Comparing Fiscal Strategies for the U.S. in a New Keynesian Framework

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ABSTRACT

In this paper, I use Coenen, McAdam, and Straub's (2008) (CMS) structural macroeconomic model to compare and contrast three fiscal strategies for the U.S.: (1) short-run stimulus followed by fiscal consolidation, with stimulus financed by future spending reductions, (2) short-run stimulus followed by fiscal consolidation, with stimulus financed by future tax rate increases, and (3) short-run stimulus followed by permanently higher spending in the form of transfers. My analysis follows the framework of analysis done by Cogan et al. (2013) on fiscal consolidation strategies in the same model. I find that the model produces a temporary positive output effect from the short-run stimulus, followed by negative effects on output due to the conclusion and subsequent payment of stimulus. Long-run fiscal consolidation after stimulus is more favorable than permanently higher spending because it decreases the medium- and long-run output cost of stimulus and creates favorable conditions for long-run growth. Stimulus financed by spending reductions is preferable to tax financed stimulus in terms of output growth generated. Lastly, permanently higher spending in terms of transfers is particularly harmful to growth.

Keywords: fiscal consolidation, CMS model, stimulus, output growth, structural model

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1 Introduction

The Financial Crisis of 2008 and the ensuing global recession, widely dubbed the Great Recession, have drawn numerous comparisons with the Great Depression in the United States. Indeed, many have noted that the Great Recession was the most serious economic downturn since the Great Depression. And if we credit the Great Depression for forcing a sea change in the economics profession via the birth of modern macroeconomics, the Great Recession has forced a reevaluation of many of those same tenets of macroeconomics. Never mind the inability of macroeconomists to predict the onslaught of the crisis. The question of how to respond to the enormous output gap in 2009 was enough to reinvigorate debates about the efficacy and nature of stabilization policy.

The record of stabilization policy in the U.S. since 2008 is unprecedented. The rapid and large deterioration in aggregate demand following the crisis plunged the U.S. into a deep recession. The Federal Reserve and federal government responded with an ambitious and massive stabilization effort, heeding the perceived lessons from the Great Depression and basic prescriptions of macroeconomic theory. For its part, the Fed lowered interest rates quickly and reached the zero lower bound by December of 2008. Having exhausted its primary policy tool, the federal funds rate, the Fed used various unconventional tools such as quantitative easing (QE) and credit easing to put further downward pressure on short- and long-term borrowing costs. However, the limits faced by monetary authorities drove many countries, including the U.S., to enact aggressive fiscal responses.

The U.S. enacted two large fiscal stimulus measures. The first was the Economic Stimulus Plan of 2008, passed in February 2008. Authored by the Bush Administration, the law amounted to $152 billion of stimulus, mostly in the form of one-time tax rebates. In February

2009, with the U.S. economy demonstrating further weakness, Congress passed the American Reconstruction and Reinvestment Act (ARRA) under the Obama administration. The measure authorized $787 billion of government spending,[1] making it the largest countercyclical fiscal stimulus in U.S. history (Romer 2011). The ARRA spending consisted of a combination of tax rebates, transfer payments, federal aid to states, and increases in government purchases and investment (Coenen 2012).

The magnitude of both the recession and the fiscal response has raised the stakes and contentiousness of the debate over the efficacy of short-run fiscal policy. After two rounds of stimulus, the U.S. recovery remained weak and the unemployment rate remained stubbornly high throughout 2010-12. The question of how to move forward became an urgent one for economists and remains relevant today. On the one hand, scholars like Christina Romer, Alan Blinder, and Paul Krugman have argued for additional stimulus since the ARRA. Romer determined a high government expenditure multiplier and has conducted empirical studies showing that the ARRA added a significant number of jobs (Romer 2009). On the other side of the debate, John Taylor and John Cogan argue that the government expenditure multiplier is below one and at times negative because of the crowding out effect on private spending and investment. They claim the ARRA failed to stimulate the economy (Cogan et al. 2010). They are joined by Alberto Alesina and Silvia Ardagna, who have argued that fiscal consolidation can indeed have expansionary effects (Alesina 2010) and whose paper has energized many austerity advocates on both sides of the Atlantic.

The question of what constitutes optimal fiscal policy is one of the big unresolved questions in macroeconomics. Its significance is both timely and timeless. Recent economic

[1] The spending number has since been revised to about $830 billion for the 2009-2019 period, according to CBO (2014a).

turmoil has revealed the limits of knowledge of the channels through which fiscal policy affects the macro-economy. Recent fiscal responses have given scholars rich new data to conduct further studies. At the same time, as long as there are business cycles, the issue of optimal countercyclical fiscal policy will remain relevant. The Great Recession eliminated $7.7 trillion in U.S. household net worth and pushed the unemployment rate above 10% (CNN Money 2011). The pain and trauma of economic fluctuations makes the understanding and effective use of fiscal policy urgently important priorities.

The more specific manifestation of this question is what fiscal strategy would be ideal for the U.S. today, both in the short- and long-run? In this paper, I consider three comprehensive short- and long-run fiscal strategies: (1) the gradual and sustained fiscal consolidation with no stimulus analyzed by Cogan et al. (2013), (2) a temporary fiscal stimulus followed by gradual and sustained consolidation, with stimulus financed by either future tax hikes or spending reductions, and (3) a temporary fiscal stimulus with permanently higher transfers and therefore no consolidation. I simulate the effects of each strategy on the U.S. economy via the Coenen-McAdam-Straub (CMS) model, which is New Keynesian in nature. I find that temporary stimulus results in a temporary boost to output but is followed by a drop below baseline GDP largely due to substantial negative effects on investment. The results suggest that consolidation may work to reverse such medium-term decreases in GDP. Therefore, a fully deterministic temporary fiscal stimulus followed by consolidation is a promising fiscal strategy that can close the output gap during a recession and stabilize output in the medium- to long-term. The promise of such a strategy is of course dependent on further tests for robustness in other macroeconomic models.

2 Literature Review

The existing recent literature on the effects of short- and long-term fiscal policy is truly extensive. For the sake of reasonable brevity and relevance to this paper, I will not attempt a thorough treatment of all the literature, but instead focus on the major papers within each type of study that is also relevant to the topic of government expenditure on output. Two general insights are worth noting. First, since fiscal policy, both discretionary and non-discretionary, is a central component of public policy, this issue is inevitably political. While such considerations are definitely valuable, my analysis focuses on analytical and empirical studies of fiscal policy from the economics profession. Second, for all the rigorous scholarship on this topic, there is still no consensus among economists over how effective short-run fiscal policy is to GDP growth.

The most widely used metric to think about the effect of short-run government expenditure on GDP is the government expenditure multiplier. First developed by the Keynesians, the multiplier measures the ratio of change in output over change in government purchases only, not total government spending. The recent literature on the government expenditure multiplier includes several types of studies: (1) theoretical analyses, (2) empirical studies (including vector auto-regressions (VAR) using historical data), and (3) structural macroeconomic models.

2.1 Theoretical analyses

Woodford (2011) provides a widely cited, thorough, and rigorous theoretical model to study the expenditure multiplier, which he solves analytically. Woodford starts with a simple economy where output consists of just consumption and government purchases. In precise mathematical terms, Woodford argues that value of the output multiplier depends fundamentally on assumptions about prices. In his neoclassical benchmark, he assumes fully flexible prices,

and produces a multiplier of less than one. Under the classical competitive economy with perfectly flexible prices and perfect foresight, constrained optimization leads to Woodford's expenditure multiplier,

$$\frac{dY}{dG} = \frac{\eta_u}{\eta_u + \eta_v}, \qquad (1)$$

where η_u and η_v are elasticities of marginal utility of consumption and labor, respectively, and both variables are positive. Mathematically, the multiplier is positive but always less than one.

The assumption of sticky prices within the New Keynesian models allows for the possibility of higher multipliers, but the realization of such high multipliers depends crucially on monetary policy. The key insight here is that under sticky prices, monetary policy will be able to affect real activity in the economy, whereas under flexible prices it only affects nominal variables. In his New Keynesian benchmark, Woodford assumes that the monetary authority holds real interest rates constant for the duration of changes in government spending. The result is a constant level of consumption per period, with output defined by the following:

$$Y_t = \bar{C} + G_t \qquad (2)$$

Equation 2 shows us that output increases one-for-one with an increase in government purchases. Therefore, under sticky prices and a constant real interest rate, the theoretical expenditure multiplier is 1. There is no crowding out in loanable funds, but no additional boost to private consumption (Woodford 2011).

Woodford then considers alternative degrees of monetary accommodation. He notes that some hawkish monetary policies would produce neoclassical-type multipliers even in the New Keynesian model of sticky prices. For instance, if the monetary authority maintains a strict inflation target, it would increase real rates in response to higher government purchases, thereby

producing a multiplier identical to Equation 1. Under a Taylor rule, the level of monetary tightening is less severe than under the strict inflation target, but some level of tightening occurs, which raises real interest rates. Woodford obtains a multiplier less than one but greater than the neoclassical level in this case.

The multiplier becomes larger than one when monetary policy is at the zero lower bound. In such a situation, the monetary authority would not tighten policy in response to a government spending increase. With nominal policy rates at zero, an increase in G would increase inflation expectations and therefore *lower* the real interest rate. Monetary policy would effectively be more accommodative than keeping real interest rates constant. And since constant real interest rates led to a multiplier of 1, lower real interest rates will produce a multiplier greater than 1. Such situations develop when there is an elevated credit spread between real rates and the policy rate resulting from widespread panic in the financial intermediation process, such as during the Great Depression or the 2008 Financial Crisis.

Woodford (2011) brings up a final key determinant of the multiplier, which is duration. Multipliers are substantial and above one only when government spending occurs during the time at which the zero lower bound is binding, or when credit spreads are elevated. Once the zero lower bound is no longer binding and rates are again determined by the Taylor rule, higher government purchases will crowd out private investment, leading to lower multipliers.

Figure 1: From Woodford (2011)

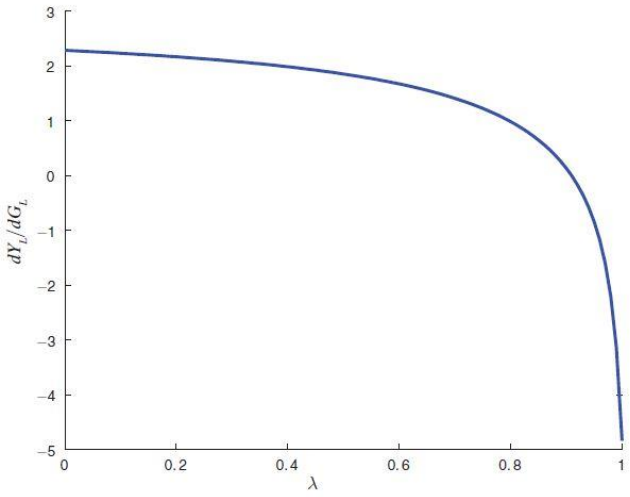


Figure 1 shows how the value of the multiplier depends on λ, which measures the degree of persistence of fiscal stimulus following the end of a financial disturbance. The longer fiscal stimulus lasts after the disturbance, the less effective it will be. At high enough duration, it can be counterproductive. Therefore, Woodford (2011) argues that in order for short-term fiscal stimulus to be effective, it has to happen quickly and within the window of "financial disruption."

Woodford (2011)'s analysis finds support in Hall (2009), which calculates that the expenditure multiplier may be as high as 1.7 when the economy is at the zero lower bound.

2.2 Empirical studies

Other noted economists have sought to determine the multiplier empirically by running regressions and other econometric analyses on historical data. On a general level, these studies identify periods of higher discretionary spending and seek to isolate the effects on GDP caused solely by that higher spending. These studies have to deal with the problem of endogeneity, as government spending levels could rise or fall simply because of external economic factors, such as economic expansions or downturns. Including those episodes may cause omitted variable bias in the results. Ramey (2011) deals with this potential problem by using historical data on U.S.

military spending only, since levels of military spending are tied more closely to geopolitical conditions than economic conditions and can be thought of as exogenous. Using analysis including vector auto-regression (VAR), Ramey (2011) finds that the multiplier can range from 0.6-1.2 depending on the timing of the increased spending. Using a VAR/event study approach, Blanchard and Perotti (2002) find that positive government spending shocks consistently increase output, while tax increases decrease output.

On the tax side, much research has been done as well. Romer and Romer (2010) estimate tax multipliers based on historical U.S. data. To decrease the possibility of simultaneous causality and other omitted variables, they analyze the political record to determine the reasons for each tax change. They focus exclusively on tax changes made for ideological reasons because such changes would be relatively unaffected by external output forces (and economic policy made in response to economic conditions), which would bias the output results. They find that the effects of tax increases are "highly contractionary," and are both significant and robust.

One flashpoint in the debate is the notion of an expansionary fiscal consolidation. Textbook Keynesian theory indicates that during a recession, expansionary fiscal policy consists of increasing government purchases, cutting taxes, or both. However, Alesina and Ardagna's 2010 article, "Large Changes in Fiscal Policy: Taxes Versus Spending," argues that cutting government purchases during a recession can be expansionary due to effects on consumer confidence. This study is a further development of the possible mechanism behind fiscal consolidation, a phenomenon suggested by Giavazzi and Pagano (1990) regarding the consolidations in Denmark and Ireland in the 1980s.

2.3 Structural Macroeconomic Models

Structural macroeconomic models are another popular method to simulate the effects of fiscal policy. These models are a complex and large collection of equations and relations among key macroeconomic variables. The models contain numerous constants, or parameters, that economists estimate empirically. These parameters then feed into the equations. Given specific shocks or policies, the model solves the equations and arrives at an impulse response function and other steady state values. One advantage the macroeconomic models have is their ability to let economists explore hypothetical situations with no historical data or precedent (Coenen 2012). Therefore, such models are widely used by central banks.

Using the ACEL model, Christiano et al. (2009) find further evidence that the multiplier is significantly larger than one when the zero lower bound is binding. There are many types of macroeconomic models, many of which have quite different assumptions of consumer behavior. One of the major sources of disagreement lies in the macroeconomic models on which economists base their conclusions. Romer and Bernstein (2009) use the FRB-US model, traditionally known as more Keynesian in nature, to evaluate the effects of the ARRA. They find expenditure multipliers as high as 1.6. Cogan et al. (2010) use the Smets-Wouters 2005 model, a New Keynesian model assuming more forward-looking consumers, to analyze the ARRA and find that its multipliers were decidedly less than one. Finally, the IMF (2010) used its GIMF model to analyze the effects of fiscal consolidation, and found that they were decidedly contractionary—contrary to the conclusions of Alesina and Ardagna (2010). While both sides claim to be New Keynesian in the sense that their models account for forward-looking consumers, rational expectations, and price stickiness, the models vary based on the degree to which such assumptions hold.

Given such lack of agreement amongst economists on the value of the multiplier, several economists have sought to study these models comparatively. Wieland et al. (2012) introduce the Macro Model Base (MMB), a thorough database of all major macroeconomic models that allows computerized comparisons of how different models respond to the same shock or other policies. Coenen et al. (2012) investigate the responses to different types of fiscal stimulus across seven major models, and find a surprising degree of commonality across models. While both studies have made strides in the model comparison, this realm of study is still young and developing. Many comparisons deal with simple shocks instead of longer time paths of spending or other macroeconomic variables. Moreover, not many papers have compared different fiscal strategies within a model, as I do in my analysis.

3 Methodology

3.1 The Model

I use a structural macroeconomic model called the Coenen-McAdam-Straub (2008) model, hereafter referred to as the CMS model, to conduct my analysis. The model is also called the New-Area-Wide Model (NAWM) because a version of it is has replaced the Area-Wide-Model (AWM) used in the European Central Bank's macroeconomic simulations (Cogan et al. 2012). The CMS model is a New Keynesian dynamic stochastic general equilibrium (DSGE) model. It is New Keynesian in the sense that it features forward-looking households, nominal rigidities necessary for short-term price stickiness, and imperfect competition. It also has a detailed fiscal sector and has a basic account of government debt (Cogan et al. 2012).

The CMS model covers the U.S. and the Euro area. Its parameter values are derived from estimates or measurements of economic statistics from both economies. The parameters are numerical constants fed into the model equations, thereby defining the output of the model to any given shock or alteration in inputs. The process of setting numerical values for the parameters is known as calibration. I use the Cogan et al. (2013) implementation of the model, which uses U.S. data from Cogan et al (2010) to calibrate the model.[2] The model therefore mainly predicts outcomes on the U.S. economy from changes in U.S. government spending, with projections of spillover effects into the Euro area as well (Cogan et al. 2013).

The model assumptions and equations follow a distinctively New Keynesian framework. The model features two types of households, *I* and *J*, both of which maximize the following utility function:

[2] Specifically, I used the replication files for the model simulations used in Cogan (2013). The files are written in Dynare 4.2 code and are run in MATLAB. Implementations of the model are also available in the Macro Model Base (MMB) run by Volker Wieland. Many thanks to Volker Wieland, Maik Wolters, et al for providing the replication files.

$$E_t\left[\sum_{k=0}^{\infty}\beta^k\left(\frac{1}{1-\sigma}\left(C_{i,t+k}-\kappa C_{I,t+k-1}\right)^{1-\sigma}-\frac{1}{1+\theta}\left(N_{i,t+k}\right)^{1+\theta}\right)\right], \qquad (3)$$

where C represents consumption, N is hours worked, θ is the inverse of the Frisch labor supply elasticity, σ is the inverse of the intertemporal elasticity of substitution, and κ is the degree of habit formation. As demonstrated by the utility function, households consume based on an infinite time horizon and are forward looking, with β as the discount factor of future consumption.

Households *I* may smooth consumption through access to the bond market, whereas households *J* can only do so by holding money and therefore cannot accumulate physical capital. Households *J* are therefore liquidity-constrained, since they face higher costs to saving or borrowing across time periods. Liquidity-constrained consumers are more likely to make consumption decisions out of present income, known as consuming "hand-to-mouth," which is a distinctly old Keynesian assumption about consumption decisions. Members of household *J* face a budget constraint without bonds, but taxes factor into the budget constraints for both *I* and *J*. And since consumers are forward looking, both changes in fiscal variables today as well as expectations of future changes will affect the consumer's optimization problem. The share of liquidity constrained households (Households *J*) to total households in the CMS model is 27%, which is relatively low compared to other major models (Coenen et al. 2012).

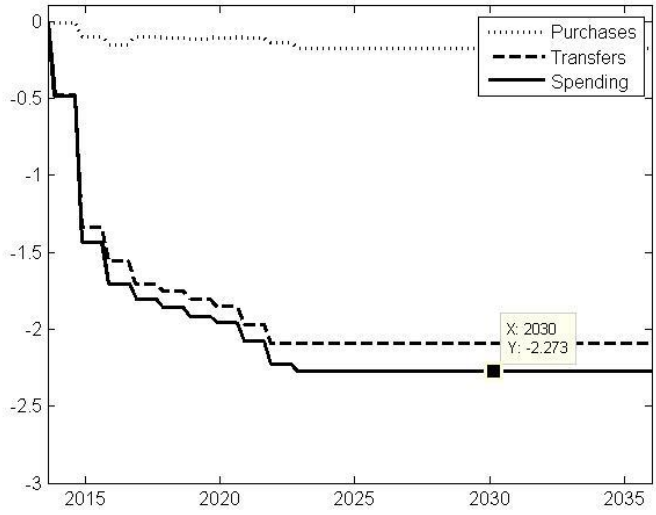
The model incorporates price stickiness via the staggered price contracts of Calvo (1983). In the fiscal authority's budget constraint, all taxes are set exogenously. As mentioned earlier, the tax rates flow through the model to the household budget constraint, thereby affecting consumption-saving and labor-leisure decisions. Lastly, the monetary authority follows a Taylor-type rule with both output and inflation targets.

Given a shock or alteration of one or more variables over time, the model uses the equations and its given set of parameters to calculate the time path and steady states for output, investment, and many other variables over time.[3] The variables of interest to Cogan et al. (2013) and this paper are government spending and taxes, and their effects on other variables in the economy—output most importantly.

3.2 Fiscal Strategies

The government spending pathway for the fiscal consolidation strategy tested by Cogan et al. (2013) is shown below.

Figure 2: Government spending (consolidation) from Cogan et al. (2013)



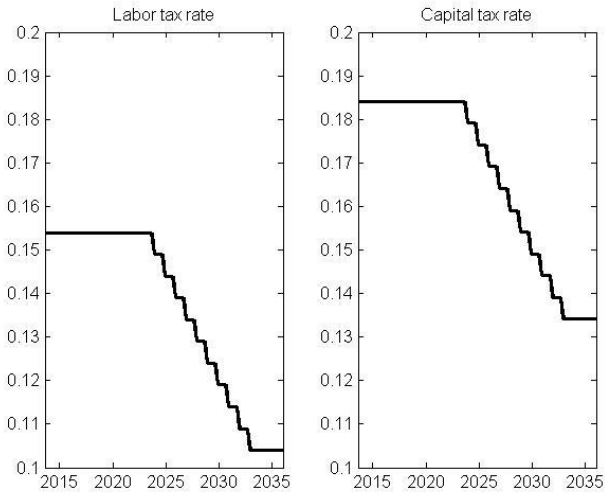
All y-axis values are percentage deviations from baseline spending as a share of GDP. Cogan et al. (2013) define baseline spending as the Congressional Budget Office's (CBO) projections of future government spending from 2012 to 2022 assuming no policy changes. The CBO projections show sustained higher spending as remnants of the substantially higher levels of

[3] For more details on the CMS model, please refer to Cogan, John F., John B. Taylor, Volker Wieland, and Maik H. Wolters. 2012. "Fiscal consolidation strategy," Center for Financial Studies (Goethe University Frankfurt). Working Paper No. 2012/12, September.

spending during the financial crisis. Therefore, baseline spending, which is depicted by the x-axis above, is actually a slightly growing stock of government spending (Cogan et al. 2012). The Cogan et al. (2013) pathway is both pure and gradual—pure because it is completely consolidative with no stimulus or expansion for the duration of the strategy, and gradual because the consolidation is achieved in a stepwise, phased-in manner, with the long-run steady state value achieved by 2023. The steady state value is a total reduction in government spending of 2.27% of baseline GDP, the sum of 2.09% in transfers reduction and 0.18% in government purchases reduction.

Cogan et al. (2013) choose the following path for taxes rates:

Figure 3: Labor and Capital Income Tax Rates from Cogan et al. (2013)



Labor income tax rates are held constant at 15.4% until the start of the long-run steady state in government spending, after which they gradually decrease 5%. Capital income tax rates are similarly constant at 18.4% until 2022, after which they also decrease 5%. From the start of the simulation (2013) to the start of the long-run steady state (2022), the government spending reduction is applied entirely to deficit and debt reduction. After reaching the steady state, Cogan et al. (2013) use some of the decreased spending to finance tax cuts on labor and capital income.

All strategies tested by Cogan et al. (2013) and me are deterministic; in other words, all agents have perfect information concerning the levels of government spending in the future, and government spending in the future is certain.

I test two alternative sets of fiscal strategies: short-term stimulus followed by long-term consolidation (a "mixed" strategy), and short-term stimulus with permanently higher transfer payments (a "pure" strategy). All strategies, Cogan et al. (2013) included, are deterministic in nature. In other words, agents immediately anticipate and have perfect knowledge of the spending pattern of each strategy when it is enacted in the model. There is no uncertainty.

3.2.1 Stimulus followed by consolidation ("mixed" strategy)

Stimulus followed by consolidation has been suggested by economists working for both sides of the aisle. Such a strategy is politically very difficult to accomplish, since it requires the fiscal authority to commit to spending reductions at a specified future time period. Nevertheless, the effect of this "mixed strategy," feasibility aside, is theoretically interesting. Under the best case scenario, this strategy could help to extricate an economy from recession and spur long-run sustainable growth. The short-run stimulus in the near term should increase output and decrease unemployment, and once the economy approaches full employment, the consolidation would increase consumption and labor supply through lower taxes and increase investment as government lowers spending. Relatively few papers have looked at the effects of such a mixed strategy in the context of structural macroeconomic models.

I test two varieties of stimulus followed by consolidation. Both varieties feature the same stimulus path, with the only difference existing in financing: one strategy finances the stimulus through decreased future government spending, while the other finances stimulus via higher future tax rates. I do not test a third type of financing, which is financing by additional debt only.

In practice, the U.S. government uses this option frequently by financing additional spending through higher levels of borrowing.

The reasons for the exclusion of debt financing are two-fold. First, the CMS model does not thoroughly account for the effects of debt on long-run output growth. Government debt does manifest itself in the form of bond holdings in the government budget constraint. The model also includes a fiscal rule in which lump-sum taxes react to debt levels (Coenen 2012). However, the CMS model does not incorporate changes in the risk premium on domestic interest rates when debt levels are high, nor does it include a government debt risk premium (Coenen 2012). These are important channels through which high debt levels raise interest rates, which in turn can lower GDP growth. The fact that the model does not account for these mechanisms suggests that a comparison of two strategies with different long-term debt levels may not be accounting for important differentiating factors. The spending and tax strategies I test are effectively ways to account for the "cost" of debt in the future.

Second, the imposition of spending and tax controls amounts to a marginal balanced budget operation. Any marginal debt increase caused by the higher spending of short-run stimulus is made up in the future via lower spending or higher taxes. This strategy is in accordance to the government's inter-temporal budget constraint,

$$B_t = \sum_{i=1}^{\infty} (1+r)^{-i} PB_{t+i,} \qquad (4)$$

[4]

where B_t is the government's total stock of debt today, r is the interest rate on public debt, and PB_t is the primary surplus. The gist of the above equation is that the government's current stock of public debt must equal the present value of all future surpluses. Put another way,

[4] http://en.wikipedia.org/wiki/Fiscal_sustainability#cite_note-Bohn2005-7

PV(future taxes) = PV(future spending) + national debt. (5)

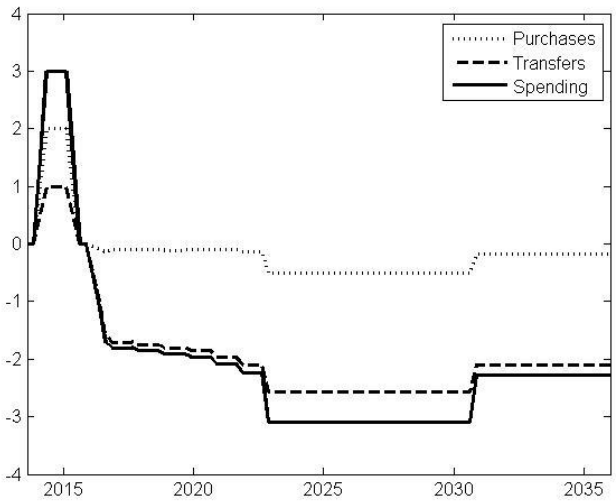
If we keep the present value of national debt constant, then any increases in spending must be balanced by reductions in future spending (to keep the present value constant) or increases in future taxes (to maintain the equality).

To summarize, I test two varieties of the mixed strategy: (1) stimulus followed by consolidation with further spending reductions, and (2) stimulus followed by consolidation with tax increases. To abbreviate, I will refer to (1) as "spending financed" and (2) as "tax financed."

Mixed strategy, spending financed

The spending financed mixed strategy is depicted in the figure below.

Figure 4: Government spending for Stimulus then consolidation, spending financed



The stimulus begins at the start of the simulation (2013) and lasts two years (8 quarters). The increased spending shock comprising the stimulus is a total of 3% of baseline GDP, with purchases increasing 2% and transfers increasing 1%. Both purchases and transfers take two quarters to reach their peaks and stay at those levels (+2% for purchases, +1% for transfers) for 4 quarters before coming back down to 0%. After the end of stimulus, both purchases and transfers immediately catch up to the exact values of Cogan et al. (2013). However, matching

the Cogan et al. (2013) values is not enough; I must make up, or "pay for", the additional spending I accrued over the Cogan et al. (2013) path up until convergence with their path. I calculate this spending difference over time by differencing the integral of my path with the integral of the Cogan et al. (2013) path.[5] I take the area difference between my curve and the Cogan et al. (2013) curve, not the x-axis, because that is the only way to logically compare my results to that of Cogan et al. (2013).

By taking the simple difference in areas, I determine the spending difference across the duration of my stimulus and their consolidation is 6.4% of GDP. Starting in 2022, I decrease spending by 0.8% over the Cogan et al. (2013) steady state for eight years to pay for that difference in spending. In doing so, I make the simplifying assumption that the interest rate equals the rate of growth in real GDP each year.[6] Since the interest rate is the growth rate of debt, having equal rates of debt and GDP growth means that a stock of debt equal to 6.4% of GDP in 2014 will remain at 6.4% of GDP in 2023. Therefore, I can make up 6.4% of 2014 GDP plus interest accrued by reducing spending by 0.8% for eight years. The spending reduction is made so that the reduction in purchases equals the difference in purchases between the two curves, and the same goes for transfers. Since all the financing is done on the spending side, tax rates follow the Cogan et al. (2013) path exactly. After the eight years, spending (purchases and transfers) revert back to the Cogan et al. (2013) levels.

[5] Integration was done through the MATLAB function trapz(), which integrates numerical curves using the trapezoidal method.

[6] This assumption is a bold one. I find that the interest rate on bonds is roughly equal to real GDP growth in the period under simulation, according to CBO (2014b).

Figure 5. Government spending comparison: Mixed strategy, spending financed vs. Cogan et al. (2013) consolidation

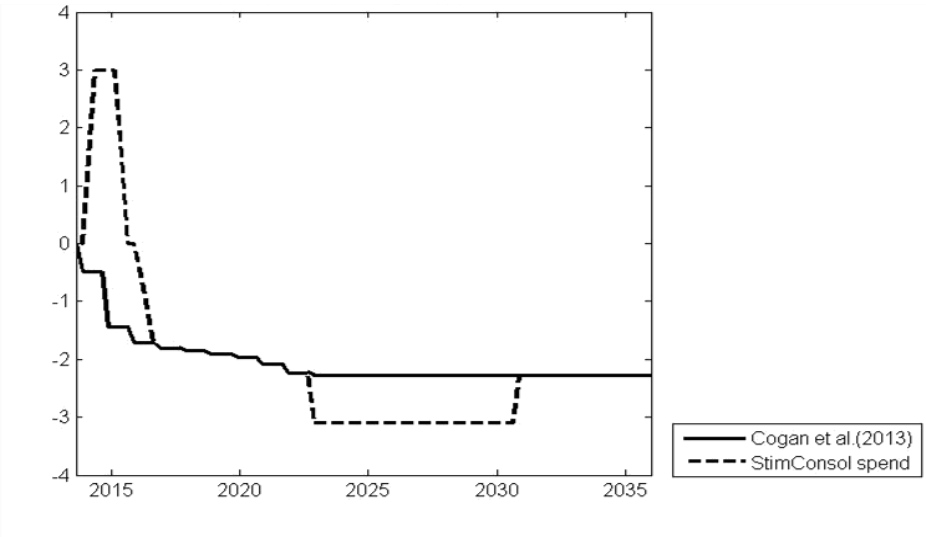


Figure 5 shows the mixed strategy financed by spending compared to government spending in Cogan et al. (2013). The area between the two paths during and immediately following stimulus equals the area between the two curves after steady state.

Mixed strategy, tax financed

The other type of mixed strategy I test is stimulus followed by consolidation financed with tax hikes. This strategy features the same stimulus (2 years, 3% of GDP in additional spending). I immediately follow the Cogan et al. (2013) consolidation afterward, and do not deviate for the rest of the simulation.

Figure 6. Government spending comparison: Mixed strategy, tax financed vs. Cogan et al. (2013) consolidation

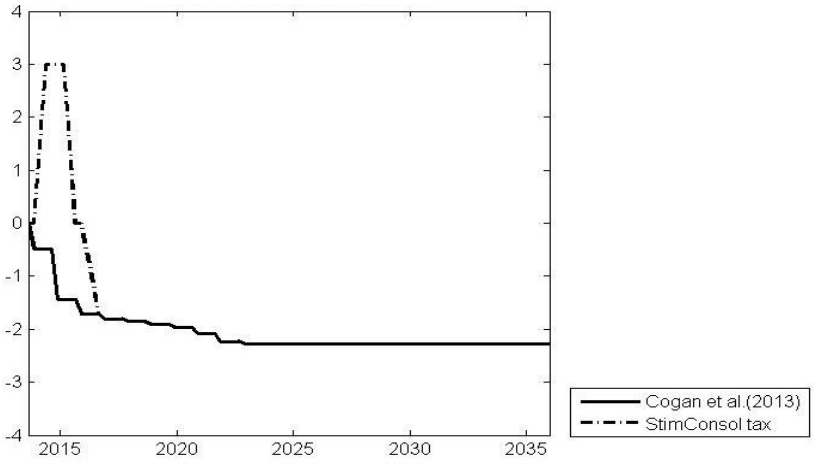


Figure 6 shows no additional spending cuts from steady state. Instead, the 6.4% of additional spending is made up exclusively with tax increases over the Cogan et al. (2013) rates for eight years starting in 2022, which is the same time horizon as the mixed strategy financed with spending cuts.

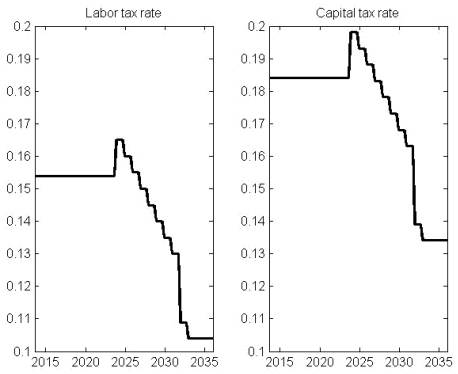
I make the same assumption that interest rates will equal real GDP growth. To calculate tax rate increases, I first use data from the CBO (2014) on individual income tax revenue as a share of GDP and NIPA data on labor income and capital income as a share of total income.[7] Using these data, I determine the labor income tax base and capital income tax base. I split the 6.4% of additional debt into labor tax revenue and capital tax revenue, and divide both by their respective tax bases to arrive at a one year rate increase.

Spread over eight years, the calculation shows that labor income tax rates must be 1.6% higher than the Cogan et al. (2013) rate, and capital income tax rates must be 1.9% higher per year, as depicted below in Figure 7.

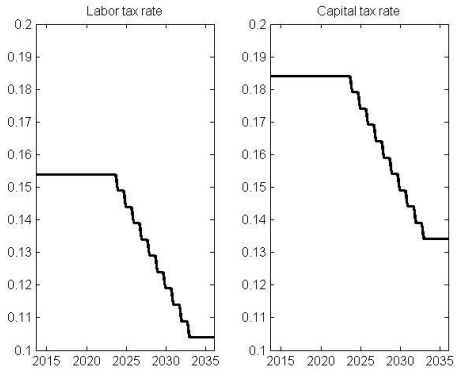
[7] I accessed the data of the NIPA tables at www.bea.gov. From NIPA Table 12, I take labor income to be the compensation for wage employment calculated in Q4 2013, which coincides with the start of the simulation. The ratio of wage compensation to total national income is about 60%. Therefore, labor share of total income is 60%, capital share 40%.

Figure 7. Comparison of tax rates

Mixed strategy, tax financed



Cogan et al. (2013)

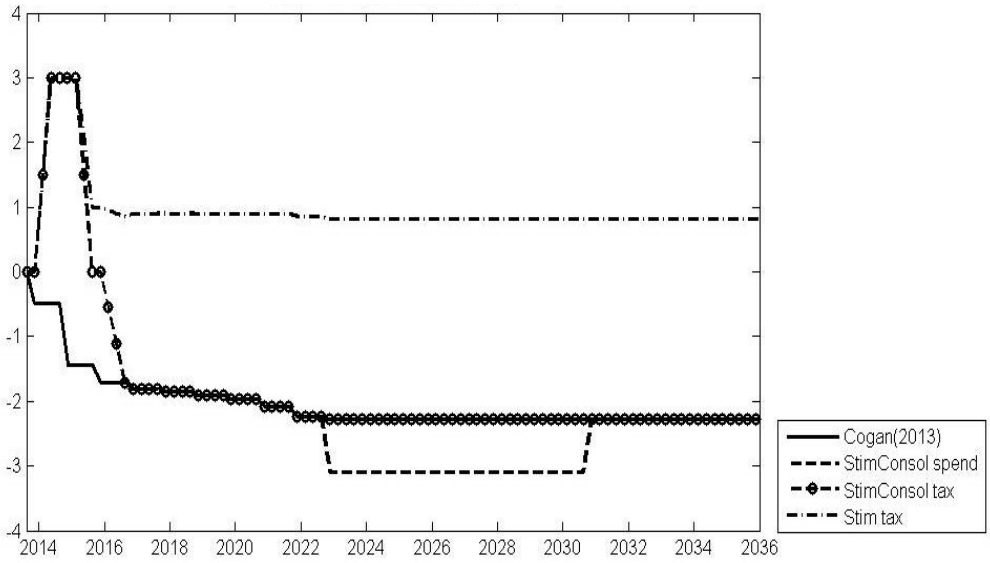


After the eight years, tax rates revert back to the Cogan et al. (2013) levels.

3.2.2 Stimulus with permanently higher spending ("pure stimulus")

In the pure stimulus strategy, I enact the same stimulus as in the mixed strategy (2 years, +3% GDP for one of those years). After the stimulus, purchases revert to the Cogan et al. (2013) path for the rest of the simulation. Transfers, however, stay at their stimulus level of 1% above baseline for the rest of the simulation. Since transfers are 1% higher and purchases are 0.18% lower, spending is 0.82% higher permanently. The pure stimulus spending path is shown below, compared with both mixed strategies and the Cogan et al. (2013) consolidation.

Figure 8: All spending paths

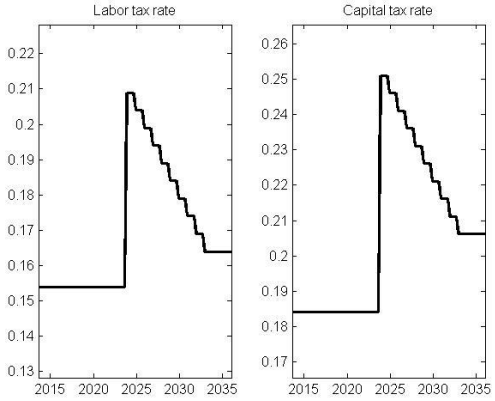


Since spending is permanently higher, tax rates must be permanently higher. Tax financing is also the only option, since one cannot finance permanently higher spending with lower total spending. In addition, tax rates must rise by more than they do in the mixed strategy because the spending to be made up each year is higher. Specifically, I must pay for the difference in steady state spending each year, which is about 3% of GDP. The difference in spending from the start of stimulus to the start of steady state in 2022 is 25% of GDP. Since that sum is so extensive, I assume that the fiscal authority can spread the 25% of GDP over a sufficiently long time span to make the tax rate increase negligible.[8] The rate increase would therefore come exclusively from the permanently higher transfer spending; I find that labor income tax rate must be 6.0% higher, and capital income tax rates must be 7.2% higher per year than the Cogan et al. (2013) path. The rate increases are depicted in Figure 9 below.

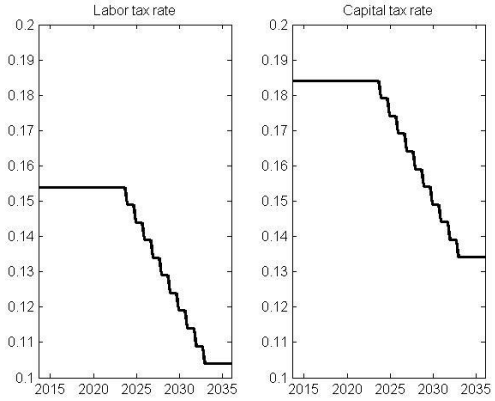
[8] One could argue that this assumption causes one to underestimate the tax burden that must be borne in the future, since the 25% difference is not included. However, choosing a time horizon for inclusion is also difficult; there is a vast range of possible time horizons to choose from—not just the 8 years used before—because the strategy is no longer consolidative. To avoid this conundrum, I only bear the burden of the higher permanent spending, so the results should reflect this choice.

Figure 9. Comparison of tax rates

Pure stimulus, tax financed



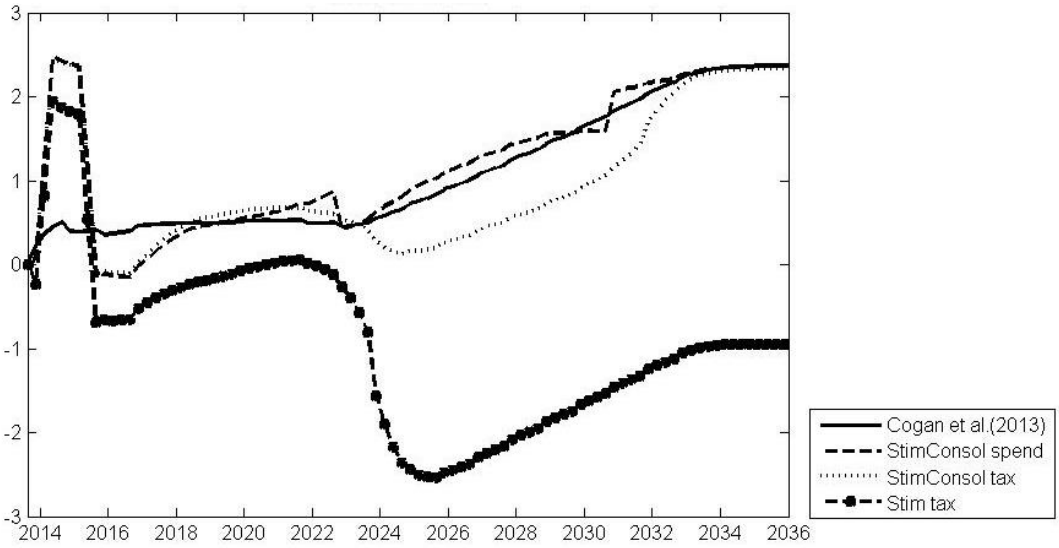
Cogan et al. (2013) consolidation



4 Results and Analysis

As mentioned above, I am testing three alternative strategies: mixed strategy with spending financing, mixed strategy with tax financing, and pure stimulus (tax financing by default). All other parameters in the model are kept constant. Below are the output paths produced by the CMS model for each strategy:

Figure 10: Output comparison across fiscal strategies



The first thing to note about Figure 10 is the Cogan et al. (2013) output path, which features both an immediate as well as sustained increase in GDP. This is evidence of substantial forward-looking consumption-savings preferences within the model. Since this strategy is deterministic, individuals see that government spending will continue to decrease in the short run and tax rates will fall in the long run. Lower government spending causes higher permanent income for households, since taxes rates will not experience as much upward pressure in the future. Cogan et al. (2013) also point out that lowering labor income tax will raise labor income and incentivize more labor supply, while lower capital income taxes will induce more investment

in the long run. With consumption and investment trending up in the short- and long-run, GDP maintains a sustained upward trajectory.

4.1 Comparison of the three alternatives on output

The three alternative strategies follow roughly similar trajectories, though each one takes on quite different values of output. All three alternative strategies produce a sizable boost to output during the first two years because of the short-run stimulus. Output rapidly falls to a value under baseline towards the end of the stimulus (~2015). After a few quarters under baseline GDP, output reverts to positive growth until it comes time to pay for the stimulus starting at the end of 2022. The spending reduction or tax increase is a negative shock to output. Output resumes its growth, and, in the case of the mixed strategies, receives a positive shock at the conclusion of the additional spending reductions or tax hikes over the Cogan et al. (2013) values. One can thus summarize the similarities among the three strategies as follows: the CMS model shows that short-run stimulus boosts GDP in the short-run, but has medium-run costs owing to the conclusion of stimulus and long-run costs due to paying for the stimulus.

The boost to GDP is promising for the short-run effects of fiscal stimulus. In the spending financed mixed strategy, output peaks at 2.47% above baseline GDP in Q2-2014. The absolute value of additional output can potentially help to close an output or employment gap, but the greater value lies in its effectiveness relative to government purchases. Purchases are 2% above baseline at that time, implying a government expenditure multiplier greater than one, which most economists would argue is a fairly efficient and effective fiscal stimulus. This multiplier, however, measures the effectiveness of spending up to that point in time with respect to output changes up to that point in time. The whole concept of an output path vividly

illustrates the fact that the expenditure multiplier is not a static value; rather, it changes from quarter to quarter.

To get a simple theoretical sense of the employment effects, I use Okun's Law, which states that a 1% increase in the unemployment rate is associated with a fall of 2% in real GDP growth (Mankiw 2007). Applying this law to the 2.47% increase in output, I get about 1.24% decrease in unemployment. A 1.24% fall in unemployment is quite significant, especially in recessionary conditions. With the U.S. unemployment rate at stubbornly high levels, economists view even a few tenths of a percent decrease in unemployment over a few months as real progress. While timing of output effects is theoretical at best and divorced from reality at worst in structural models, the fact that this fall in unemployment is achieved three quarters into the stimulus is worthy of note. The CMS model results suggest that stimulus can be highly effective if done rapidly.

The effects of each strategy also differ in important respects. Between the two types of mixed strategies, the spending financed one appears to be more favorable to output. Output peaks at a higher level (2.47% versus 2.44%) in the spending financed compared to the tax financed strategy. After the drop below baseline following the stimulus, both paths more or less mimic each other until we near the payment period starting in 2022. Here, the trade-offs inherent in financing become apparent. Under the spending financed mixed strategy, output grows until the spending reduction, declines for one quarter after the cuts, and promptly resumes growth. The *magnitude* of that decline, however, is large: output falls from 0.86% to 0.42%, a fall of about 50%. Under the tax financed strategy, output gradually starts to decrease starting in 2020, so output levels fall below that of the spending financed strategy even before the payment period begins. Output continues to fall, hitting a trough of 0.41% above baseline in 2024. At this point,

output under spending financing is at 0.8%. Output gradual recovers its upward trend but never catches up to the spending financed path until the end of the simulation.

This comparison demonstrates that tax rate increases are more harmful to output than government spending reductions. Other than the financing method, all other aspects of the two mixed strategies are identical. I can therefore state with confidence that higher taxes cause the lower output in the model than do spending reduction. I will demonstrate later that this observation is consistent with the model's theoretical foundations.

The output path of the pure stimulus strategy does strictly worse than both mixed strategies and the Cogan et al. (2013) consolidation in terms of output. Output peaks at only 1.8% above baseline, compared to 2.47% under mixed with spending reductions, and 2.44% under mixed strategy with tax financing. Output falls below baseline following the stimulus and reemerges briefly into positive territory before falling permanently below baseline. One could view this path as a more exaggerated version of the tax financed mixed strategy. Labor income tax rates increase 6.0% and capital income tax rates increase 7.2%, much more than the 1.6% and 1.9% increase in the mixed strategy. As such, the downturn in output caused by the tax hike is much larger. Output falls from a peak of 0.05% in 2021 to a trough of -2.53% in 2025. Afterward, growth resumes, but GDP reaches only -0.95% below baseline by the end of the simulation. Evidently, the negative effect on output from higher taxes exceeds the supposed positive effects on consumption and investment caused by higher transfers.

One could argue that the unfavorable results come from spreading the tax burden over too short a time horizon, thereby creating greater initial GDP shocks. Indeed, there are many time horizons across which one could spread the tax burden, and it is true that the output would be less adversely affected, at least initially, if we increased rates by a smaller amount over more

years. However, recall that I incorporated only the difference in permanent spending levels between the pure stimulus and Cogan et al. (2013) consolidation into the tax hike, excluding spending difference from the start of stimulus up to 2022. Therefore, the results should contain a favorable bias to the output path of the pure stimulus strategy, since I am arguably underestimating the cost of the strategy. Treating the output path as an overestimate, or "upper bound," on the output effects of pure stimulus leads me to conclude more confidently that the CMS model produces less favorable results when given the characteristics of the pure stimulus path. In other words, permanently higher levels of spending in the form of transfers will harm output significantly through the highly distortive effect of higher tax rates.

4.2 Considering the mixed strategies

Deciding which mixed strategy is preferable depends on one's preferences. If individuals in the economy place a higher value on stability of income, then the tax financed path may be desirable because its output path is smoother. If individuals place a higher value on the absolute level of income than stability of income, then the spending financed path is superior. Indeed, I compute a measure of total output produced over the entire time horizon by adding up each year's output value, which effectively amounts to an integral. The area under the spending financed curve is 27.3%, greater than the 20.9% produced by the tax financed mixed strategy.

To further evaluate the two mixed strategies, it is helpful to think in terms of benefits that better implementation can achieve. A more gradual spending reduction phased in over a longer period of time would dampen the abruptness and lessen the magnitude of the negative shock to GDP. It is more difficult to imagine more gradual tax reductions increasing the level of output under the tax financed path. As mentioned before, the CMS model features forward-looking consumers, so a tax rate hike, no matter how lightly distributed over time, will hurt output. Since

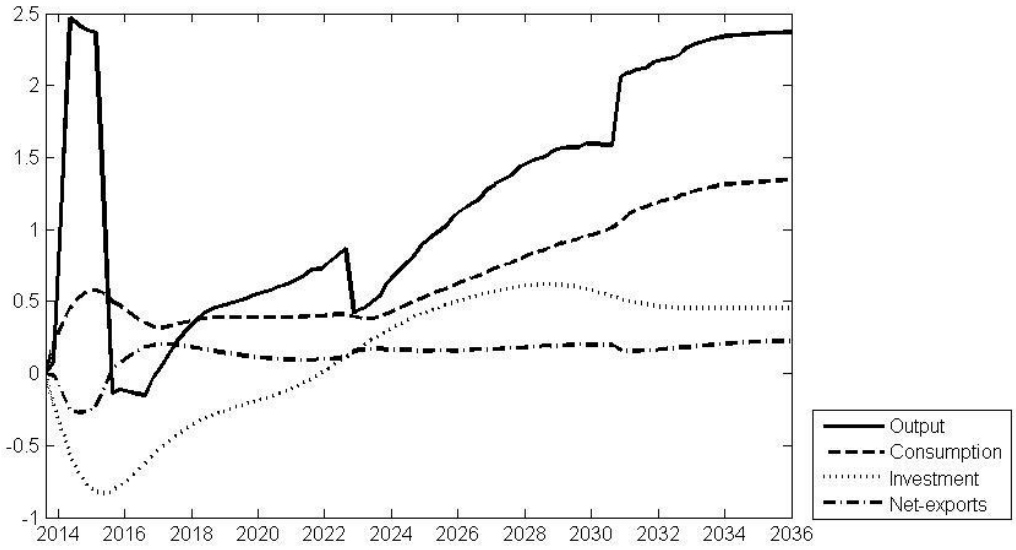
the spending financed strategy is superior in terms of total output produced, and potentially at least as good in terms of stability, it seems to be more promising in general.

Another interesting comparison is with the Cogan et al. (2013) output path in terms of cumulative GDP produced. All three output paths exceed the Cogan et al. (2013) path for a few quarters, creating a positive difference in area. However, all three also fall below the Cogan et al. (2013) path for some period of time afterward, so the output comparison involves comparing the positive and negative areas. The stimulus path unequivocally produces lower total output than Cogan et al. (2013). The areas under both mixed strategies are quite close to that of Cogan et al. (2013). In fact, the total area under the Cogan et al. (2013) curve is 24.48, meaning that the mixed strategy with spending produces slightly more output (at 27.3%), whereas the mixed strategy with tax financing produces slightly less (at 20.9%).

Based on the comparison among the alternative strategies and with the Cogan et al. (2013) path, the mixed strategy with spending financing appears particularly promising. I will therefore explore the results of this strategy in greater depth. Subsequently, I will explore select variables for the other two alternatives. The other variables can be found in the Appendix, which contains all figures produced by the CMS model for each alternative strategy.

4.3 Stimulus then consolidation, spending financed, in detail

Figure 11: Output for mixed strategy, spending financed



For the mixed strategy with spending reductions, Figure 11 above plots the output path (as shown before) along with the time paths of the components of output. We see now that the boost in output is produced primarily by the increases in consumption and government purchases. The fact that consumption increases along with purchases demonstrates that the additional spending increases aggregate demand itself and stimulates demand from consumers. Interestingly, investment trends negative immediately after the stimulus, suggesting a clear crowding-out effect that government spending has on private saving. The decline in output at the end of the stimulus consists of the decrease in government purchases along with continued negative values in investment. Consumption has not increased enough to counteract both negative effects. This phenomenon emphasizes the importance of a smooth "exit strategy" in which the government can withdraw stimulus without large shocks to GDP.

The figure suggests two ways to craft a good exit strategy. Firstly, a more gradual decrease in spending may lessen the shock to output. Currently, the conclusion of the stimulus is

abrupt, as spending goes from 3% higher than baseline to 0% in two quarters. Indeed, the smoothness of the consumption, investment, and net exports curves implies that smoothing out the government purchases path through more gradual changes can essentially lessen the abruptness of output changes. For instance, the shocks to output during the spending reduction of 2022 and expansion of 2030 are each less than 0.8% of GDP reduction and expansion in those years. This means decrease in spending is counteracted by increases in other expenditures such as consumption and investment. Dampening the extent of the spending decrease each year should allow the positive trends in consumption and investment to become relatively stronger.

The second option is consolidation, which may help to halt the downward trend caused by the government's exit. Indeed, the growth in investment is largely responsible for pushing output higher following stimulus, and the investment growth could be caused by anticipation of lower taxes from consolidation. Cogan et al. (2013) show that investment trends higher immediately from a consolidation strategy. In this strategy, investment is crowded out due to stimulus, but reverts to growth once the stimulus is over and consolidation begins. Thus, consolidation can help to soften the landing at the end of stimulus via the growth it generates in investment.

As mentioned earlier, the consistent long-run growth in output, despite temporary shocks from the spending reductions, is consistent with the theory of the CMS model. The CMS model features forward-looking, consumption-smoothing consumers, most of whom are not significantly liquidity-constrained. Importantly, the fact that the stimulus is financed through spending cuts means that tax rates follow the Cogan et al. (2013) cuts in the future. These cuts are anticipated by individuals, which appear to remove distortions to investing in particular, since investment consistently trends upward. Under this scenario, the CMS model shows that

increases in consumption and investment more than compensate the cuts in government spending, resulting in rising output.

Figure 12: Labor and Capital, Mixed Strategy-spending financed

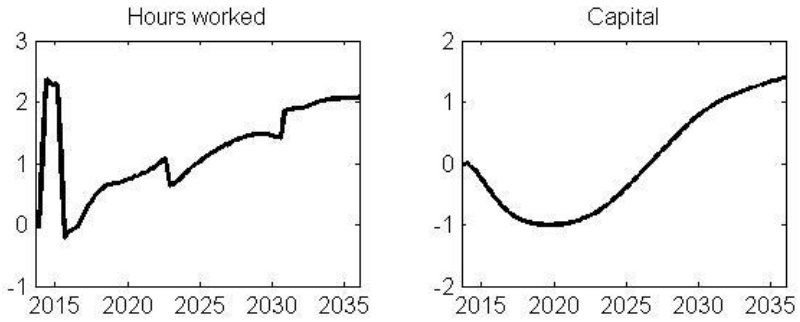


Figure 12 depicts the trends in labor and capital stock. Together, they help to provide a micro perspective to the macro trends. The rising long-run trend in hours worked is caused by higher labor incomes due to lower labor income taxes. Additionally, the short-run shocks of stimulus and government spending are apparent as well. A possible explanation for the closeness with which hours worked mimics output is the Frisch elasticity of labor supply, which is set to 0.5 in the model. Increased spending increases total output, or income. Since labor supply elasticity is positive, hours worked responds positively to a rise in total income. Higher labor income becomes an incentive to individuals to supply more labor. The decrease and subsequent increase in investment manifest themselves in the initial decline and subsequent rise in capital stock. The decline in capital lasts longer than does the reduction in investment because of important lags between capital stock and investment. Moreover, individuals can effectively "invest" by utilizing existing capital more intensely as well instead of acquiring new capital.

Figure 13: Real and nominal variables

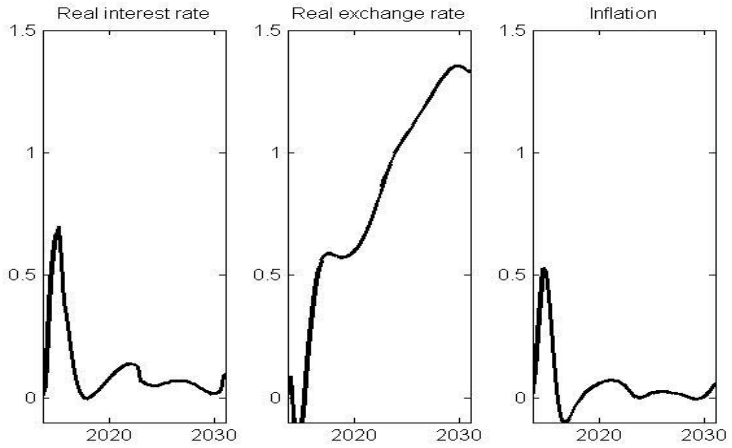
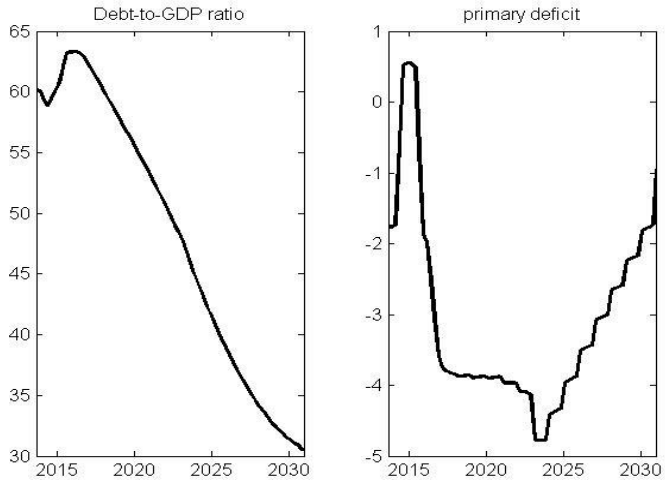


Figure 13 plots a few key benchmarks. The real interest rate is the real cost of borrowing and lending in the economy. It is affected by many forces, so seeking an intuitive explanation is likely not thorough. However, the trend in the real interest rate is consistent with the crowding-out effect. The government purchases resources by issuing debt, which partially diverts resources from other areas of the economy as well as decreases the supply of loanable funds. The shift in supply in the market for loanable funds increases the nominal interest rate, which can lead to a rise in the real interest rate if the magnitude of the rise is great enough. The rise in inflation is consistent with the price level effects of any increase in aggregate demand. Net exports growth is driven by a real depreciation of the dollar, or an increase in the real exchange rate.

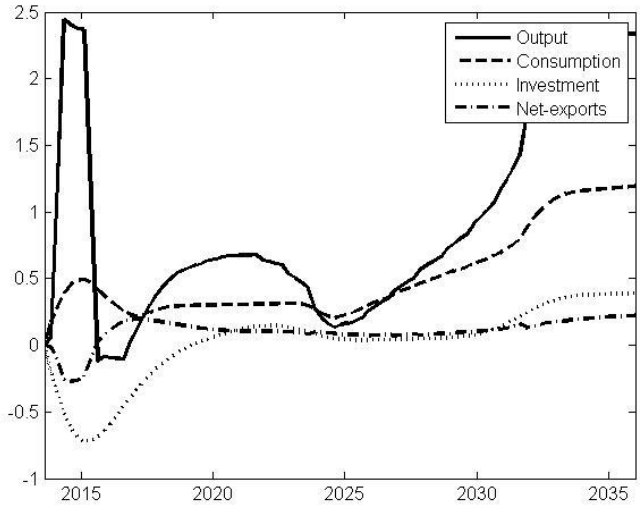
Figure 14: Debt and Deficits



Under the mixed strategy, the stimulus adds to the stock of debt while increasing GDP as well. Figure 14 shows that debt grows comparatively faster compared to GDP during the stimulus. However, consolidation decreases the debt to GDP ratio. Stimulus increases the primary deficit, but consolidation decreases the deficit and even produces years of surplus.

4.4 Tax financed mixed strategy, component analysis

Figure 15: Output under mixed strategy, tax financed

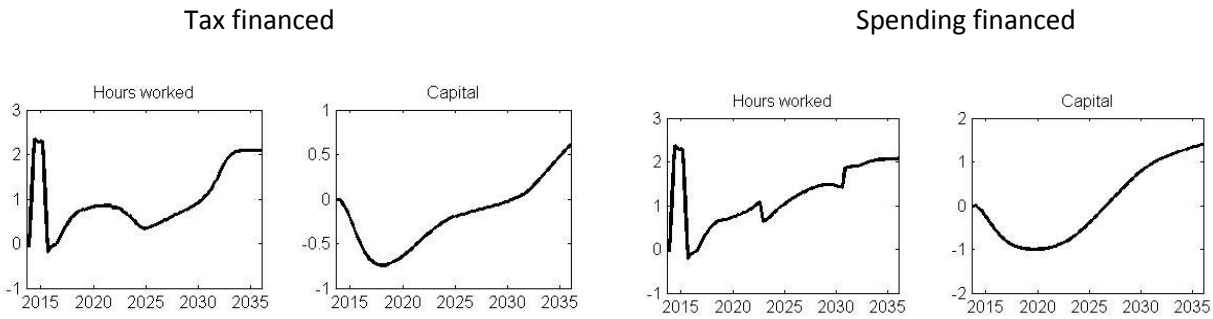


The tax financed mixed strategy is initially very similar to spending financed. The stimulus boosts output in the short run, mainly driven by consumption and government purchases. Stimulus also crowds out investment in the short run. Consolidation appears to soften the negative effects of withdrawing the stimulus, once again via increased investment.

One major difference under the tax financed strategy is that output starts to fall several years before tax rates rise, mostly due to decreases in consumption and investment. Once again, this result is consistent with the CMS model's theoretical foundations. As forward-looking agents mostly with effective tools of smoothing consumption, individuals anticipate the tax hikes as a certain decrease in future income, which puts a damper on both consumption and investment growth.

The especially distortive effects of taxes over spending are evident in Figure 16, which compares the paths of labor and capital between the two mixed strategies.

Figure 16: Labor and capital comparison across mixed strategies



Capital under the tax financed scenario undergoes less accumulation than in the spending scenario most likely due to the disincentive caused by higher taxes. Integrating both "Hours worked" curves shows that total hours worked under spending financed exceeds hours worked in the tax financed scenario. This is further evidence that taxes exert a more negative affect on equilibrium quantity of labor and investment than do spending cuts.

4.5 Stimulus with permanently higher spending, component analysis

Figure 17: Output under pure stimulus

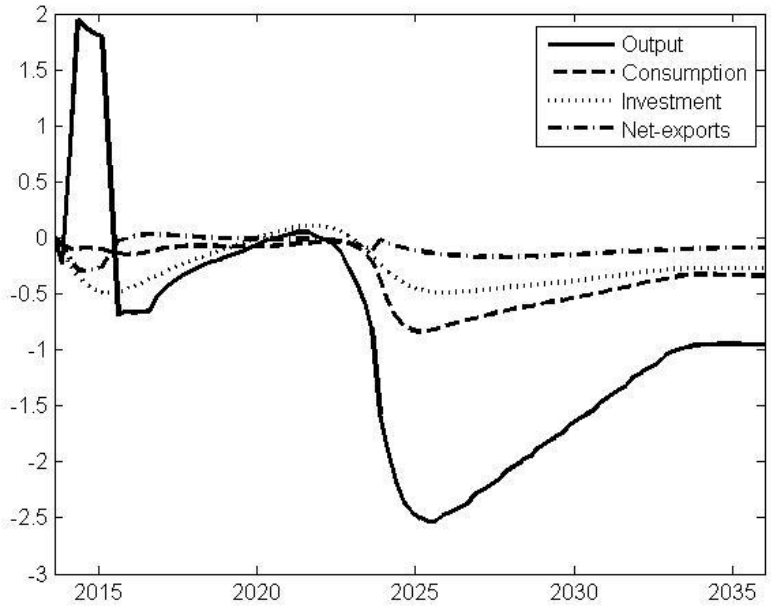
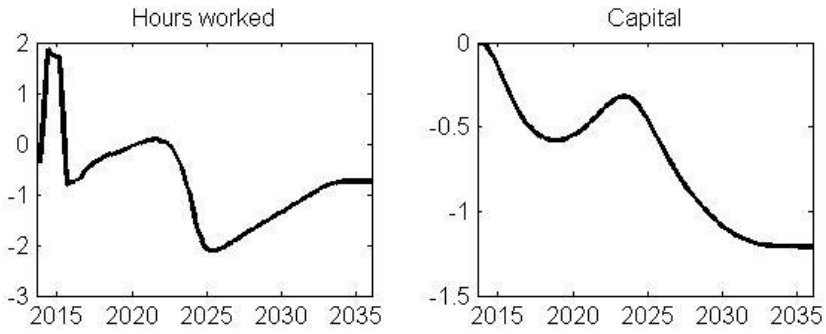


Figure 17 decomposes the output path into its components under the pure stimulus path. Rather surprising is the fact that, immediate after the end of stimulus, output falls to a lower level than it does in the mixed strategy. One would expect output to be at a higher level due to the increased spending that exists after the short-run stimulus in this strategy. However, all of the increased spending is in the form of 1% higher transfers. The results suggest that higher transfers are not a particularly effective stimulus measure. They are supposed to stimulate more consumption by boosting incomes, but the flat path of consumption after 2014 shows that this effect does not materialize. Once again, the ability of individuals to smooth consumption and anticipate the higher taxes may help to explain consumption's relative unresponsiveness to additional stimulus in the long run.

One especially material and evident effect is the large decrease in output due to the massive tax rate hike starting in 2022. Even with anticipation, individuals experience a significant disincentive to work in the case of higher labor income taxes, and a large disincentive to acquire capital because of the costs to do so. The specific effects on labor and capital are shown in Figure 18 below. The trends in both are similar to those in the mixed strategy with tax financing, but the magnitude of the swings is much higher, and the long run trend is downward.

Figure 18: Labor and capital under pure stimulus strategy



5 Conclusion

In this paper, I compared three alternative fiscal strategies in the CMS model. While the analysis was not heavily mathematical, a few insights stand out.

First, temporary stimulus creates a noticeable short-run boost to output, but also creates a medium-run cost to output due to the conclusion of the stimulus and a long-run cost when it comes time to pay for the stimulus.

Second, consolidation can be a valuable means to lessen the medium-run cost of withdrawing the stimulus, since consolidation's positive effect on investment can counteract negative effects on government spending and consumption. Consolidation can also spur long-run economic growth after the stimulus by increasing permanent incomes.

Third, financing matters. Within the same mixed strategy, raising taxes to finance stimulus is more harmful to output in the long run than lowering spending.

Fourth, the mixed strategy of stimulus followed by consolidation, financed by spending, is a promising strategy. The CMS model suggests that this strategy can boost output in the short-run and mitigate medium and long-run costs through consolidation. Indeed, the total output produced by this strategy exceeded the Cogan et al. (2013) consolidation as well as the other mixed strategies. This strategy has obvious feasibility problems. It requires the fiscal authority to commit to increasing spending and then cutting it at a specified future time, which requires an enormous and fairly unrealistic amount of political will. This paper, however, focuses on the economic and theoretical effects of the strategy.

Finally, the results show that stimulus followed by permanently higher spending has by far the most harmful effects on output of all strategies tested. Whatever short-run benefit accrued by stimulus is completely eliminated in the lower than baseline GDP of the future. This

result warns us of the dangers to output inherent in letting higher spending from stimulus become entrenched into permanent spending, especially in the form of transfers.

Further research along these lines could potentially focus on conducting a comparison in the CMS model along more rigorous, analytical lines by analyzing the vast body of equations and identifying the precise mechanism behind each effect. A more ambitious study could test similar strategies across different models. The above conclusions are inherently limited because they are derived from one model with one particular set of assumptions. Specifically, the CMS has lower share of liquidity-constrained consumers than in other models (Coenen 2012), so other models may produce significantly different results. Overall, a comparative study of fiscal strategies within and across macroeconomic models should continue to yield provocative and interesting insights that are relevant to current policy.

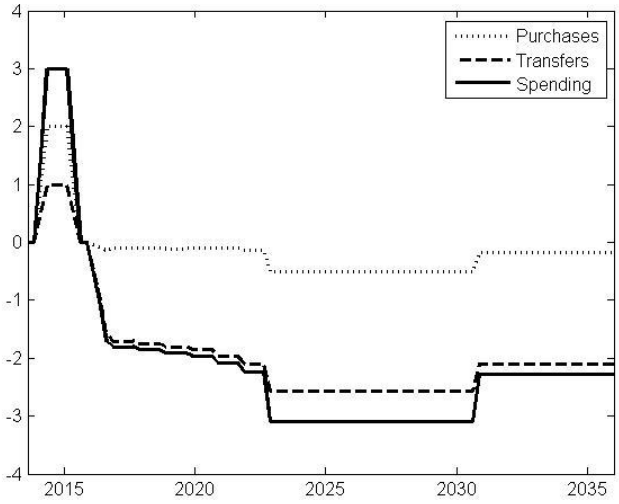
Appendix

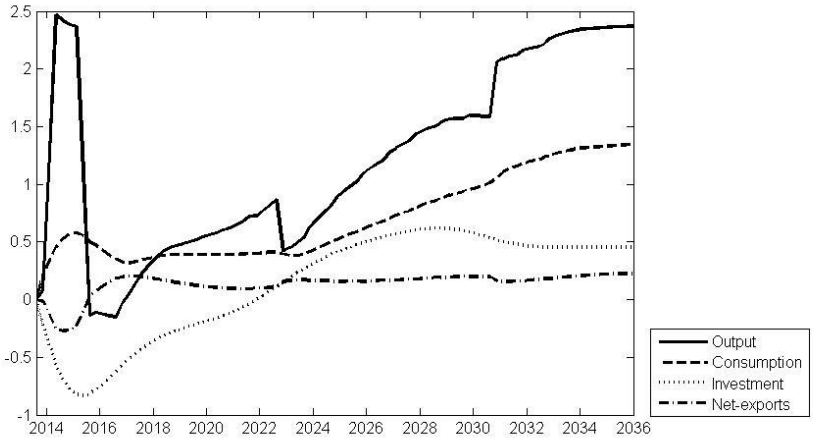
Below is a thorough list of the CMS model output for each of the three alternative strategies I tested.

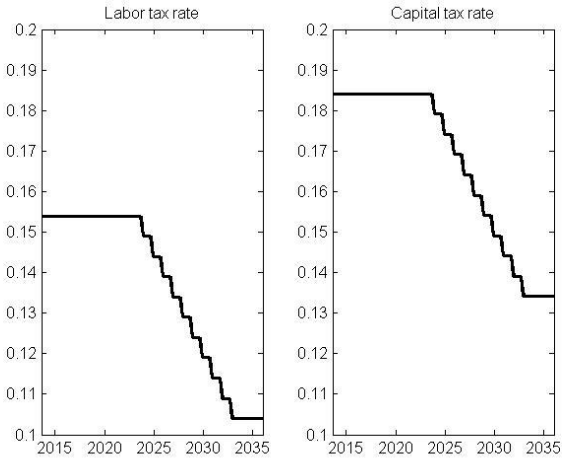
Note on the output plots:

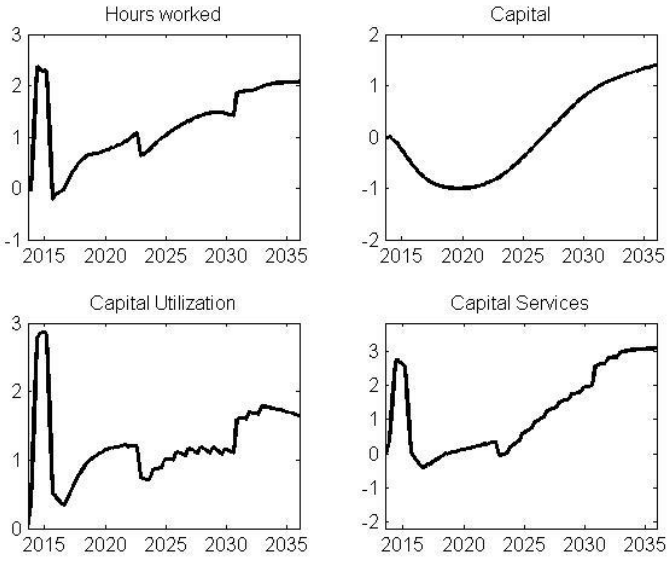
The sum of the values of consumption, investment, government spending, and net exports does not always equal the values in the output path because the model incorporates additional costs from adjusting capital utilization. The output identity (Y = C+I+G+NX) does hold in the long-run steady state of the model, which is not pictured in most plots. However, the trends in each component do manifest themselves in the output trend; such trends are the focus on my analysis.

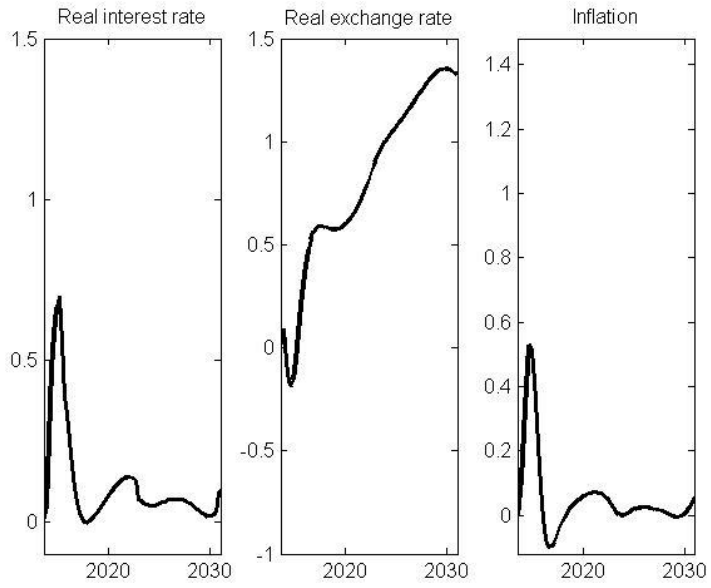
Mixed strategy, spending financed:

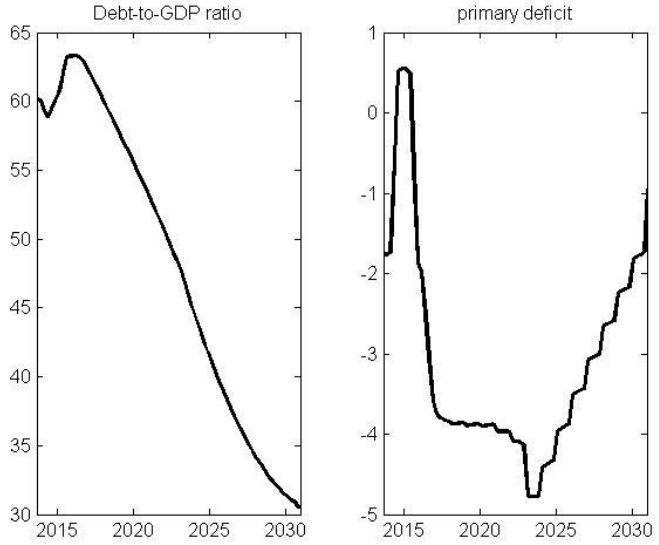



Output
Consumption
Investment
Net-exports

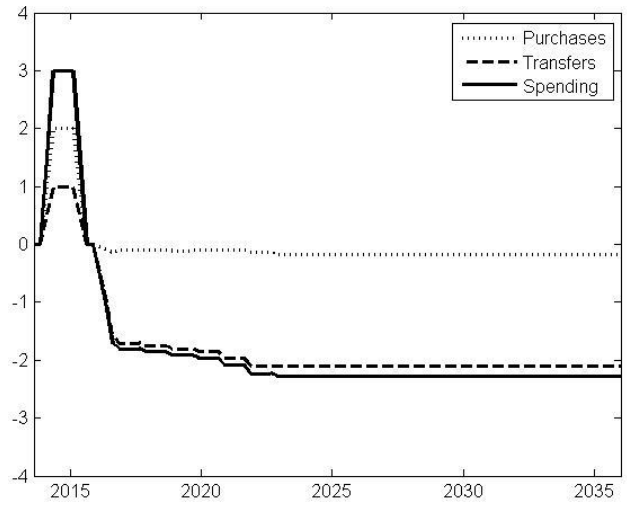

Labor tax rate
Capital tax rate

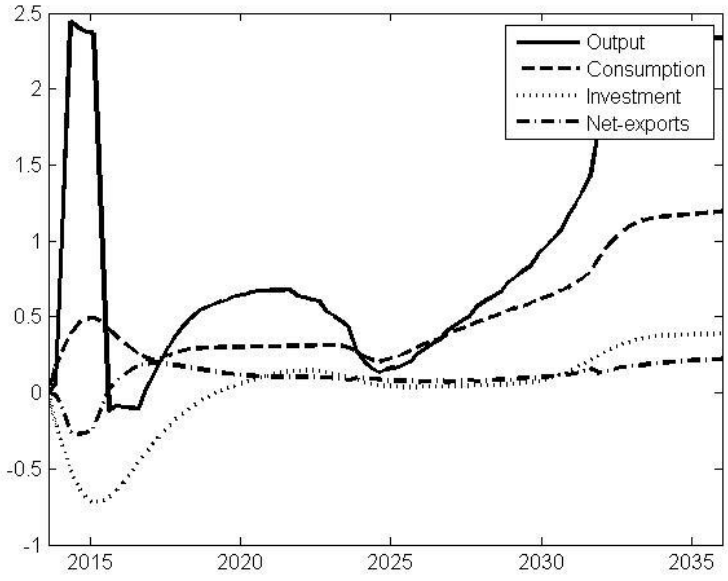

Hours worked
Capital
Capital Utilization
Capital Services

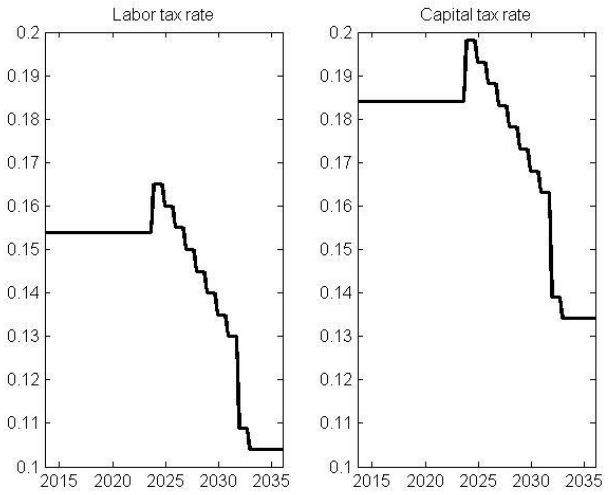

Real interest rate
Real exchange rate
Inflation
1.5
1
0.5
0
-0.5
-1
1.4
1.2
0.8
0.6
0.4
0.2
2020
2030


Debt-to-GDP ratio
primary deficit
65
60
55
50
45
40
35
30
-2
-3
-4
-5
2015
2020
2025
2030

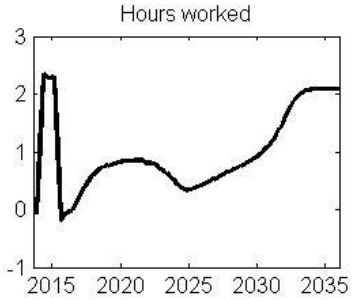
Mixed strategy, tax financed:

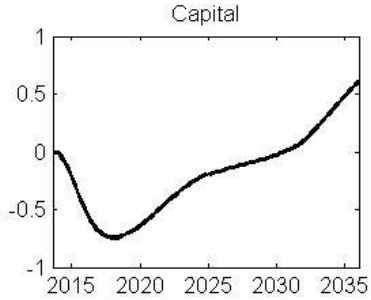


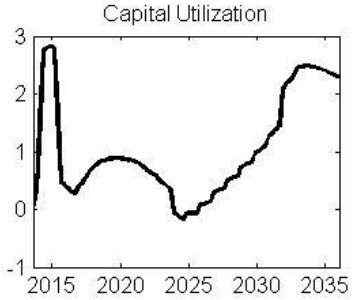


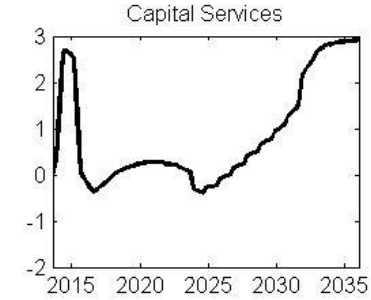

Labor tax rate
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
2015 2020 2025 2030 2035

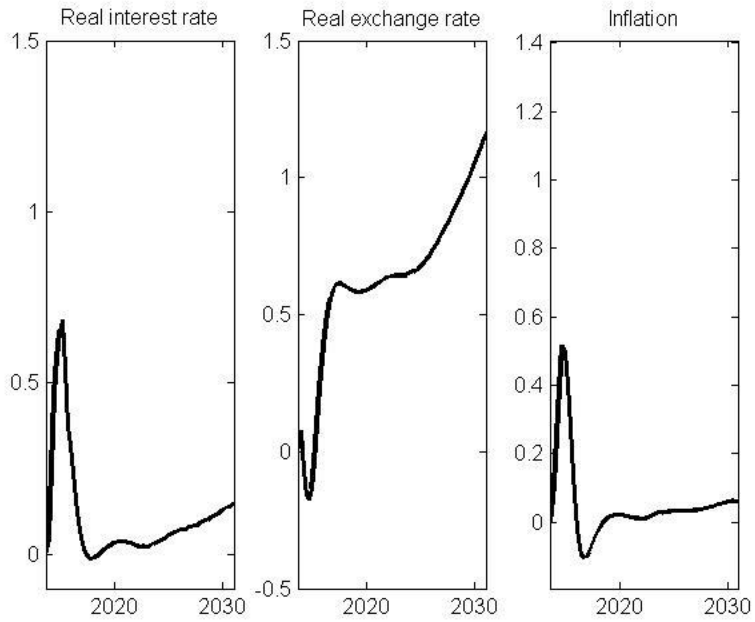
Capital tax rate
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
2015 2020 2025 2030 2035

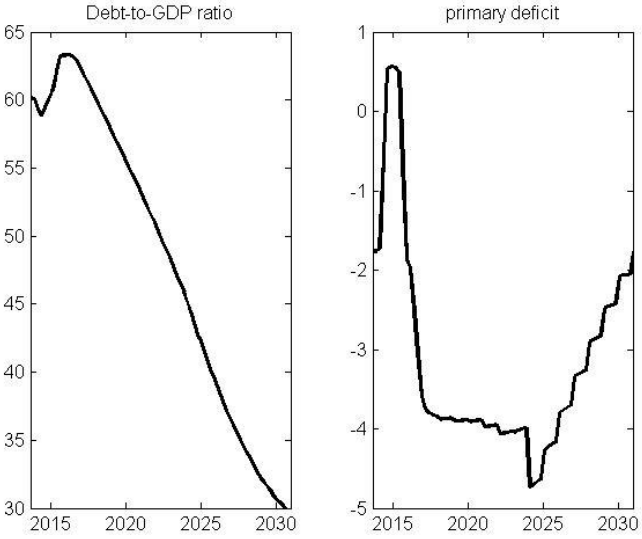

Hours worked
3
2
1
0
-1
2015 2020 2025 2030 2035


Capital
1
0.5
0
-0.5
-1
2015 2020 2025 2030 2035

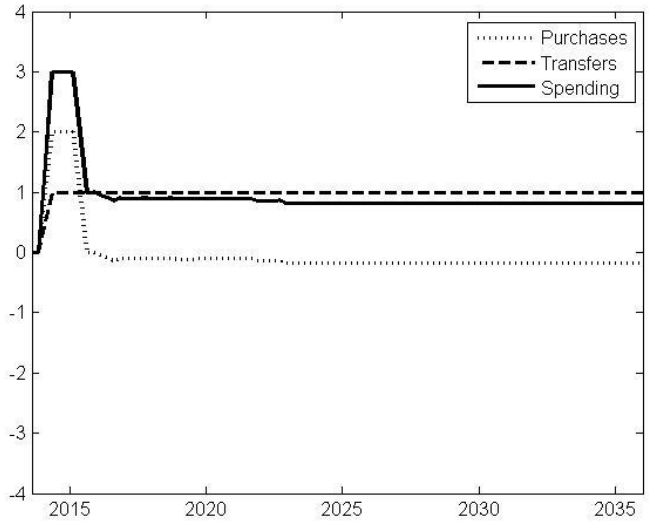

Capital Utilization
3
2
1
0
-1
2015 2020 2025 2030 2035

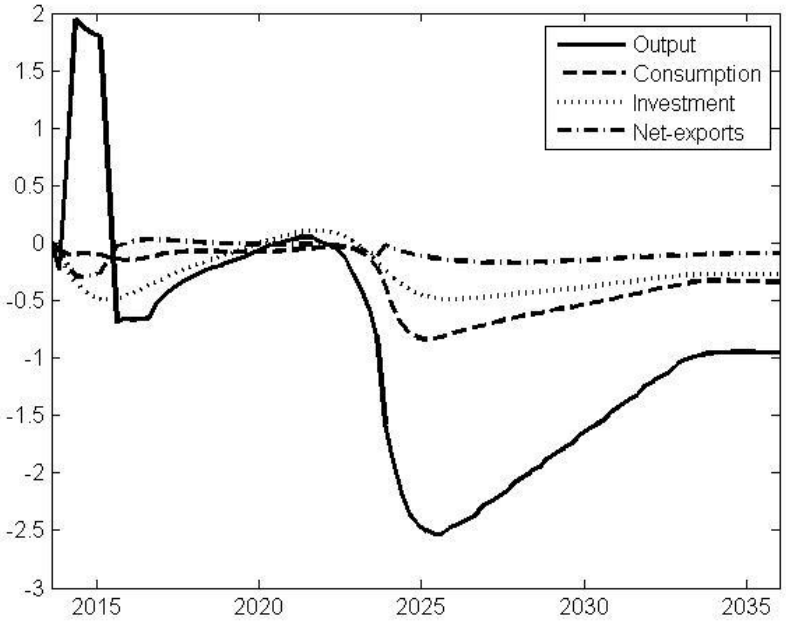

Capital Services
3
2
1
0
-1
-2
2015 2020 2025 2030 2035

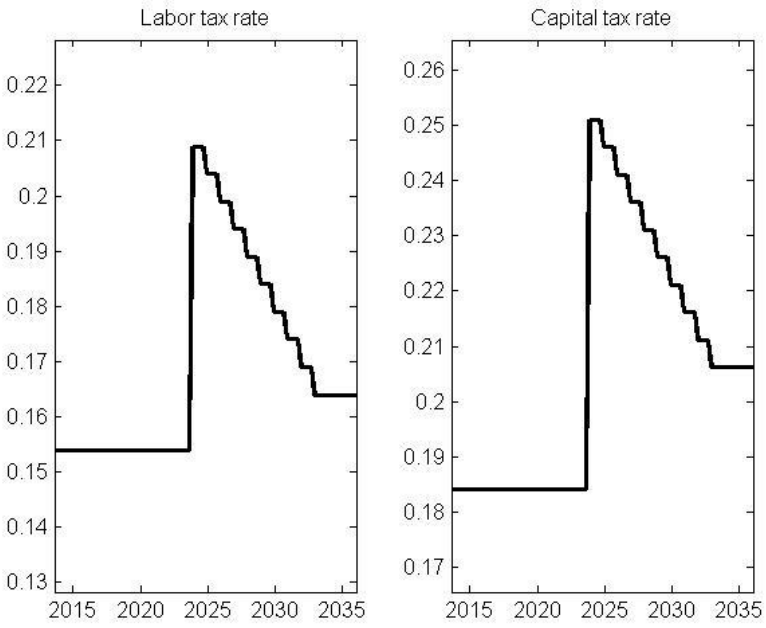

Real interest rate
1.5
1
0.5
0
2020
2030
Real exchange rate
1.5
1
0.5
0
-0.5
2020
2030
Inflation
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2020
2030

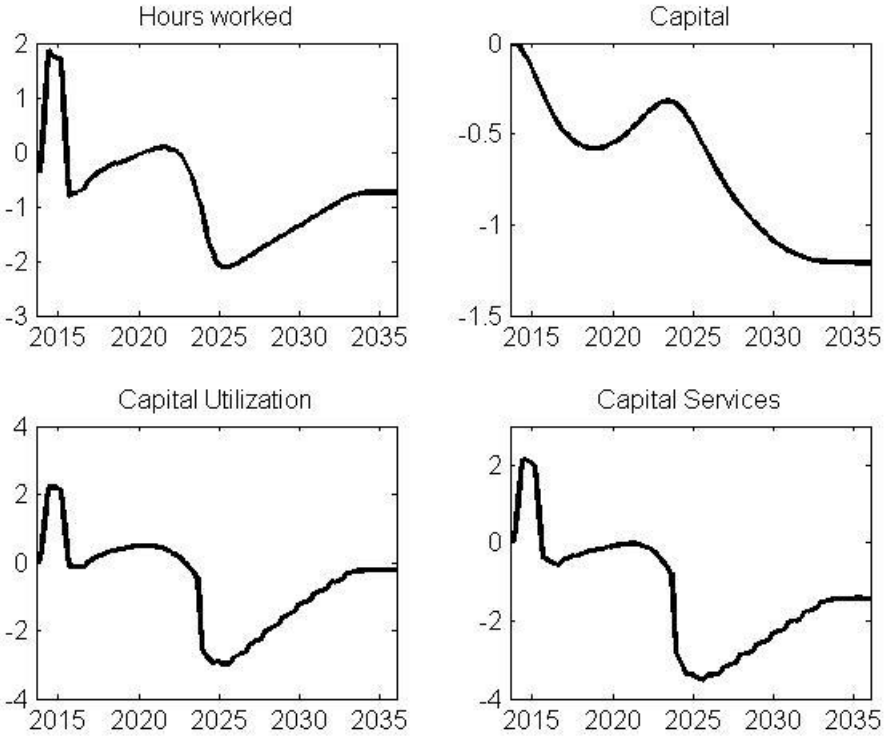

Debt-to-GDP ratio
65
60
55
50
45
40
35
30
2015
2020
2025
2030
primary deficit
1
0
-1
-2
-3
-4
-5
2015
2020
2025
2030

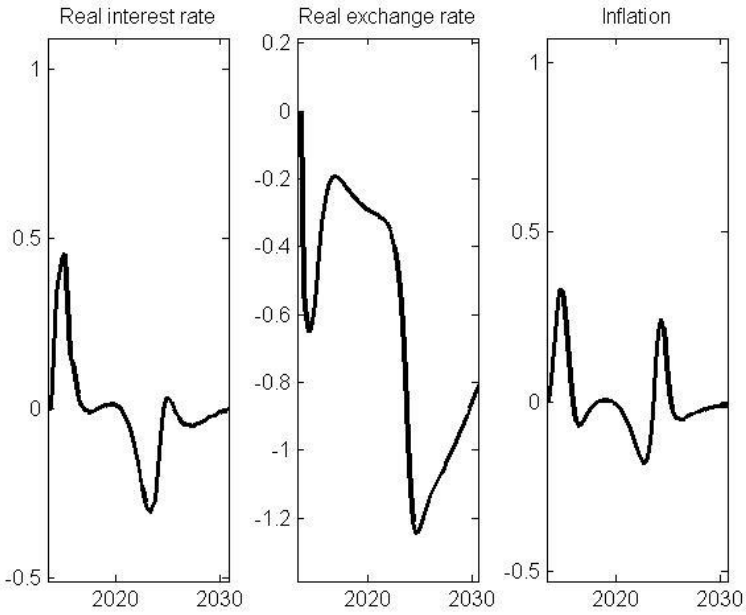
Pure stimulus strategy, tax financed:

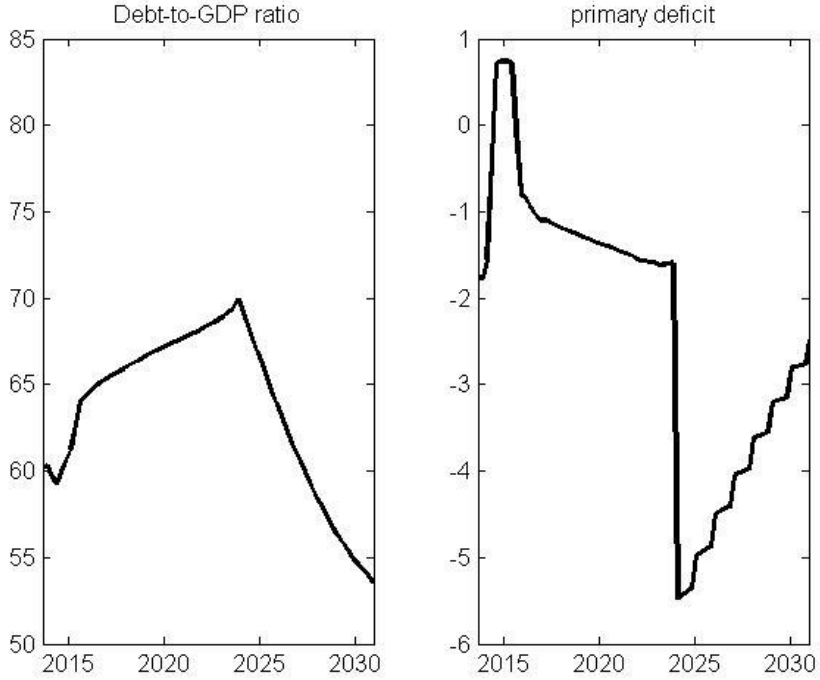




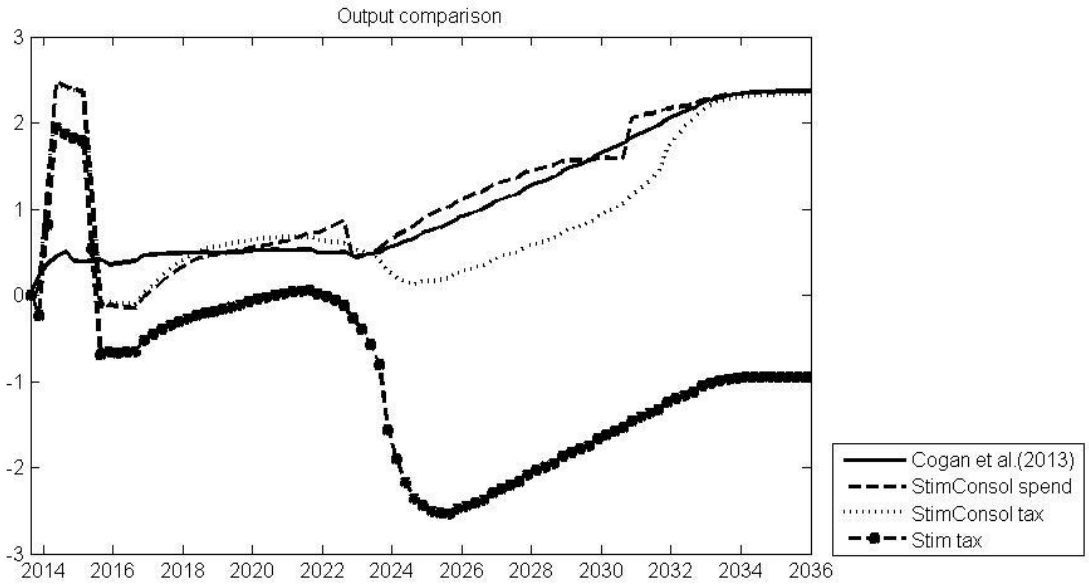

Labor tax rate
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
2015 2020 2025 2030 2035
Capital tax rate
0.26
0.25
0.24
0.23
0.22
0.21
0.2
0.19
0.18
0.17
2015 2020 2025 2030 2035


Hours worked
2
1
0
-1
-2
-3
2015 2020 2025 2030 2035
Capital
0
-0.5
-1
-1.5
2015 2020 2025 2030 2035
Capital Utilization
4
2
0
-2
-4
2015 2020 2025 2030 2035
Capital Services
2
0
-2
-4
2015 2020 2025 2030 2035


Real interest rate
1
0.5
0
-0.5
2020
2030
Real exchange rate
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
2020
2030
Inflation
1
0.5
0
-0.5
2020
2030


Debt-to-GDP ratio
85
80
75
70
65
60
55
50
2015
2020
2025
2030
primary deficit
1
0
-1
-2
-3
-4
-5
-6
2015
2020
2025
2030

Output comparison, all strategies:



Output data for above graph:

Date	Cogan consol Output	StimConsol Spend	StimConsol Tax	Stim Tax
2013.6	0	0	0	0
2013.9	0.22	0.082	0.0552	-0.2353
2014.1	0.3603	1.2756	1.2429	0.8186
2014.4	0.4521	2.4698	2.44	1.9486
2014.6	0.5079	2.4207	2.3986	1.8718
2014.9	0.3977	2.3825	2.3704	1.8189
2015.1	0.3931	2.3658	2.3643	1.791
2015.4	0.3969	1.11	1.1188	0.5408
2015.6	0.4091	-0.139	-0.1206	-0.692
2015.9	0.356	-0.1108	-0.0836	-0.6597
2016.1	0.3676	-0.1288	-0.0938	-0.6687
2016.4	0.3818	-0.1402	-0.098	-0.6638
2016.6	0.3958	-0.1498	-0.101	-0.6528
2016.9	0.4654	-0.0215	0.0335	-0.5199
2017.1	0.4721	0.0615	0.1222	-0.4545
2017.4	0.4793	0.1515	0.2178	-0.3965
2017.6	0.4866	0.2376	0.3094	-0.3464
2017.9	0.4858	0.3054	0.3823	-0.3092
2018.1	0.4908	0.3659	0.4478	-0.2718
2018.4	0.4959	0.4139	0.5003	-0.2387

2018.6	0.5007	0.4508	0.541	-0.2087
2018.9	0.4916	0.4652	0.5583	-0.1926
2019.1	0.4945	0.4855	0.5802	-0.1657
2019.4	0.4983	0.5028	0.5973	-0.1394
2019.6	0.5026	0.5186	0.6107	-0.1131
2019.9	0.5161	0.5434	0.6301	-0.0761
2020.1	0.5195	0.5594	0.6371	-0.0499
2020.4	0.5236	0.5784	0.643	-0.0243
2020.6	0.5275	0.6005	0.6472	-0.0001
2020.9	0.5248	0.6204	0.6434	0.0195
2021.1	0.5248	0.6477	0.6411	0.0371
2021.4	0.5266	0.682	0.6392	0.0488
2021.6	0.529	0.7221	0.6365	0.0522
2021.9	0.4915	0.7267	0.5922	0.0085
2022.1	0.491	0.7712	0.5829	-0.0144
2022.4	0.4933	0.8191	0.5742	-0.0558
2022.6	0.4986	0.8656	0.5658	-0.1206
2022.9	0.452	0.4194	0.502	-0.2688
2023.1	0.4621	0.4468	0.4906	-0.3991
2023.4	0.4758	0.4848	0.4769	-0.5746
2023.6	0.4951	0.5342	0.4601	-0.8081
2023.9	0.5547	0.6257	0.4583	-1.5667
2024.1	0.5883	0.6896	0.4317	-1.9007
2024.4	0.6206	0.7481	0.4147	-2.1698
2024.6	0.653	0.8019	0.4094	-2.3616
2024.9	0.7205	0.8861	0.4479	-2.4435
2025.1	0.7587	0.9371	0.4631	-2.5059
2025.4	0.7934	0.9814	0.4785	-2.5327
2025.6	0.827	1.022	0.4954	-2.5341
2025.9	0.8947	1.0948	0.5482	-2.4786
2026.1	0.9332	1.137	0.5735	-2.4469
2026.4	0.9683	1.1744	0.5967	-2.4119
2026.6	1.0023	1.2095	0.6202	-2.3738
2026.9	1.0702	1.2771	0.6786	-2.2941
2027.1	1.1096	1.3147	0.7095	-2.2476
2027.4	1.1455	1.347	0.738	-2.2043
2027.6	1.1806	1.3763	0.7664	-2.1621
2027.9	1.2494	1.4367	0.8291	-2.0816
2028.1	1.2901	1.4657	0.8645	-2.0353
2028.4	1.3277	1.4878	0.8975	-1.993
2028.6	1.3645	1.5049	0.9305	-1.9522
2028.9	1.4349	1.5509	0.9978	-1.8735
2029.1	1.4776	1.5641	1.0386	-1.8282
2029.4	1.5174	1.5688	1.0776	-1.7865
2029.6	1.5565	1.5678	1.1173	-1.7458

2029.9	1.6289	1.596	1.1919	-1.6674
2030.1	1.6741	1.5936	1.2413	-1.6215
2030.4	1.7163	1.5881	1.2898	-1.5788
2030.6	1.7577	1.5866	1.3404	-1.537
2030.9	1.832	2.0608	1.4269	-1.4579
2031.1	1.879	2.0904	1.4906	-1.4109
2031.4	1.9226	2.1091	1.5567	-1.3676
2031.6	1.9649	2.1205	1.6303	-1.3256
2031.9	2.0388	2.1621	1.7614	-1.2476
2032.1	2.0848	2.1778	1.8634	-1.2023
2032.4	2.1261	2.193	1.9489	-1.1621
2032.6	2.1643	2.2103	2.0197	-1.125
2032.9	2.2319	2.2621	2.111	-1.0544
2033.1	2.2692	2.2875	2.1661	-1.0191
2033.4	2.2981	2.3081	2.2092	-0.9924
2033.6	2.3194	2.3236	2.2421	-0.9739
2033.9	2.3344	2.3348	2.2669	-0.9619
2034.1	2.345	2.3429	2.2856	-0.9548
2034.4	2.3526	2.3489	2.2999	-0.9509
2034.6	2.3581	2.3536	2.3109	-0.9492
2034.9	2.3625	2.3576	2.3196	-0.9489
2035.1	2.366	2.361	2.3265	-0.9495
2035.4	2.3692	2.3642	2.3322	-0.9505
2035.6	2.3721	2.3672	2.3369	-0.9517
2035.9	2.3748	2.3701	2.341	-0.9531
2036.1	2.3775	2.3729	2.3447	-0.9544

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