ages 0 to 14 if they maintain the same share of the workforce.
2. **A 1 percent increase in the participation rate for mothers with a youngest child ages 0 to 14.** This is a narrower case of focusing only on mothers with children. The 2020 participation rate for these mothers would require an increase from 70.7 percent to 71.4 percent, or an additional 210,700 mothers in the labor force. Approximately 29.8 million mothers are in the category, with 1.19 million unemployed and 8.73 million not in the labor force. The required 210,700 mothers represent 17.6 percent of unemployed mothers and 2.4 percent of those not in the labor force.
3. **A 1 percent increase in the participation rate for women with all children ages 0 to 4.** This is a far narrower scenario of focusing only on mothers with very young children. The 2020 participation rate for this group of mothers would rise from 69.3 percent to 70.0 percent, or an additional 44,900 mothers of children ages 0 to 4 in the labor force. Approximately 6.47 million mothers are in the category, with 259,800 unemployed and 1.98 million not in the labor force. The required 44,900 workers represent 17.3 percent of unemployed workers and 2.3 percent of those not in the labor force.

The scenarios represent three unique cases of increased labor force participation. The variation in the size of the groups is expected to produce substantial variation in projected income growth. We assume that new workers added to the labor force are equally as productive and skilled on average as existing workers in the economy. This entails using the same average long-run elasticity (0.87 percent) between labor force participation and real income per capita in all three scenarios. Participation rates for other classifications of workers are assumed to remain constant.

The share of workers using paid child care is assumed to change along with labor force participation based on estimated long-run cointegration relationships estimated earlier in the report. Hence, changes in the labor force produce expected changes in the number of children in paid care.

Scenario 1 - Female Participation Rate.

An effort to raise the U.S. female labor force participation rate by 1 percent (from 72.9 percent to 73.6 percent, or 569,100 females added) is a significant undertaking. For context, the female participation rate for females ages 18 to 54 is now about three percentage points below the recent high of 76.0 percent in 2000. If achieved, it would have a sizeable influence on the broader U.S. economy.

The required addition of 569,100 females would raise the total labor force in the U.S. by 0.47 percent and push the overall U.S. participation rate from 77.8 percent to 78.2 percent. Based on earlier results that a 1 percent increase in the participation rate is associated with an estimated 0.87 percent long-run increase in real personal income per capita across the states (Figure 13), average real personal income per capita is estimated to increase by 0.41 percent.

Based on 2020 U.S. real income per capita of \$53,701, a 0.47 percent change in the participation rate implies a \$221 average increase in real personal income per capita across the states in the long run. This is roughly half the income gain expected for a 1 percent increase in the overall U.S. participation rate, including both males and females. Using 2020 U.S. population of 329,484,000, the expected increase in total real personal income is \$72.8 billion. The estimated income gain is equal to 0.4 percent of current nominal U.S. personal income totaling \$19.61 trillion in 2020.

Paid Care. The increase in the labor force participation of females is also accompanied by an expected long-run increase in the use of paid child care. The estimated long-run cointegration coefficient for the female participation rate in Figure 9 is 1.216 for children ages 0 to 4 and 1.027 for children ages 0 to 14. The coefficient for children ages 0 to 4 is interpreted as an expected 1.216 percent change in the share of children in paid care for a 1 percent increase in the labor force participation rate for females. The coefficient for children ages 0 to 14 is interpreted similarly.

The share of children in paid care is expected to rise from 29.4 percent to 29.8 percent for those ages 0 to 4 and from 16.0 percent to 16.24 percent for those ages 0 to 14. Based on 5.71 million children ages 0 to 4 in paid care in 2019, the increased female participation rate would produce an expected gain of 69,500 children ages 0 to 4; the current 12.29 million children ages 0 to 14 in paid care would increase by an estimated 126,200.

An effort to raise the U.S. female labor force participation rate by 1 percent (from 72.9 percent to 73.6 percent, or 569,100 females added) is a significant undertaking.

Relative to the expected labor force increase of 569,100 females, the change would be accompanied by an expected increase of 126,200 children ages 0 to 14 in paid child care. An average of 0.22 children would enter paid care for each new female entrant into the labor force.

Scenario 2 - Mothers With a Youngest Child Ages 0 to 14.

An effort to raise the participation rate of mothers with a child ages 0 to 14 by 1 percent is a smaller undertaking influencing a far smaller population of potential workers. The participation rate for these mothers has remained relatively steady in a range around 71 percent since the late 1990s.

The required addition of 210,700 mothers in the group would raise the U.S. labor force by 0.18 percent and push the participation rate from 77.8 percent to only 77.9 percent. Based on earlier results that a 1 percent increase in the participation rate is associated with an estimated 0.87 percent long-run increase in real personal income per capita across the states (Figure 13), average real personal income per capita is estimated to increase by 0.18 percent.

Based on 2020 U.S. real income per capita of \$53,701, a 0.18 percent change in the participation rate implies only an \$81 average increase in real personal income per capita across the states in the long run. Using 2020 population of 329,484,000, the expected increase in total real personal income is \$26.9 billion. The estimated income gain is equal to 0.14 percent of current nominal U.S. personal income totaling \$19.61 trillion in 2020.

Paid Care. The increase in labor force participation for mothers with a youngest child ages 0 to 14 is expected to produce a long-run increase in the use of paid child care. The estimated long-run cointegration coefficient for the participation rate for these mothers in Figure 9 is 1.212 for children ages 0 to 4 and 0.991 for children ages 0 to 14. The coefficient for children ages 0 to 4 is interpreted as an expected 1.212 percent change in the share of children in paid care for a 1 percent increase in the labor force participation rate for these mothers. The coefficient for children ages 0 to 14 in paid care is interpreted similarly.

The share of children in paid care is expected to rise from 29.4 percent to 29.8 percent for those ages 0 to 4 and from 16.0 percent to 16.24 percent for those ages 0 to 14. These changes roughly match the expected responses for the overall female participation rate in Scenario 1 due to nearly equal estimated elasticities for both groups. Based

on 5.71 million children ages 0 to 4 in paid care in 2019, the increased participation rate would produce an expected gain of 69,300 children ages 0 to 4; the current 12.29 million children ages 0 to 14 in paid care would increase by an estimated 121,800.

Relative to the expected labor force increase of 210,700 females, the change would be accompanied by an expected increase of 126,200 children ages 0 to 14 in paid child care. Mothers entering the labor force would place an average of 0.58 children in paid care.

Scenario 3 - Mothers With all Children Ages 0 to 4. An effort to raise the participation rate of mothers with all children ages 4 and under by 1 percent focuses on a very small segment of potential workers. However, participation rates for this group have risen steadily since the early 2000s, up from a low of 61.5 percent in 2004 to 66.5 percent in 2020.

The required addition of 44,900 mothers in the group would increase the labor force in the U.S. by only 0.04 percent and leave the U.S. participation rate essentially unchanged. Based on earlier results that a 1 percent increase in the participation rate is associated with an estimated 0.87 percent long-run increase in real personal income per capita across the states (Figure 13), average real personal income per capita is estimated to increase by only 0.03 percent.

Based on 2020 U.S. real income per capita of \$53,701, a 0.04 percent change in the participation rate implies an average increase of only about \$17 in real personal income per capita across the states in the long run, a negligible contribution to economic growth. Using 2020 U.S. population of 329,484,000, the expected increase in total real personal income is \$5.7 billion. The estimated income gain is equal to 0.03 percent of current nominal U.S. personal income in 2020. Any efforts to produce economic gains from the small group of mothers with all children ages 0 to 4 is unlikely to produce any meaningful economic growth effects.

Paid Care. The increase in labor force participation for mothers with all children ages 0 to 4 is similarly expected to produce a long-run increase in the use of paid child care. The estimated long-run cointegration coefficient for the participation rate for these mothers in Figure 9 is 0.493 for children ages 0 to 4 and 0.390 for children ages 0 to 14. The coefficient for children ages 0 to 4 is interpreted as an expected 0.493 percent change in the share of children in paid care for a 1 percent increase in the labor force participation rate for these mothers. The coefficient for children ages 0 to 14 in paid care is interpreted similarly.

The share of children in paid care is expected to rise from 29.4 percent to 29.56 percent for those ages 0 to 4 and from 16.0 percent to 16.13 percent for those ages 0 to 14. These changes are proportionately smaller than the responses in the first two scenarios due to smaller estimated elasticities. Based on 5.71 million children ages 0 to 4 in paid care in 2019, the increased participation rate would produce an expected gain of 28,200 children ages 0 to 4; the current 12.29 million children ages 0 to 14 in paid care would increase by an estimated 47,900.

Relative to the expected labor force increase of 44,900 females, the change is accompanied by an expected increase of 47,900 children ages 0 to 14 in paid child care. Or each mother entering the labor force would place slightly more than one (1.07) child in paid care on average. The higher share of children in paid care reflects the greater share of children under the age of 5 in the analysis. There is also typically more than one

child per household in paid care. In 2019, there were 1.56 children in paid care per household among those with children in paid care.

Discussion of Estimated Growth Effects. The three economic growth scenarios highlight some important conclusions for policymakers pursuing efforts to increase the labor force participation of women and mothers:

1. Changes in labor force participation are associated with expected future changes in both real income and paid child care usage.
2. While participation rate changes are believed to be a direct factor in both income growth and paid care usage, changes in paid child care use accompany economic growth only indirectly through its relationship with changes in participation.
3. The size of the pool of potential workers determines in large part the size of any potential economic gains to increased participation. The pool of mothers is declining in size over time and offers far less potential for economic growth than the broader group of women with no children. Mothers with children ages 0 to 4 are far fewer in number than women with either older children or no children and offer less potential to affect overall U.S. income trends by increasing their workforce participation.
4. The expected long-run elasticity between labor force attachment and real personal income growth plays a key role in determining the size of any potential income gain as labor force attachment increases. The estimated elasticity of 0.87 measured across the full labor force suggests a slightly less than proportional gain in real personal income per capita as participation rates increase.

Changes in labor force participation are associated with expected future changes in both real income and paid child care usage.

5. The long-run response of paid child care use to changes in labor force participation vary greatly by both the age of the child in care and the age of children in the household. The elasticities range from just above a one-to-one response to less than a 0.5 percent response. However, the ratio of new children in paid care per new entrant in the labor force is highest for mothers, particularly those with young children at home.
6. The total potential income gains from increased labor force participation are quite large when spread across large groups of potential workers. A 1 percent increase in the participation rate for females (from 72.9 percent to 73.6 percent) is associated with an expected \$72.8 billion long-run increase in total personal income in the U.S. This increase in labor force participation would represent only a modest rebound in the participation rate relative to losses in recent years. Potential income gains are far lower from increasing the labor force participation rates among smaller groups of mothers.



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Glossary

Best-Fit Line

A best fit line through a scatter plot of data best expresses the linear relationship between those points. The straight line provides the best approximation of the relationship between the data points. The slope of the line provides a quantitative estimate of both the direction and magnitude of the relationship. Best fit lines are also commonly referred to as trendlines or linear regression lines.

Birth Rate

Measures of the birth rate reflect the number of births in a population over time (typically one year). Commonly used measures of the birth rate include the crude birth rate and fertility rate.

Capital Investment

Capital investment is the purchase of tangible and intangible assets by firms, governments, and individuals for the purpose of pursuing their business and operating goals and objectives. Capital investment is measured in the child care report using net private fixed investment as defined by BEA. The estimated measure of capital is net of depreciation and includes the broad asset categories of equipment, structures, and intellectual property. Public sector assets are excluded from the analysis. State-level estimates are formed by partitioning national data on net private fixed assets at the industry level based on a region's share of national household earnings at the industry level.

Child and Dependent Care Tax Credit (CDCTC)

The Child and Dependent Care Tax Credit is a federal tax credit available to pay for the care of eligible children and adult dependents (qualifying persons) to enable taxpayers to work or look for work. To claim the credit, you (and your spouse if filing jointly) must have earned income during the year. Child and dependent care expenses must be work-related to qualify for the credit. There is a special rule for education. The spouse is treated as having earned income for any month that he or she is a full-time student, or physically or mentally not able to care for himself or herself. If filing a joint return, this rule also applies to either spouse. You can be treated as having earned income for any month you are a full-time student or not able to care for yourself. The credit is calculated based on earned income and covers a percentage of expenses incurred for the care of qualifying persons. For tax year 2021, the American Rescue Plan Act of 2021 extended the credit up to \$4,000 for one qualifying person and \$8,000 for two or more qualifying persons and made the credit temporarily refundable.

Children of Child Care Age

Children ages 14 and under are considered most likely to participate in formal or informal child care. The group of children of child care age is divided into two groups in the report: younger children ages 0 to 4 and older children ages 5 to 14. This definition follows the Current Population survey which measures paid child care usage for children ages 14 and under.

Child Care Cost Burden

The child care cost burden of a household reflects expenditures on paid child care as a percentage of household income. This measure reflects the notion that the cost burden of child care is best measured relative to ability to pay. The cost burden is calculated as child care expenditures divided by total household income. Burden can be measured on a per child basis or for all children in a household.

Civilian Non-Institutional Population

The civilian non-institutional population measures those persons ages 16 and older and their children not on active duty in the Armed Forces or residing in institutions (e.g., correctional institutions or long-term care facilities for the aged).

Cointegration

Cointegration is a statistical concept that refers to the long-run co-movement of two or more data series over time. If variables are found to be cointegrated, estimates can then be made of the long-run elasticity between two cointegrated factors over time. The concept of cointegration is closely tied to the notion of Granger causality but focuses on the long-run dimension of the relationship among a group of variables over time. A set of cointegrated variables maintain a long-run equilibrium relationship over time, with any short-run deviations from the long-run relationship corrected over time through an error-correction process. In fact, two cointegrated variables are expected to have short-run Granger causality present in at least one direction.

Correlation

Correlation is a statistical measure of the degree of linear dependence between two series over a specified period. Correlated series tend to move in coordination with one another over time. Positively correlated variables tend to move in the same direction; negatively correlated series tend to move in the opposite direction. If X and Y are correlated, the calculated correlation is the same for both series in each direction in the period.

Cost-of-Living

Cost of living reflects differing prices across geographic areas for a range of typical living expenses including housing, food, energy, and other items. Measures of the cost of living are often used to compare how costly it is to live in one geographic area versus another. Cost of living adjustments are made in the report using state-level regional price parity (RPP) indexes produced by the Bureau of Economic Analysis (BEA) along with the national implicit price deflator to adjust for national price changes over time.

Crude Birth Rate

The crude birth rate is the number of births per 1,000 population in a geographic area.

Current Population Survey (CPS)

The Current Population Survey, also commonly referred to as the household survey, is a sample-based monthly survey of about 60,000 eligible households. It provides a comprehensive body of data on the U.S. labor force by demographic and labor force characteristics.

Current Population Survey (CPS) Annual Social and Economic Supplement (ASEC)

A widely used supplement to the Current Population Survey is the Annual Social and Economic Supplement (ASEC) conducted by the Census Bureau every February, March, and April. The supplement collects data on health insurance coverage, work experience, income from all sources, receipt of noncash benefits, poverty, migration, geographic mobility, and other special topics. The CPS ASEC also collects data on the number of children in paid child care and the expenditures of households and families using paid care. Use of the ASEC requires a tradeoff from monthly to annual data but provides a broader sample and larger universe than the basic CPS.

Educational Attainment

Educational attainment refers to the highest level of education that an individual has completed. Attainment is often measured using the number of years of education completed, especially when used to describe the average attainment across the population of a geographic region. Attainment is distinct from the level of schooling that an individual is attending currently.

Elasticity

Elasticity is an economic concept used to measure the percentage change of one economic variable in response to a change in another. The response is deemed elastic (or highly responsive) if the resulting change in a variable is more than proportional to the initial change and inelastic (or not highly responsive) if less than proportional.

Employment-Population Ratio

The employment-population ratio (or employment ratio) is a measure of labor force attachment that measures the share of the population activity employed. The ratio is calculated as the number of employed workers divided by the civilian noninstitutional population. The employment ratio does not consider unemployed workers as attached to the labor force. As a result, the employment ratio is far more volatile than the labor force participation rate across the economic cycle.

Family

A family is defined in the Current Population Survey (CPS) as a group of related individuals who are all members of the same household. Multiple families can be domiciled within the same household.

Female Labor Force Participation Rate

The female labor force participation rate measures the rate of participation of women in the labor force.

Fertility Rate

The fertility rate is the number of births per 1,000 women ages 15 to 44 in a geographic area.

Goods-Producing

Goods-producing sectors of the economy are those that produce products rather than services. These typically include NAICS sectors covering farming; forestry, fishing, and related activities; mining; and manufacturing.

Granger Causality

Granger causality is a statistical test of the usefulness of one variable in forecasting future values of another. Granger causality is present between two variables if future forecasts of variable X are improved by using variable Y in its prediction, above the level present when using only information about the history of X. Granger causality can be present in a single direction from either X to Y or Y to X, in both directions (bi-directional), or may not be present at all. If there is no Granger causal relation found from Y to X, Y is deemed strictly exogenous to X in providing useful forecasting information. Granger causality also differs greatly from measuring the correlation between two time series. Correlation simply measures the linear dependence between two series over a specified period. If X and Y are correlated, the calculated correlation is the same for both series in each direction in the period. Granger causality, however, measures statistical predictability in both directions and in the time dimension.

Great Recession

The Great Recession refers to the steep decline in economic activity associated with the U.S. recession lasting from December 2007 to June 2009, as well as downturns in national economies globally. It is the longest recession in the post-World War II period and generally considered the most significant economic downturn since the Great Depression.

Household

Survey data from the Current Population Survey (CPS) Annual Social and Economic Supplement (ASEC) are organized using samples of households or dwellings. A household is defined as all persons who occupy a single dwelling unit. A dwelling unit is a room or group of rooms intended for occupation as separate living quarters and having either a separate entrance or complete cooking facilities for the exclusive use of the occupants. In a small percentage of cases, multiple family units occupy a household.

Household Income

Household income represents all combined forms of gross income, both earned and unearned, for all members of a household ages 15 and over.

IPUMS-CPS

IPUMS provides census and survey data from around the world integrated across time and space. IPUMS integration and documentation makes it easy to study change, conduct comparative research, merge information across data types, and analyze individuals within family and community context. Data and services available free of charge. IPUMS CPS harmonizes microdata from the monthly U.S. labor force survey, the Current Population Survey (CPS), covering the period 1962 to the present. Data include demographic information, rich employment data, program participation and supplemental data on topics such as fertility, tobacco use, volunteer activities, voter registration, computer and internet use, food security, and more. IPUMS-CPS, University of Minnesota, www.ipums.org.

Labor Force

The labor force includes all persons in the civilian noninstitutional population classified as either employed or unemployed. The labor force does not change as individuals move from employment to unemployment, and vice versa. The labor force changes only when new entrants enter the labor force or existing participants exit.

Labor Force Status

Labor force status measures the degree of labor force attachment for persons ages 15 years and older. Persons are generally classified as either in the labor force or not in the labor force. Those in the labor force are further classified as either employed or unemployed. Many persons are not in the labor force due to school, retirement, health, personal choice, and other factors. Members of the Armed Forces are excluded from most measures of work status.

Labor Force Attachment

Labor force attachment is a general economic term referring to a person's status as a participant in the labor force. Persons attached to the labor force include those either employed or unemployed. Those who are unattached do not participate in the labor force. The two most widely used measures of the degree of labor force attachment for the population of a geographic area are the labor force participation rate and the employment-population ratio.

Labor Force Participation Rate

The labor force participation rate is the most widely cited measure of labor force attachment and is calculated as persons in the labor force (either employed or unemployed) divided by population (civilian noninstitutional) ages 16 and over. In other words, it captures the percentage of the population of a geographic area that is either employed or unemployed and looking for work. The inclusion of the unemployed is the key characteristic of the participation rate versus the employment ratio, another popular measure of labor force attachment.

Maternal Labor Force Participation

Maternal labor force participation refers to the labor force participation of women with children.

Mean Reversion

Mean reversion refers to the tendency of observations in a data series to gradually move towards the long-term mean of the series. Large deviations away from the mean are expected to be followed by a return toward the mean in a mean reverting series.

Median Household Income

For households, the median income represents the level of household income where half the households in a geographic region (including those with no income) earn more and half earn less. Median household income is also referred to as the midpoint of the income distribution or the 50th percentile of household income.

Outlier

An outlier is an observation or data point that differs significantly from others in the same sample. Outliers can be due to measurement error or may simply reflect unusual and unexpected behavior among the observations in the sample. Outliers are sometimes excluded from the data set to gauge the sensitivity of any statistical findings to the presence of the outlier(s).

Paid Child Care

Paid child care is defined in the report as any form of child care arrangement for a child ages 0 to 14 for which a parent makes a direct expenditure on care to enable them to work. This follows the definition of paid child care used in the Current Population Survey (CPS). Paid options can include both formal and informal care arrangements such as neighbors or friends, which may or may not be regulated by states.

Panel Data

Panel data refers to data observations categorized for a given entity or data measure observed across time. Panel data is also known as longitudinal or cross-sectional time series data. Panel data used throughout the child care report is defined for multiple states (cross sections) and multiple time periods.

Panel Model

Panel model techniques are statistical tools and methods that simultaneously utilize the information contained in the economic behavior of an entity or data measure across time. Unit root, Granger causality, and cointegration tests used throughout the child care report are all panel modeling techniques that use a 50-state panel dataset. The use of a panel of states rather than national data can provide for more robust estimates of the fundamental factors driving paid care usage.

Personal Income

Personal income includes all forms of income that persons receive in return for their provision of labor, land, and capital used in current production and the net current transfer payments that they receive from business and from government.

Per Capita Income

Per capita income measures the amount of income earned per person in a geographic region. Per capita income is commonly used as a measure of standard of living of the population in a region.

Prime Working Age Women (ages 25-54)

Women of prime working age are those ages 25 to 54 who actively participate in the labor force. These women are more likely to participate in the labor force than younger and older women and have likely completed pre-career education and training.

Probability Value (p-value)

A probability value, or p-value, is a statistical parameter used within hypothesis testing that determines the probability of obtaining the observed results assuming a given probability distribution of the test statistic and that the null hypothesis is true. In other words, it is the predetermined level of probability at which statistical significance is found. A p-value of 0.05 (5 percent) or lower is typically considered the threshold of statistical significance.

Public Preschool Education

Public preschool includes a range of publicly funded early childhood education programs accessed by children before they begin compulsory education at the primary school level. Public pre-kindergarten (or Pre-K) programs are commonly available to children ages 4 to 5 in many states (i.e., 5-year-old children not yet enrolled in public kindergarten). In some states, public preschool also serves 3-year-old children. Publicly funded preschool could be located in a school or in a mixed delivery setting such as child care centers and family child care homes depending upon state or local school district decisions.

Quartile

A quartile is a statistical tool used for summarizing data by dividing the observations into four groups that are more-or-less of equal size. Data is often ranked along some measure of the value of the underlying data and then assigned to quartiles. As with other forms of quantiles (e.g., terciles, quintiles, deciles, etc.), quartiles provide a convenient means of comparing data across grouped intervals.

Real Personal Income

Personal income calculated at its nominal, or current, value and then adjusted for the effects of inflation over time is deemed real personal income. At the state level, an additional adjustment is made to nominal personal income to reflect state-level differences in cost-of-living when calculating real personal income. The cost-of-living adjustments are made using Regional Price Parity (RPP) indexes developed by the Bureau of Economic Analysis.

Sample Size

Sample size refers to the number of individual observations in a sample of data.

Service-Providing

The service-providing sectors of the economy produce intangible services instead of goods. A range of services are produced by both private and public sector entities under the NAICS classification system.

Stationarity

A stationary data series will have a mean, variance, and autocorrelation structure that is stable over time. Visually, stationary series tend to be mean reverting and do not trend strongly upward or downward. They also do not have periodic patterns such as seasonality. A non-stationary data series, or one with a unit root, may have to be differenced one or more times to achieve stationarity. The level of integration, denoted as $I(i)$, is used to describe the number of times (i) a data series must be differenced to achieve stationarity.

Statistical Causality

The statistical notion of causality tests for the increased predictability of the future path of one variable, X , using another variable, Y . While not addressing the issue of economic causality in the traditional sense, tests of statistical causality provide an empirical measure of the historical responses and timing embodied in the relationships among data series. Granger causality is a common approach to testing for statistical causality. Because economic causality also operates in the time dimension, economic causal relations are often informed using Granger-type methods, particularly in forecasting applications.

Statistical Significance

In statistical hypothesis testing, a result is statistically significant if it is deemed unlikely to have occurred due to chance given the stated hypothesis tested. Statistical significance is usually determined by rejection of the null hypothesis.

Subsidies and Cost Offsets

Several federal and state subsidies, tax credits, and other forms of cost offsets are available to assist families in meeting the cost of paid child care. Subsidies and offsets examined in the report include those provided through the Child Care and Development Fund (CCDF), the Temporary Assistance for Needy Families (TANF) block grant, and the Child and Dependent Care Tax Credit (CDCTC).

Time Series Analysis

Time series analysis describes a group of statistical techniques and methods for analyzing time series data to extract meaningful characteristics of the data. These techniques are used most often to examine relationships present between variables over different points in time. The Granger causality and cointegration tests used in the reports are widely used methods of time series analysis.

Time Series Data

Time series data is a collection or sequence of data observations collected over time intervals. Time series data is commonly collected on an hourly, daily, weekly, monthly, quarterly, or annual time interval and indexed in time order.

Todo-Yamamoto Method (TY Method)

All Granger causality tests in the child care report are implemented within a VAR model framework using the method of Todo and Yamamoto (1995). The TY method allows for causality testing among a group of data series within a system framework. The system includes an equation for each data series with the series as the dependent variable and the remaining variables as explanatory (independent or right-hand side or) variables. The TY method is noteworthy in that it is robust to the presence of unit roots, or the order of integration of the time series. The base VAR used in the tests is augmented, or overfit, by including an additional lag of the level of each variable as an additional exogenous variable in each equation of the VAR.

Traded Activity (or Openness)

Traded activity is defined as production for trade outside a region, or a region's degree of openness. The concept traces its origins to the notion of enhancing the 'basic' industries located within a region. Basic industries produce goods and services that are exported for sale outside the local market. This includes trade with other states as well as internationally. States with large manufacturing, mining, and Federal government sectors (including military) tend to have the most traded activity with outside regions. Traded activity captures spending from outside the region which in turn helps support the development of the region's 'non-basic' sectors. Non-basic industries are believed to merely recirculate existing purchasing power, which exerts less influence on overall regional growth than an equivalent injection of spending from outside the region.

Unit Root Test

Unit root tests are used to test the stationarity of a data series and establish its degree of integration. $I(0)$ variables are stationary in levels (no unit root) and require no differencing, while $I(1)$ variables have a unit root and must be differenced once to achieve stationarity. An $I(2)$ series is one that must be differenced twice to achieve stationarity. Most nonstationary series are $I(1)$ and become stationary after differencing once. Few data series require differencing twice (or more) to achieve stationarity.

Unpaid Child Care

Some families may use unpaid child care, which reflects time children spend out-of-the-home. However, for purposes of this report series, only the use of paid child care was reviewed. The series compares the average income of families with children age 14 and younger that use paid child care compared to families with children of the same age that do not use paid child care. The same analysis is also included for families with children under age 5 that use paid care compared to families with children under age 5 that do not use paid care.

Vector Autoregressive (VAR) Model

Vector autoregressive models are a time series technique used to investigate the relationships among a group of time series variables. The estimated model includes an equation for each data series with the series as the dependent variable and the remaining variables as explanatory (independent or right-hand side or) variables. Each equation in the VAR model includes only each variable's lagged (or past) values, lagged values of the other variables in the model, and an error term. The VAR model imposes no structural assumptions on the data but instead treats all data in the model as endogenous to the system.

Women of Working and Childbearing Age (ages 18-54)

The population of women ages 18 to 54 are of both working age and childbearing age. These women are the most likely to use paid child care services for children ages 0 to 14. This measure captures a broader group of women than prime working age women (ages 25-54) by including younger women ages 18-24 who are typically of childbearing age.



Abbreviations and Acronyms

BLS	Bureau of Labor Statistics
BEA	Bureau of Economic Analysis
CCDF	Child Care and Development Fund
CDCTC	Child and Dependent Care Tax Credit
CED	Committee for Economic Development of The Conference Board
CPS	Current Population Survey
CPS ASEC	Current Population Survey, Annual Social and Economic Supplement
ECPP	Education Early Childhood Program Participation
HHS	US. Department of Health and Human Services
IPUMS-CPS	IPUMS-Current Population Survey
IRS	Internal Revenue Service
NAICS	North American Industrial Classification System
NIEER	National Institute for Early Education Research
RPP	Regional Price Parity
SIPP	Survey on Income and Program Participation
SPM	Supplemental Poverty Measure
TANF	Temporary Assistance for Needy Families
VAR	Vector Autoregressive Model

Endnotes

- 1 The first report in the series examines historical trends in paid child care usage and household expenditures on paid care in the U.S. The second report reviews the labor force participation of women and mothers in greater detail (across income, race, and education). The final report in the series provides a data primer for those interested in learning more about the availability and use of child care-related data in the Current Population Survey.
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- 3 Data for the academic year are measured in the Fall of the prior calendar year and compared to population measured in July of the prior academic year. For example, academic year 2020 data measures enrollment in the Fall of 2019 and compares it to 2019 Census population data measured in July 2019. We offset the measure of the share of children in preschool by one year in the empirical tests.
- 4 For a discussion of nonresponse to the Current Population Survey (CPS) during Covid-19, see: Ward, Jason M. and Kathryn Anne Edwards. "CPS Nonresponse During the COVID-19 Pandemic: Explanations, Extent, and Effects." 2021. *Labour Economics*, Volume 72.
- 5 For an accessible introduction to stationarity as a property of a time series, see: <https://www.itl.nist.gov/div898/handbook/pmc/section4/pmc442.htm>
- 6 For more details on the implementation of the Bai and Ng approach in EViews, see: http://www.eviews.com/help/helpintro.html#page/content/advtimeser-Cross-sectionally_Dependent_Panel_Unit_Root_Test.html
- 7 For a more detailed discussion of issues surrounding unit root testing, see: Kim, Jae-Hoon and In Choi. "Unit Roots in Economic and Financial Time Series: A Re-Evaluation at the Decision-Based Significance Levels." September 2017. *Econometrics*, 5(3), 41.
- 8 See, for example: Stokes, Patrick A. and Patrick L. Purdon. "A study of problems encountered in Granger causality analysis from a neuroscience perspective." 2017. *Proceedings of the National Academy of Sciences (PNAS)*. Available online at: <https://www.pnas.org/doi/10.1073/pnas.1704663114>
- 9 Research also questions whether spending more on higher education necessarily provides larger returns for the local economy. Vedder's (2004) work on state-level growth suggests that states with higher spending on colleges and universities often fail to have faster economic growth than states with lower spending, even after controlling for differences in other key variables. This research does not question whether higher education is an important factor in promoting economic growth but does suggest that the returns on public spending for higher education may be limited.
- 10 Bils and Klenow (2000) similarly argue that higher incomes may, in fact, be driving gains in education in the highest income regions, and not the reverse. The suggestion is that parents of students completing education beyond high school generally earn higher incomes which in turn increases the ability of these families to absorb the cost of increased formal education. A similar concern persists at the international level that many countries are now rapidly increasing their overall level of educational attainment because they are increasingly growing richer and able to afford more costly education systems.
- 11 For a detailed discussion of the approach, see Yamarik (2013). The regional earnings data at the industry level used to partition the national data contain many missing and suppressed values. We estimate the missing values using a large-scale RAS approach. Priors for the estimation process are determined using either disclosed values across the full period or national industry ratios.
- 12 Traded sectors are those with the following BEA industry numbers at approximately the 3-digit NAICS level: farming (71 and 81); forestry, fishing, and related activities (100); mining (200); manufacturing (500); air transportation (801); rail transportation (802); water transportation (803); truck transportation (804); transit and ground passenger transportation (805); pipeline transportation (806); scenic and sightseeing transportation (807); telecommunications (905); ISPs, search portals, and data processing (906); securities, commodity contracts, and investments (1003); arts, entertainment, and recreation (1700); accommodation (1801); and Federal government - civilian and military (2001 and 2002).
- 13 The population estimate is based on the mid-year 2020 population estimate produced by the Bureau of Economic Analysis.
- 14 The size of the education response in the model is consistent with, but generally smaller than, the average effect reported in Garofalo and Yamarik (2002) and Yamarik (2011).

