SAVING FOR SUSTAINABILITY: WHY A 10% PERSONAL SAVING RATE IS TOO LOW

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ABSTRACT

This paper analyzes and discusses expected outcomes for an individual consistently saving 10% throughout his/her work life. Including consideration for Social Security retirement benefits, we find the 10% saving rate would require continuous employment and an aggressive portfolio allocation to provide over 20 years of consumption security in retirement. These results suggest that a personal saving rate of 10% should be considered as a minimum, and a higher saving rate is required to provide consumption security throughout a worker's career and retirement. **JEL Classification:** D14

INTRODUCTION

While almost everyone is aware that one should eat at least five servings of fruits or vegetables a day and that weight, cholesterol, and blood pressure readings should be maintained below certain thresholds, a simple rule for how much an individual should save does not seem to be as well established. Just as these health measures lead to a better life, might a saving "rule of thumb" help the financial security and sustainability of U.S. households? The financial press (and the many gurus found there) frequently state that everyone should have six months of living expenses set aside as an emergency, but should saving goals end with the short-term? Additionally, it is often stated that if one's employer offers a matching contribution in the firm's retirement plan, the employee should save at least enough to capture all of the matching funds, but is that enough to provide for future needs? What level of saving should a worker without an employer-sponsored plan maintain? While there are various opinions and suggestions on how an individual's net worth should be divided between short-term assets (such as bank accounts and C.D.s), long-term assets (such as bonds and stocks), and real assets (such as real estate and gold), a minimum and/or a preferred level of saving over the work life is not as widely reported. However, some popular personal finance books support a 10% saving rate, but after closer examination, we believe this level is too low to provide consumption security throughout a worker's lifetime, including retirement.[1] This paper aims to clarify this discussion by presenting a life-cycle model where saving is stated as a percentage of earnings and net worth is measured by years of consumption available. By using years of consumption as the measure of wealth, this approach differs from the models where the focus is on specific dollar amounts saved and/or portfolio allocation.

These ideas are important because many people are not exposed to the basic tenets of finance. For example, consider how saving is discussed in the educational setting. In most economics courses, saving is used as a source of funds for macroeconomic capital and investment (which is vital for long-term economic growth) or as an alternative to consumption (and a restriction to short-term growth). Meanwhile, in most finance courses, saving is used as the resource of investment decisions (and portfolio allocation is the focus). In this paper, the positive and negative macroeconomic externalities provided by personal saving are set aside, and portfolio allocation is simplified. Here, the goal of saving is to provide the individual with retirement consumption as well as provide a safety net from income interruption and uninsured losses throughout the work life. In other words, the goal of this research is to stress the private benefits of savings, including personal economic sustainability.

The paper proceeds by reviewing data on the behaviors and beliefs about saving and life expectancy, and then it presents a base case that analyzes how a 10% saving rate would provide for an individual in retirement. After this base case is presented, alterative assumptions are discussed with some obvious and not so obvious results. These alterative assumptions include examining workers with periods of unemployment, worker with higher incomes, and the issue of how home ownership impacts retirement saving and asset accumulation. This paper concludes by highlighting the key points of these various projections.

AN OVERVIEW OF SAVING AND LIFE EXPECTANCY

Over the past two decades, the monthly U.S. saving rate has varied between 2.0% and 8.3% of disposable income (after-tax income) while averaging 5.1% (as calculated by the Bureau of Economic Analysis using the NIPA accounts), and this is below the minimum of 10% that will be analyzed below.[2] The tendency to save appears to differ significantly across cultures. OECD countries with high household saving rates over the past decade include France, Germany, and Switzerland (with saving rates varying between 8% and 12% of disposable income) while much lower levels of saving were observed in Greece, Denmark, and Estonia (all of which reported negative saving rates during some years), and the U.S. saving rate tends to be in the lower-half of developed countries (OCED, 2013). According to the 2010 Survey of Consumer Finances ("SCF"), just over 50% of U.S. households save, and the probability of a household saving increases with income. While the percent of families who save tends to be pro-cyclical, higher income households tend to have a greater probability of saving. In the four SCFs between 2001 and 2010, the percentage of families in the lowest income quintile who save varied from 30.0% to 34.0%, and between 80.6% and 84.8% of the families in the top decile saved (Bricker, et al, 2012, Table 1). SCF respondents also reported that the dollar amount of savings a household would need in case of an emergency increases with income. However, the average estimate from each income quintile with respect to the percentage of income needed for emergencies was fairly consistent (varying from 8.9% to 14.1% of usual annual income), and the percentage of income needed for emergencies did not monotonically increase or decrease with the income quintile. The median ratio of estimated emergency saving to usual annual income was 10.8%, or between one and two months of average income, and liquidity and retirement were given as the two most important reasons for saving (*ibid*, Table 3.1 and Table 3).

Saving behavior may be a habit passed from one generation to the next, or individuals from different cultures may materially differ in their perception about current and future conditions and the need for savings. Setting aside these customs and perceptions, the focus of this paper is to provide a simple and understandable standard of saving of *at least* 10% of earnings by using a life-cycle model to predict the outcome if this level of saving is maintained. Based on the statistics noted above, it is likely that many people would find this suggested level of saving to be high, but it should also be noted that the worker following this rule does not retire affluent. For example, assume that someone is consistently employed beginning at age 25 and retires at 67 and saves 10% of earnings throughout his/her career. This worker should have enough resources in retirement (combining income from savings, drawing down on the balance of savings, and Social Security retirement payments) to sustain their pre-retirement consumption through age 90, but it is up the individual to decide if that enough. For example, a worker may have the expectation of exceptional longevity or, alternatively, this worker may believe that there will be increasing expenses in retirement, and both expectations would require a higher saving rate throughout the worker's career. While individuals need to make their own judgment on how important is it to have resources into their nineties, the U.S. Life Tables show that approximately 1 in 5 adults who reach 25 (the start of the work life in this model) will live into their nineties, and the likelihood of a long life increases with age. The U.S. Life Tables also show that women are more likely to reach these advanced years (and approximately 1 in 4 females who reach their 25th birthday will live into their nineties).[3] Under the base-case saving model with a 10% saving rate, individuals who live into their nineties will have only Social Security providing income and those benefits, on average, provide less than one-half of the worker's average consumption.

In a recent analysis of poverty in the United States, the tendency of outliving one's resources was noted. In a November 2013 Congressional Research Service report, 12.1% of the 65 to 74 year olds were considered poor or "near poor", and that percentage increased to 17.8% for those who are 75 years of age and older (Gabe, 2013, pg. 9).[4] While the Social Security and Medicare programs have significantly reduced the level of poverty among the elderly (which was over 25% prior to 1975 (Gabe, 2013, Figure 2)), individuals may want to consider the implication of a longer-term survival horizon on consumption sustainability as labor market opportunities tend to decrease with age. Due to economic and health issues, workers entering their 60s and 70s with limited resources have few options to generate income or wealth at that advanced age. While many workers may plan on worker longer, few actually do, and labor force participation rate (the percent of the civilian population working or looking for work) decreases with age. Currently, over 80% of the population between the ages of 25 and 54 are in the labor force, but the participation rate drops to about 64% for those in their late 50s and early 60s, and it continues to drop well before the age of full Social Security retirement benefits. The labor force participation rate is below 32% for those 65 to 69, and it is below 18% for those 70 or older (BLS, Household Data, 2014).

BASE-CASE MODEL ASSUMPTIONS, A WORKER EARNING $40,000 ANNUALLY

The financial returns and average earnings for the base-case assumptions use U.S. averages with some rounding for readability; however, we do not propose that this is a portrait of the "average" U.S. worker. Our aim is to use assumptions to construct a model that provides easily understandable output (which is the number of years of consumption security in retirement) and then show how assumptions changes alter the output. While the appropriateness of these assumptions is always debatable, whether they are conservative or aggressive will be left for the reader to decide. As with all economic models, changes in these assumptions may significantly alter the results, and some of the more significant and interesting alternative assumptions will be discussed in the sections that follow. In order to provide a starting point to the discussion, the details of the base-case assumptions include:

1. All growth rates are real growth rates and all dollar amounts are adjusted to 2014 levels.
2. The worker is single and has completed his/her education, initial job sorting, and training by the age of 25 and begins employment.
3. The worker maintains steady and uninterrupted employment starting on his/her 25th birthday through age 66 and retires on his/her 67th birthday.
4. Average earnings over the lifetime are $40,000 per year.
5. Earnings have a real growth rate of 0.5% annually.
6. Throughout his/her work life the worker saves 10% and consumes 90% of labor market earnings as consumption. Labor market earnings are adjusted for Social Security tax of 6.2% (based on program specifics 2014).[5]
7. Saving is divided into two asset classes: short-term assets (e.g., bank accounts and C.D.s), long-term assets (e.g., bonds and stocks). Short-term funds earn a real return 0.25% annually. Long-term funds (a portfolio of 60% stocks and 40% corporate bonds) earn a real return 5.25% annually.[6]
8. At the beginning of the work life, all saving is directed to the short-term account (which is an emergency and income replacement account) until 0.5 years of consumption is saved. This takes approximately four and one-half years.
9. After the emergency and income replacement fund is established, the worker continues at the same saving rate of 10% of labor market earnings, and this saving is split between the short-term accounts (10% of dollars saved) and long-term accounts (90% of dollars saved).[7]
10. Once retired, the short-term and long-term funds are combined into an account that has a real return of 1.75% annually. This is based on approximately 30% held in the long-term funds (stock and bond portfolio) and 70% held in short-term (and less volatile) assets.
11. Accumulated savings is economically the same as net worth (assets minus outstanding debt). In other words, contribution to savings is an increase in net worth, and debt cannot be used to fund savings. (The terms "savings", "net assets" and "net worth" are used interchangeably.)
12. Consumption in the first year of retirement is the same as the consumption in the last year of the work life. After that, real consumption increases by 0.5% throughout retirement.
13. Retirement consumption is provided by Social Security payments (based on 2014 rules), earnings on assets (the combined short-term and long-term assets accumulation), and withdrawal of the assets from the saving accounts.[8]

For a base-case model, are these assumptions reasonable? The real returns for short-term and long-term assets are based on past performance, and the portfolio allocations are not overly aggressive (although individuals may not have the tolerance for risk that investment in the stock market requires). The suggested level of saving is about double the historical U.S. average, but this model assumes that the saving and consumption decisions are under the control of the worker. While saving for the future reduces current consumption, it is assumed that a worker without dependents who earns at approximately the U.S. average of $40,000 per year is able to save at this level and still have enough after-savings earnings for consumption (BLS, Earnings Data, 2014).

DISCUSSION OF THE BASE-CASE MODEL RESULTS AND THE CHALLENGES TO THE BASE ASSUMPTIONS

With these assumptions, the worker saving 10% of labor market earnings retires with approximately 11 years of consumption available in accumulated financial assets. A combination of Social Security retirement benefits, income from the retirement assets, and drawing down of those retirement assets allows this worker to sustain the same level of consumption through his/her 90th birthday. This period of consumption is beyond the life expectancy of a 67-year worker (which is age 84), so the probability that a worker will outlive his or her assets is less than fifty percent. However, once those reserves are depleted at that advanced age, the 10% saver's sole source of income and consumption is Social Security benefits, but those payments would provide less than one-half of the individual's average level of consumption. These results are summarized on the first line of Table 1.

As discussed above, this model could easily be challenged by the life expectancy or the growth rate of assets assumptions, but a worker faces more uncertainty than those two factors. Other assumptions used, including the condition of continuous employment and that consumption in retirement will have very modest growth as compared to pre-retirement levels, eliminate a great deal of uncertainty that a real worker faces. While these conditions are necessary to develop this model, it becomes apparent that the 10% saving rate does not provide the worker with security against these and other downside risks.

Continuous employment, steady real increases in earnings, and predictable retirement consumption may have been much easier to obtain in the past than it will be for workers now and in the future. While the U.S. had an extensive period of economic growth during the 1990s and early 2000s, the recent "Great Recession" provided a reminder to workers of the many challenges the business cycle places on the individual. During this downturn, unemployment rates, underemployment rates, and the length of the unemployment period were all higher than the average of the previous two decades. While these conditions confronted workers at all ages, it appears that older workers face greater challenges if they lose their jobs. In addition to the income lost during a period of unexpected unemployment, it is likely that when the worker regains employment, earnings will be lower in the new job.

A recent government report highlights some of these conditions. Since the 2008 recession, the number of workers unemployed for more than 26 weeks (considered as the long-term unemployed) has increased for workers of all ages. For unemployed workers over the age of 55, 55% have been looking for work for more than six months, and for unemployed workers under 55, 47% of them need this length of time to complete a job search (GAO, 2012, Figure 8). It appears that as a worker ages, the time to find a new job increases while the ability to recover to the previous level of earning decreases (GAO, 2012, Figure 10). In addition to the business cycle, as workers age, the probability of illness increases and medical complications are often accompanied by unemployment and income interruption. The strong relationship between illness and financial hardship (including personal bankruptcy), has been repeatedly reported in the popular press over the past decade (see Cussen, 2010; Factcheck, 2008; and Mangan, 2013). A *Health Affairs* study found that between 30% and 50% of personal bankruptcy have health and medical issues as the root cause (and the percentage varies based on how closely linked the illness is to the bankruptcy filing) (Himmelstein, *et al,* 2005). Finally, in addition to the risks of unemployment from economic forces and job interruption due to medical conditions, some workers may simply prefer to not work at some point in their life, and common reasons for labor market interruptions include using time for care-giving and education. These employment trends are summarized by the labor force participation rate, which reaches a maximum of over 80% for workers in their 30s and 40s, but begins to drop after age 50. Between the ages of 55 and 64, average labor force participation drops to 64%. For workers between the ages of 65 and 69, less than 32% of the civilian population remains active in the work force, and for workers aged 70 and older, that ratio falls below 18% (BLS, Household Data, 2014). For all of these reasons, the assumption of continuous employment may be an aggressive and overly optimistic base-case condition.

Another assumption in the base-case model that is challenging to support is that pre- and post-retirement consumption will be consistent. While this assumption is based on two, counter-balancing, economic forces, it may be difficult for an individual to plan the level of retirement consumption. On one side, retirement should decrease work-related expenses (such as commuting and child/elder care expenses), but these reductions are balanced by increases in everyday expenditures (since there is more time for activities and travel) and increases in medical services consumption. Unless a worker has significant work-related expenses, it seems likely that consumption would increase in retirement, as the possibility of catastrophic medical condition increases with age. While our model uses the assumption that pre- and post-retirement consumption remains constant, it does so without empirical support and acknowledges that it is in contrast with the conditions often provided in the financial press (where it is often assumed consumption in retirement will decrease).

Summarizing the base-case model, a 10% saving rate throughout the work life would contribute significantly to consumption security and sustainability in retirement, but that level of saving does not provide much insurance against periods of unemployment, uninsured losses, increasing consumption in retirement, or other downside risks.

ALTERNATIVE ASSUMPTIONS, INCLUDING HIGHER AVERAGE EARNINGS

The results of most alternative assumptions change the outcomes as expected, but two alternatives provided results that were not so obvious. The easier to understand alternatives and results will be discussed first and these alternative assumptions are grouped by those related to the actions of the worker, those resulting from labor market variation, and those associated with changes from financial market returns and government policy. Two changes in labor market conditions led to results that are not commonly or frequently discussed are presented at the end of this section.

Of the conditions that can be controlled by the worker, perhaps the most obvious is that higher saving rates would provide for longer periods of consumption security. Other conditions that the worker may be able to adjust include beginning work earlier and retiring later, and either of those changes would increase the assets available for retirement consumption. Alternatively, beginning work later and retiring earlier will reduce the retirement assets. Post-retirement consumption greater than pre-retirement consumption would deplete the assets more quickly than projected while lower post-retirement consumption would increase the life of the assets. Similarly, any use of the savings before 67, or any interruption in earnings and savings, would reduce the resources available during retirement.

While the exact impact of an interruption can vary based on the timing within the career, each year away from the labor market decreases the retirement savings by more than the lost year's savings, since total savings is reduced in three ways: 1) accumulated savings must be used for current consumption; 2) there are no contributions to savings during the period outside the labor market; and 3) the savings generates less earnings (due to the lower level of accumulated assets).[9] As would be expected, the longer the earnings interruption and the earlier in the work life the interruption occurs the greater the decrease in final retirement savings. While an earnings interruption for illness and injury may be beyond the worker's control, the loss of contributions or the drawing down from savings for unplanned (or uninsured) medical expenses will impact the accumulation of retirement assets similar to any other earnings interruption.

Details of this type of change in assumption, for example, retiring early at age 66, are shown in the second line of Table 1. Leaving the labor force one year earlier than in the base case would reduce the years of retirement consumption by almost three years (from 90 to 87). This reduction holds whether the Social Security payments are started at 66 (at a reduction from the full retirement payment amount) or if the worker consumes out of saved assets for the first year of retirement.

Another condition that is under the control of the worker includes the mix of assets in the portfolio. Shifting assets from the short-term to the long-term asset class would likely increase retirement savings, while holding proportionately more assets in the short-term account would likely decrease total savings. These decisions would also alter the risk of the retirement portfolio.

Variations from the labor market could include non-voluntary employment interruptions resulting from the business cycle, the creative destruction of jobs as the labor market evolves, or the geographic shift of the worker, firm, or industry. Again, any earnings interruption would require a higher saving rate throughout the work life to provide the same level of retirement consumption as the base case.

Also as expected, financial market forces and government policy will alter the accumulation of assets available for consumption in retirement. Higher rates of return would increase the assets at retirement while lower rates return would decrease those assets. Any reduction in the current Social Security benefits schedule would require the worker to save more than the 10% of earnings assumed above if the worker wanted to maintain the length and level of consumption previous described.

The most interesting results were found when changes to the pattern of expected life time earnings were altered. Both the level of average earnings and the growth rate of earnings had a noticeable impact on the required minimum saving rate, and higher than average earnings or faster earnings growth required an increase in the percent of earnings saved in order to maintain the same level of retirement consumption. As average earnings rise above the $40,000 per year used in the base case, the replacement ratio provided by the Social Security retirement benefits decreases, and in order to maintain the same level of retirement consumption, the worker's savings must replace a greater percentage of consumption. For example, comparing two workers using the same 10% saving rate, a worker with average annual earnings of $80,000 would deplete his or her savings approximately four years sooner than a worker earning $40,000 per year. The results for a worker with higher earnings are shown in the third line of Table 1, and if this higher earner maintains the base-case saving rate of 10%, their retirement assets are depleted by age 86. Alternatively, if the higher-earning individual wanted to have the same asset longevity in retirement, that worker's saving rate would have to increase to between 11% and 12%.

As the average earnings over the work life increases, the portion of retirement consumption replaced by Social Security decreases. This situation indicates that higher-earning individuals need higher personal saving rate to maintain consumption in retirement. Returning to Table 1, at the start of retirement, Social Security benefits replace approximately 49% of the consumption for worker with average earnings of $40,000, but Social Security only replaces 37% of consumption for the worker whose average earnings are $80,000. For a worker with average earnings of $100,000 (who is at the upper limit of the ninth decile of wage earners according to BLS Earnings Data (2014)), Social Security only replaces 33% of consumption at the start of retirement. Workers should understand that the replacement rate of Social Security retirement benefits decline as average life time earnings increase, and those workers need to plan appropriately.

The second assumption alteration that provided an interesting result was that faster earnings growth (holding the lifetime average constant), requires a higher saving rate. This result is due to the condition that the savings from the first part of the worker's career do not contribute as much to retirement when compared to the higher level of consumption later in life. For example, if a worker experiences 1% real annual growth in earnings and consumption throughout life (which is twice the base-case assumption), the retirement savings would be depleted approximately six years earlier than the worker with the lower growth rate. Details of these results are shown on the fifth line of Table 1, and the individual with the higher earnings growth rate would have to increase the saving rate to approximately 12% of labor market earnings in order to have the same consumption longevity as the worker with the lower growth rate of earnings.

After this review of these alternative assumptions, it appears that in order to have a saving plan provide sustainability through life's ups and downs, the worker should save more than the 10% established for the stable and predictable world. As a final addition to the summary results from the alternative assumptions, the last line of Table 1 shows the increase in retirement consumption security if the base-case worker saves 15%. If consumption security in retirement is the worker's goal, clearly there are benefits to increasing savings in the financial markets throughout one's work life.

The following section considers a common decision outside of the labor and financial markets that is often associated with retirement consumption security, and the benefits and costs associated with home ownership are discussed next.

ANOTHER ALTERNATIVE: HOME OWNERSHIP

The above analysis assumes the worker is a renter, which leads to the question on how the purchase of a home would impact the base-case results. Home ownership and retirement saving are not necessarily related. The home equity (gained through principal payments or outright purchase) could be considered as either additional savings or it could be part of the 10% annual saving (which would put the real estate into the retirement portfolio). Whether the home equity is treated as additional saving or as part of the primary portfolio (and it is funded from the 10% of annual savings) will have major implications on the availability of assets for consumption in retirement.

If the home purchase is treated as a consumption good (with all housing expenses, including principal, paid from after-saving earnings), then the above results would hold, and the retiree would have home equity in addition to the previously discussed assets. While it might sound odd to consider all home expenses as consumption items, such expenses as maintenance, insurance, property taxes, and mortgage interest are clearly consumables. Only the equity and growth of the real estate value contributes to net worth accumulation. If the worker can pay for the home outside the 10% of earnings saved, the worker is increasing the assets available for consumption in retirement.

On the other hand, if home equity payments reduce retirement savings, the worker is altering the retirement portfolio to include an asset that is fixed in place and historically has had a real growth rate of less than 1%.[10] This would reduce the expected value of the retirement assets, reduce the liquidity of those assets, and reduce the years of consumption available to the retiree. If the home is part of the retirement assets, the cost of the home relative to the annual earnings also has impact on retirement sustainability. The more expensive the home (relative to the worker's annual earnings), the greater the reduction of the more liquid assets the worker has for consumption in retirement. This issue is captured in the common expression of someone being "house poor", a condition where home ownership crowds out other forms of consumption.

While it is fully acknowledged that home ownership provides a dividend in the form of housing (which is roughly equivalent to the expenditure for rent), it must also be pointed out that this model assumes that the individual either consumes or saves all earnings.[11] If a worker includes a home as part of the retirement portfolio and reduces the amount of retirement savings in order to purchase and maintain the home, the worker will be decreasing the amount of financial assets available in retirement. The home cannot provide for the necessary consumption (other than housing) after this worker has left the labor force, but the worker needs more than housing to sustain consumption for several decades in retirement.

CONCLUDING REMARKS

If the future was predictable, retirement savings (and many other decisions) would be easy. However, the world continues to change and the average worker needs to plan within this framework of uncertainty. At the very minimum, workers should continuously save 10% of their earnings throughout their work life in order to provide some reasonable level of consumption security in retirement. Unfortunately, this level of saving does not provide a significant cushion against downside risks such as earnings interruption or other uninsured, unplanned expenditures. Perhaps a more practical "rule of thumb" is a saving rate of 15%, even for worker whose goals include maintaining continuous employment and working until age 67. While this higher level of saving provides more consumption security, workers who plan to be out of the labor market for some period, who have higher than average earnings, or who have experienced higher than average growth in earnings over the work life should consider greater saving ratios. Any combination of these events would require still higher levels of saving in order to provide the same base level of sustainability throughout retirement.

Additionally, if the worker believes that stock and bond market returns in the future will be lower than their historical average, that worker should save more. A higher saving rate is also needed if the worker believes that future Social Security benefits will be less than the current program pays.

This analysis also concludes and acknowledges that significant saving may materially change many financial decisions throughout a worker's life, and these suggested rates are two or three times the average U.S. saving rate. As the worker assesses the value of current consumption against future consumption sustainability, such decisions as whether one should live alone or have roommates, the timing and size of major purchase such as vehicles and homes, how much of current earnings should be consumed for leisure activities, and if or how large of a family to have may need to be considered. While no one looks forward to a reduction in current consumption, the reward for saving is more financial security and sustainability throughout one's work life and retirement years.

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TABLE 1:
SUMMARY OF RESULTS FROM BASE-CASE AND ALTERNATIVE ASSUMPTIONS

Average Annual Earnings over Work Life	Saving Rate	Change to Base-Case Model	Estimated Age When Retirement Assets Depleted	Social Security Payments as a Percent of Average Consumption (Beginning of Retirement)	Social Security Payments as a Percent of Average Consumption (Retirement Assets Depleted)
$40,000	10%	(None)	90	49%	44%
$40,000	10%	Retires at Age 66	87	45%	41%
$80,000	10%	Increased Earnings	86	37%	33%
$100,000 (upper limit of 9th decile)	10%	Increased Earnings	84	33%	30%
$40,000	10%	Earnings Growth = 1%	84	45%	38%
$40,000	15%	Saving Rate = 15%	104	52%	43%

ENDNOTES

[1] For examples of the 10% saving rate suggestion, see Andrew Tobias' "The Only Investment Guide You'll Ever Need".

[2] Based on series "PSAVERT" as calculated by the U.S. Department of Commerce in Nov 2013. See Guidolin and La Jeunesse (2007) for a discussion on the two primary methods of calculating of the U.S. saving rate.

[3] See Table 1 of United States Life Tables, 2008, second column of data. Of 100,000 live births, 98,293 survive to their 25th birthday 81,364 survive to their 67th birthday, and 22,347 survive to their 90th birthday. At all of these ages, the expected survival for females is higher.

[4] "Near poor" is defined in this report as 125% of the poverty threshold.

[5] Income is adjusted for Social Security tax and retirement benefits under the current program, but no adjustment is made for income tax on labor market earnings, capital gains, or dividends. While including income tax assumptions may seem practical for understanding the results, this paper treats income tax as part of the workers consumption bundle. Simulations using income tax added complication to the model without altering the general results. This tax assumption is conservative in that income tax as a percent of income tends to decrease after retirement (e.g. higher standard deduction, partial exemption for Social Security benefits, lower tax rate for capital gains). Therefore, this model may slightly understate the consumption available in retirement, assuming current and future U.S. tax policy is constant.

[6] The returns on short-term assets are less volatile than the returns on long-term assets or real assets. Long-term returns are based stock and corporate bond real returns (total returns minus inflation, annually) for the 20 year periods (average holding period of these assets) since 1926 (Morningstar: SSBI data, S&P total return at http://www.spindices.com/indices/equity/sp-500).

[7] While not explicitly model (since the work maintains continuous employment and never uses the short- or long- term savings prior to retirement and income taxes are not included), withdrawal from short-term accounts carry no economic penalty (no transaction costs), but withdrawals from long-term accounts would likely carry a penalty (based on current law with respect to 401(k)-type accounts and IRAs).

[8] As with other income taxes, the income tax burden on Social Security burden is not included in this model as such analysis is complex. However, it should be noted that the higher level of other taxable income in retirement, the more likely Social Security benefits will be subject to federal income tax, but at most, 85% of Social Security benefits are subjected to federal income tax.

[9] For a detailed discussion on how labor market interruptions impact retirement savings, see the GAO report (2012).

[10] A real growth rate of 0.72% for home values is based on comparison of home price index (Federal Housing Finance Agency) and CPI for all goods minus shelter (BLS CPI data) from 1984 through 2012. For housing price index, see http://www.fhfa.gov/DataTools/Downloads/Pages/House-Price-Index.aspx. For the CPI for all goods minus shelter, see series CUUS0000SA0L2 (Consumer Price Index-All Urban Consumers, U.S. City Average). For methodology, see http://www.fhfa.gov/Media/PublicAffairs/Pages/Housing-Price-Index-Frequently-Asked-Questions.aspx#quest17.

[11] Remember, in this model, any post-saving earnings are consumed. While homeowners may argue that home ownership is cheaper than renting, if any difference (any gain) from home ownership is consumed, this difference does not benefit the worker in retirement.

AN EMPIRICAL RE-EXAMINATION OF THE FISHER HYPOTHESIS: PANEL COINTEGRATION TESTS

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ABSTRACT

There is no unanimity in the literature on the Fisher hypothesis. This study will revisit this academic quandary with a powerful econometric test proposed by Pedroni (2004). The strength of this test is that the test statistic is able to accommodate short run dynamics, deterministic trends and different slope coefficients.

The study will use monthly interest rate and inflation data for the G5 countries. The study starts with stationarity characteristics of the data and then applies the Pedroni panel cointegration tests. This will shed some light on the Fisher hypothesis and the mixed evidence that exists in the literature. **JEL Classification:** F410

INTRODUCTION

The Fisher hypothesis is one of the most controversial topics in financial economics, with serious ramifications for policy analysis. Fisher basically states that there should be a one-to-one correspondence between the nominal interest rate and the rate of inflation, resulting in stable (if not fixed) real interest rates. It implies that there is effectively no correlation between expected inflation and ex ante real interest rates. If this theory holds (as claimed), then in the long run the real interest rate would remain unchanged under monetary policy shocks.

This study will extend Dutt and Ghosh (2007) studying the Fisher effect for G5 countries in which they found mixed evidence in favor of the hypothesis. There is no unanimity among the researchers and by extension policy makers since the empirical literature is all over the place. Therefore this study will revisit this academic quandary with a powerful econometric technique proposed by Pedroni (2004), where he introduces pooling of economic data which allows for one to vary the degree of heterogeneity among the panel members. It examines both the between dimension and within dimension residuals. The strength of this test is that the resultant "test statistic" is able to accommodate short run dynamics, deterministic trends and also different slope coefficients. This test statistic is "standard normal' and free of nuisance parameters.

This test has been used for studies of Purchasing Power Parity (hereafter PPP) and seems particularly suitable for an analysis of the Fisher effect. One property of cointegration tests is that the span of the data (and not the number of observations) is important in increasing the power of the tests (Pedroni 2004). Increasing the span of the data may not be possible in some cases due to the lack of availability of data, and in others may introduce structural changes like regime changes which would call into questions the validity of the results. Therefore, the study will use the Pedroni (2001, 2004) methodology to test for PPP. This procedure allows us to increase the power of the tests even when we don't have access to a larger span of data.

The next section presents a brief literature review. The third section describes the model that is estimated in this paper and the fourth section is a description of the data set. The fifth section is a description of the Pedroni panel cointegration procedure and the sixth section is a description of our empirical results. The final section contains some concluding remarks.

LITERATURE REVIEW

Fisher (1930) hypothesized that:

$$i_t = r_t + \pi_t^e \qquad (1)$$

where i_t is the nominal interest rate and it is composed of two entities, namely the expected rate of inflation (π_t^e) and the real interest rate (r_t.) Based on this, it postulates a one-to-one correspondence between the nominal interest rate and the expected inflation rate, assuming the constancy of real interest rates over time. This theory has been extensively examined in the economics literature.

The genesis was with Fisher (1930), where he tested the relationship between nominal interest rates and inflation for the UK and USA over decades and found "no apparent correlation." But, when past inflation was substituted as a proxy measure for expected inflation, the "correlation coefficient" jumped from the 30's into the 90's. Thus price changes do affect interest rates.

This study starts with a brief survey of the different Fisher studies done over time. Fama (1975) examined US treasury bills for the period 1953-71 and found evidence that nominal interest rates did incorporate inflation rates, supporting the Fisher hypothesis. But following studies by Nelson and Schwert (1977), Carlson (1977), Joines (1977) and Tanzi (1980) did not find any evidence of Fama's "joint hypothesis." Then Mishkin (1992) found evidence supporting Fisher (high correlation between interest rates and inflation) but it changes over time. He reported that the hypothesis held over specific time intervals, but failed over others. Based on this observation he made the distinction between the short and long run fisher effect and leaned towards supporting the interest/ inflation nexus over the long run.

This long run correlation was supported by Crowder and Hoffman (1996) who report a near one-to-one correspondence between nominal interest and inflation for the USA over the period 1952-92. It is also supported by Fahmy and Kandil (2003) for the USA over the decade of the 80'S and 90'S, using cointegration techniques. Tillman (2004) also supports the Fisher hypothesis for post-war data. USA data has been generally favorable to the Fisher hypothesis, but Canadian data has not. Dutt and Ghosh (1995) use cointegration techniques and separate the entire exchange rate period into fixed and floating rate regimes, but do not find evidence supporting Fisher for Canada in neither the fixed nor the floating exchange rate regimes. But contrary to this, Crowder (1997) finds evidence supporting Fisher for Canada.

Mishkin and Simon (1995) find long run evidence supporting Fisher (but not so in the short run) for Australia. Again contrary to this, Hawtrey (1997) and Olekalns (1996) find supporting evidence for Australia. Then there is Evans (1998) who finds no evidence supporting Fisher for the UK. But Muscatelli and Spinelli (2000) find that the long run Fisher relationship holds for Italy over the long run (1948-90.) Esteve, Bajo-Rubio and Diaz-Roldan (2004) find partial evidence supporting the Fisher hypothesis for Spain.

The Atkins and Serletis (2003) study uses the autoregressive distributed lag (ARDL) model to examine Fisher for Norway, Sweden, Italy, Canada, UK and the USA, but finds little supporting evidence. Then again Atkins and Coe (2002) using the same methodology as Atkins and Serletis (2003), does not find any evidence of even a long run Fisher relationship for Canada and the USA. Interestingly enough, when they extend their study to examine for a "tax adjusted" Fisher correlation, they do not find any evidence of that either. Again Atkins and Sun (2003) find a long run (but not a short run) Fisher relationship for USA and Canada. Recent studies like Kaliva (2008) and Westerlund (2008) find significant evidence supporting the Fisher hypothesis.

The Model

According to the Fisher identity, we can write

$$R_{kt} = E_t r_{kt} + E_t \pi_{kt} \qquad (2)$$

where R_{kt} = k-period nominal interest rate at time t
r_{kt} = k-period real interest rate at time t
π_{kt} = inflation rate from time t to time t+k

The expected inflation cannot be observed. Assuming rational expectations, we will get

$$\pi_{kt} = E_t \pi_{kt} + e_{kt}$$

We can rewrite eq. 2 as

$$R_{kt} = E_t r_{kt} + \pi_k - e_{kt} \qquad (3)$$

$$R_{kt} - \pi_k = E_t r_{kt} - e_{kt} \qquad (4)$$

Expected value of e_{kt} should be zero. Therefore if R_{kt} and π_{kt} are both I(1), and R_{kt}-π_{kt} is stationary, then this would imply that the nominal interest rate and the inflation rate are cointegrated with a cointegrating vector of (1, -1). This would be an indication of a 'full Fisher effect". Even if the cointegrating vector is (1, -β) this would be evidence of a "partial Fisher effect." Absence of cointegration would mean that nominal interest rate and the inflation rate do not move together over time, and therefore there is no long run relation between them according to Lee et. al. (1998).

DATA DESCRIPTION

This study estimates and tests the Fisher equation for the G-5 countries, United States, France, Germany, Japan, and the United Kingdom. All data were obtained from the OECD National Accounts database. All data is monthly. Data is available for the different countries for different time periods, and therefore we have used different groups of the G5 countries to implement our analysis. The different groups are

G2 - Germany, United States: June 1964 – June 2013

G3 - France, Germany, United States: January 1970 – June 2013

G4 - France, Germany, United States, United Kingdom: January 1978 – June 2013

G5 - France, Germany, Japan, United States, United Kingdom: April 2002 –June 2013

PEDRONI'S PANEL COINTEGRATION TESTS

Cointegration techniques are commonplace in the economics literature, when studying long run relationships between non-stationary variables. One point of concern has been the power of traditional cointegration tests. The problem with these tests is that they inherently suffer from low power and confidence. Increasing the time span of the variable series increases its credibility, but in reality it is a difficult proposition. The time span availability of the variables is not dependent on the researcher's discretion. On the other hand if one blindly increases the data time span, the test strength will possibly increase but one could very well have introduced major policy shifts and structural economic changes. An example of this would be using pre-war and post-war data together, just to increase the time span.

Another possibility is to increase the data frequency keeping time span the same. An example would be to use daily instead of weekly data or weekly data in place of monthly data. This increases the number of observations, but that does not necessarily increase the strength of the results.

It has also been pointed out that the power of these tests depends more on the span of the data rather than the number of observations (Perron 1989, 1991). For example, if we consider a time span of 1969 to 2011, moving from annual to quarterly to monthly data will not appreciably increase the power, but increasing the span to 1960 - 2011 will increase the power of the tests. If increasing the time span of the data is not a practical solution (additional data may not be available, or it may introduce structural changes in the model) one alternative is to consider additional cross-sectional data instead of a longer time period, thus resulting in panel data.

When considering panel data, it is important not to sacrifice differences between cross sections. One remedy to solve this dilemma has been proposed by Pedroni (2001 and 2004) where he introduces similar cross-sectional data over the available time period. This pooling of similar data will help in the above stated situation. One example would be where he pooled data from economically similar countries to study PPP (Pedroni, 2004.) The problem here is that simple pooling of time series data would involve "in model" heterogeneity. Here he has constructed "panel cointegration" test statistic (Pedroni, 2004) which allows for one to vary the degree of heterogeneity among the panel members.

Moreover Pedroni (2001) has done residual based tests for the null of "no cointegration" for heterogeneous data. In Pedroni (2004) he extends the same test to include heterogeneous dynamics and slope coefficients. It examines both the between dimension and within dimension residuals. The strength of this test is that the resultant "test statistic" is able to accommodate short run dynamics, deterministic trends and also different slope coefficients. This test statistic is "standard normal' and free of nuisance parameters.

Pedroni (2004) proposes the following way of testing for cointegration in a panel data setup. He proposes the following regression

$$yit= \alpha i+\delta it+\beta Xit+eit \qquad (5)$$

where y_{it} = relevant variable where i= 1, 2….N observations and t= 1, 2….T time periods.
X_{it} = m-dimensional column vector for each member i
t= time period under consideration
and β_i == m-dimensional row vector for each member i

The variables y_{it} and X_{it} are assumed to be I(1) for each member I of the panel, and under the null hypothesis of "no cointegration" e_{it} will also be I(1). The parameters α_i and δ_i allow for differences between cross sections. The slope coefficient may also be different between cross sections. Pedroni (2004) proposes a set of residual based test statistics for the null of "no cointegration" which do not assume that the slope coefficient is the same in all cross sections.

First we test for the order of integration(non-stationarity) of the raw data series y_{it} and x_{it}. They are integrated of order one i.e., I(1.) The null is of no cointegration with an I(1) error structure. Here α_i, δ_i and β_i are allowed to be heterogeneous.

The null is:
H_o : Panel series are not cointegrated, versus the alternative
H_A : Panel series are cointegrated.

Here when we are pooling different data series, the slope coefficient β_i will not be of a common slope across different data series. The strength of these pooled tests is that the slope coefficients are not constrained to be the same, but rather allowed to be heterogeneous (i.e., allowed to vary across individual data series.) The tests distributional properties are that the standard central limit theorem (CLT) is assumed to hold for each individual series, as the time span grows. The advantage is that the error structure includes all auto regressive moving average (ARMA) processes. The matrix structure is (m+1) x (m+1) in size where the off diagonal entities Ω_{2li} capture the feedback between the regressors and the dependent variable, based on the invariance principle. Also cross sectional independence or process i.i.d. (independent and identically distributed) is assumed. This allows for the application of the standard CLT even in the presence of heterogeneous errors. Here Ω_i >0 ensures that there is no cointegration between y_{it}. The invariance and cross sectional independence help construct the asymptotic properties of the test statistic. It allows the test statistic to converge asymptotically to the actual values.

$$T^{-2}\sum_{t=1}^{T} z_{it-1}\, z'_{it-1} \Rightarrow L'_i \int_0^1 Zi(\mathrm{r})\, Z_i(\mathrm{r})'\, d_r\, L_i \qquad (6)$$

$$T^{-1}\sum_{t=1}^{T} z_{it-1}\, \xi'_{it} \Rightarrow L'_i \int_0^1 Z_i(\mathrm{r})\, d\, Z_i(\mathrm{r})'\, dr\, L_i+\Gamma_i \qquad (7)$$

These convergence results hold under standard assumptions. The assumption of sectional independence allows for "averaging" over the cross sectional sums of the panel statistic. Moreover it also reduces the effect of "nuisance parameters" due to serial correlation in the data as T→∞. This makes the computation a lot simpler. It also has another distinct advantage. Applying the limit T→∞ results in higher order terms being eliminated prior to "averaging," leaving only the first order terms of the time series.

Pedroni considers two class of statistics. The first pools the residuals of the regression "within panel dimensions" and the second pools the residuals "between panel dimensions." Similarly in equation (8) and (9)

$$Z_{\hat{v}_{NT}} \equiv \hat{L}_{11}^{2}\left(\sum_{i=1}^{N} A_{22i}\right)^{-1} \tag{8}$$

$$Z_{t_{NT}} \equiv \left(\tilde{\sigma}_{NT}^{2} \sum_{i=1}^{N} A_{22i}\right)^{-1/2} \sum_{i=1}^{N}\left(A_{21i} - T\hat{\lambda}_i\right) \tag{9}$$

and stand for "panel variance ratio statistic" and "panel t statistic" respectively. Equations (10) and (11) below pool the data "between panel dimension" to compute the group mean of the time series.

$$\tilde{Z}_{\hat{\rho}_{NT-1}} \equiv \sum_{i=1}^{N} A_{22i}^{-1}\left(A_{21i} - T\hat{\lambda}_i\right) \tag{10}$$

$$\tilde{Z}_{t_{NT}} \equiv \sum_{i=1}^{N}\left(\hat{\sigma}_i^{2} A_{22i}\right)^{-1/2}\left(A_{21i} - T\hat{\lambda}_i\right) \tag{11}$$

Pedroni (2004) then demonstrates the asymptotic distribution of the residual based tests for the null of "no cointegration" in heterogeneous panels. His results are fairly general and assumes "only finite second moments." These results apply to all cases and for any number of regressors, when we measure the slope coefficients separately for each panel data series. He also conducts Monte Carlo simulations to study the small sample properties of the 'statistic' for different panel dimensions. He demonstrates excellent convergence of the "t" statistic (as "T" increases beyond 150 observations) keeping N fixed. Then he keeps "T" fixed and varies "N." As the index becomes larger and larger the convergence properties becomes more stable. He also studies the strength and stability of his test statistic against various 'alternative hypotheses."

Now regarding the data generating process, it is

$y_{it} = x_{it} + e_{it}$ where

$e_{it} = øe_{it-1} + \eta_{it}$ and $\Delta x_{it} \sim N(0,1)$
$\eta_{it} \sim N(0,1)$, ø = {0.9, 0.95, and so on…}

The alternative hypothesis here is that the residuals e_{it} is stationary. Pedroni uses the autoregressive (AR) process, rather than a moving average (MA) error correction process. The tests are powerful enough to show that using monthly data with more than 20 years of observations, it is quite easily possible to distinguish the cases from the null of "no cointegration" when the data is pooled. Moreover the Monte Carlo simulations show that:

Case 1: For small panels, the group-rho statistic rejects the null of "no cointegration."
Case 2: For large dimensional panels, the panel –v statistic has the best power. The other statistics lie in between the two extremes of case 1 and case 2.

EMPIRICAL RESULTS

The inflation rates and interest rates for each panel are tested for the presence of unit roots using panel unit root test.

At the 5 percent level, the G2 and G3 mostly have unit roots (for the G3 one statistic is against the presence of a unit root). For the G4 group the inflation series have an unit root whereas the interest series does not. For the G5 group the inflation series does not have an unit root whereas the interest rate series does.

We then proceed to apply the Pedroni (2004) tests, which are a test of the null hypothesis that all the individuals in the panel are not cointegrated against the alternate hypothesis that a significant portion of the individuals are cointegrated. We also go on to estimate the Pedroni (2001) Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) tests which test whether the coefficient of the cointegrating equation is equal to one.

The results given in table 2 are for the Pedroni (2004) tests and there is some evidence in favor of cointegration between inflation rates and interest rates for the G-2 group of countries. The standard model results in an acceptance of the null hypothesis (H_0: all countries in the panel are not cointegrated) whereas the time demeaned model shows evidence in favor of the alternate hypothesis of cointegration (hypothesis (H_1: a substantial portion of the countries in the panel are cointegrated). This is (at best) weak evidence in favor of the weak form of the PPP hypothesis in the full data set.

The results in table 3 are for the Pedroni (2001) test which is supposed to be carried out on a data set which is cointegrated and the null hypothesis is that the coefficient in the cointegrating equation is equal to one, which would be evidence in favor of the strong form of the Fisher hypothesis. Since we have weak evidence in favor of cointegration the results from strong form test are suspect. The null hypothesis of the existence of the strong form of the Fisher hypothesis is rejected in all four cases for the panel tests, indicating that strong form of the Fisher hypothesis does not exist for the panel or for individual countries.

Tables 4-9 give the results of the Pedroni (2001, 2004) tests for the groups G3 (France, Germany, United States), G4 (France, Germany, United States, United Kingdom) and G5 (France, Germany, Japan, United States, United Kingdom). For the G3 countries the results are given in tables 4 and 5. The Panel Statistics in table 4 indicate rejection of the null in favor of the alternate hypothesis that a substantial portion of the countries are cointegrated as 6 of the eight statistics are significant. The Pedroni (2001) test results given in table 5 for the G3 countries indicates the rejection of the null hypothesis that the coefficient in the Fisher equation is equal to 1. Therefore there is some evidence for the weak form of the Fisher hypothesis for the G3 countries but no evidence in favor of the strong form of the Fisher hypothesis. For the G4 group of countries the results are given in tables 6 and 7. The Pedroni (2004) test results given in table 6 indicate that for the G4 countries 5 out of 8 statistics provide evidence in favor of rejecting the null hypothesis of no cointegration in favor of the alternate hypothesis of cointegration. The Pedroni (2001) statistics results given in table 7 indicate the rejection of the null hypothesis of the coefficient in the Fisher equation is equal to 1. Therefore the results provide evidence against both weak and strong form of the Fisher hypothesis for the G4 countries. For the G5 group the Pedroni (2004) statistics results given in table 8 indicate that the standard model is cointegrated whereas the time-demeaned model is not cointegrated. The Pedroni (2001) results for the G5 countries given in table 9 indicate a rejection of the null hypothesis that the coefficient of the Fisher equation is equal to 1. Therefore the evidence is mixed in favor of the weak form of the Fisher hypothesis but against the strong form.

There is some evidence in favor of the weak form of the Fisher hypothesis for the different groups of countries as shown in tables 2, 4, 6, and 8. The results presented in tables 3, 5, 7, and 9 however show that there is no evidence in favor of the strong form of the Fisher hypothesis.

CONCLUSION

We have looked at the evidence in favor of the Fisher effect for different groups of countries among the G-5 countries using panel data tests. These tests provide us with the opportunity for improving the power of cointegration tests when we don't have access to a greater span of data. This is an important issue since the data for some countries is limited and carrying out panel data tests allow us to obtain robust results even with limited data. The evidence in favor of cointegration is weak at best. This implies that the evidence in favor of the partial Fisher effect is weak at best. There is no evidence in favor of the full Fisher effect for any of the groups or countries. The lack of evidence in favor of the strong Fisher effect indicates that while inflation and interest rates may move together for some countries, there is no one-to-one correspondence. On the other hand, weak evidence in favor of the partial Fisher effect indicates that there is some evidence that some degree of policy coordination has taken place over time, which is not surprising as these are some of the largest economies in the world. However, the weak evidence in favor of cointegration of the inflation rates and interest rates itself indicates that the countries do not have inflation rate targets. The European central bank (ECB) does have an inflation target, but it makes decisions for only Germany and France, and that too since 1999. Prior to that time the German central bank probably did pay more attention to inflation than other European Central Banks. In the United States too the primary concern of the Federal Reserve has been growth and stable prices, and not primarily stable prices. This would explain the lack of a Fisher effect.

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TABLE 1: LEVIN AND LIN AND IPS PANEL UNIT ROOT TESTS

	Levin – Lin ADF statistic	IPS ADF statistic
G2		
Inflation	-1.38	-1.82
Interest rate	0.77	0.76
G3		
Inflation	-0.58	-1.02
Interest rate	1.58	1.99*
G4		
Inflation	-1.17	-1.69
Interest rate	2.02*	2.60*
G5		
Inflation	-4.30*	-4.66*
Interest rate	0.02	0.40

Note: All statistics in the above table are distributed as N(0,1) under the null hypothesis of an unit root. Therefore, we can conclude that all series in the data set have an unit root (there is only one significant value).

G2 – Germany, United States – June 1964 – June 2013
G3 – France, Germany, United States – January 1970 – June 2013
G4 – France, Germany, United States, United Kingdom – January 1978 – June 2013
G5 – France, Germany, Japan, United States, United Kingdom – April 2002 – June 2013.

TABLE 2: PEDRONI (2004) TESTS FOR PANEL COINTEGRATION: GERMANY, UNITED STATES – JUNE 1964 – JUNE 2013

	v-stat	Rho-stat	t-stat	ADF-stat
Panel Statistics				
Standard	0.8698	-1.9269	-0.6666	1.3921
Time demeaned	3.7894*	-4.2430*	-2.4984*	-1.8270

NOTE: All reported values are distributed as N (0, 1) under the null hypothesis. An asterisk indicated rejection of the null hypothesis at the 10% level or higher.

TABLE 3: PEDRONI (2001) TESTS FOR PANEL COINTEGRATION: GERMANY, UNITED STATES – JUNE 1964 – JUNE 2013

Country	FMOLS	t-stat	DOLS	t-stat
Germany	0.08	-58.74**	0.22	-29.11**
United States	0.10	-49.04**	0.17	-30.15**
Panel results				
Without Time Dummies				
Between	0.09	-69.89**	0.19	-41.91**
With Time Dummies				
Between	0.03	-140.44**	0.11	-61.85**

TABLE 4: PEDRONI (2004) TESTS FOR PANEL COINTEGRATION: FRANCE, GERMANY, UNITED STATES – JANUARY 1970 – JUNE 2013

	ν-stat	Rho-stat	t-stat	ADF-stat
Panel Statistics				
Standard	0.6873	-3.9694*	-1.7949*	1.4159
Time demeaned	4.1062*	-5.2421*	-3.1087*	-2.4759*

NOTE: All reported values are distributed as N (0, 1) under the null hypothesis. An asterisk indicated rejection of the null hypothesis at the 10% level or higher.

TABLE 5: PEDRONI (2001) TESTS FOR PANEL COINTEGRATION: FRANCE, GERMANY, UNITED STATES – JANUARY 1970 – JUNE 2013

Country	FMOLS	t-stat	DOLS	t-stat
France	0.11	-61.28**	0.13	-53.62**
Germany	0.09	-52.45**	0.22	-27.34**
United States	0.11	-43.96**	0.18	-28.03**
Panel results				
Without Time Dummies				
Between	0.11	-83.59**	0.18	-62.93**
With Time Dummies				
Between	0.03	-190.02**	0.07	-105.89**

TABLE 6: PEDRONI (2004) TESTS FOR PANEL COINTEGRATION: FRANCE, GERMANY, UNITED STATES, UNITED KINGDOM – JANUARY 1978 – JUNE 2013

	ν-stat	Rho-stat	t-stat	ADF-stat
Panel Statistics				
Standard	-0.1648	-0.7851	0.2043	2.5581*
Time demeaned	3.7994*	3.8049*	2.5610*	-1.7871*

NOTE: All reported values are distributed as N (0, 1) under the null hypothesis. An asterisk indicated rejection of the null hypothesis at the 10% level or higher.

TABLE 7: PEDRONI (2001) TESTS FOR PANEL COINTEGRATION: FRANCE, GERMANY, UNITED STATES, UNITED KINGDOM – JANUARY 1978 – JUNE 2013

Country	FMOLS	t-stat	DOLS	t-stat
France	0.12	-46.69**	0.14	-39.19**
Germany	0.08	-42.98**	0.25	-18.65**
United States	0.09	-46.87**	0.15	-29.35**
United Kingdom	0.07	-52.21**	0.12	-29.43**
Panel results				
Without Time Dummies				
Between	0.09	-86.57**	0.17	-58.31**
With Time Dummies				
Between	0.02	-228.73**	0.04	-106.35**

TABLE 8: PEDRONI (2004) TESTS FOR PANEL COINTEGRATION: FRANCE, GERMANY, JAPAN, UNITED STATES, UNITED KINGDOM – APRIL 2002 – JUNE 2013

	v-stat	Rho-stat	t-stat	ADF-stat
Panel Statistics				
Standard	-1.3460	2.0620*	3.0140*	2.3197*
Time demeaned	-1.2303	1.4391	1.5109	1.4027

NOTE: All reported values are distributed as N (0, 1) under the null hypothesis. An asterisk indicated rejection of the null hypothesis at the 10% level or higher.

TABLE 9: PEDRONI (2001) TESTS FOR PANEL COINTEGRATION: FRANCE, GERMANY, JAPAN, UNITED STATES, UNITED KINGDOM – APRIL 2002 – JUNE 2013

Country	FMOLS	t-stat	DOLS	t-stat
France	0.02	-22.05**	0.19	-5.27**
Germany	0.01	-24.61**	0.18	-4.73**
Japan	0.00	-20.71**	0.06	-5.30**
United States	0.02	-29.07**	0.14	-8.23**
United Kingdom	-0.04	-19.46**	-0.33	-7.08**
Panel results				
Without Time Dummies				
Between	0.00	-47.59**	0.05	-13.69**
With Time Dummies				
Between	-0.01	-81.91**	-0.09	-23.58**