On the Assessment of Economic Cost in Dynamic Economic Models

Preliminary Notes

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Issues

- Economic policy analysis in a dynamic framework involves scenario calculations in which the economy moves from one steady-state equilibrium to another.
- Economic cost can be precisely defined as an equivalent variation in income over the infinite horizon. The provides a well-defined scalar metric of the efficiency cost of a given change.
- The economy is initially on one growth path and then moves to another, inducing changes in consumption levels into the indefinite future. The only appropriate horizon for measuring cost is infinite.
- As Alan Manne has pointed out, measurement of economic effects using values from a truncated model can require many time periods to provide a close approximation to the infinite horizon.

Key ideas of this paper:

1. By applying a multiplicative term representing a geometric sum over an infinite horizon to represent post-terminal effects, it is possible to produce close approximations to infinite horizon equivalent variation, consumption and GDP using a fairly small number of periods.

2. In numerical experiments with a simple Ramsey growth model, discounted consumption (over an infinite horizon) provides a very close approximation for Hicksian EV (over an infinite horizon).

3. For economic shocks of a magnitude comparable to the Kyoto Protocol, there is virtually no difference between EV and the present value change in consumption levels. This is true even in models where the intertemporal elasticities of substitution in demand is as low as 0.25.

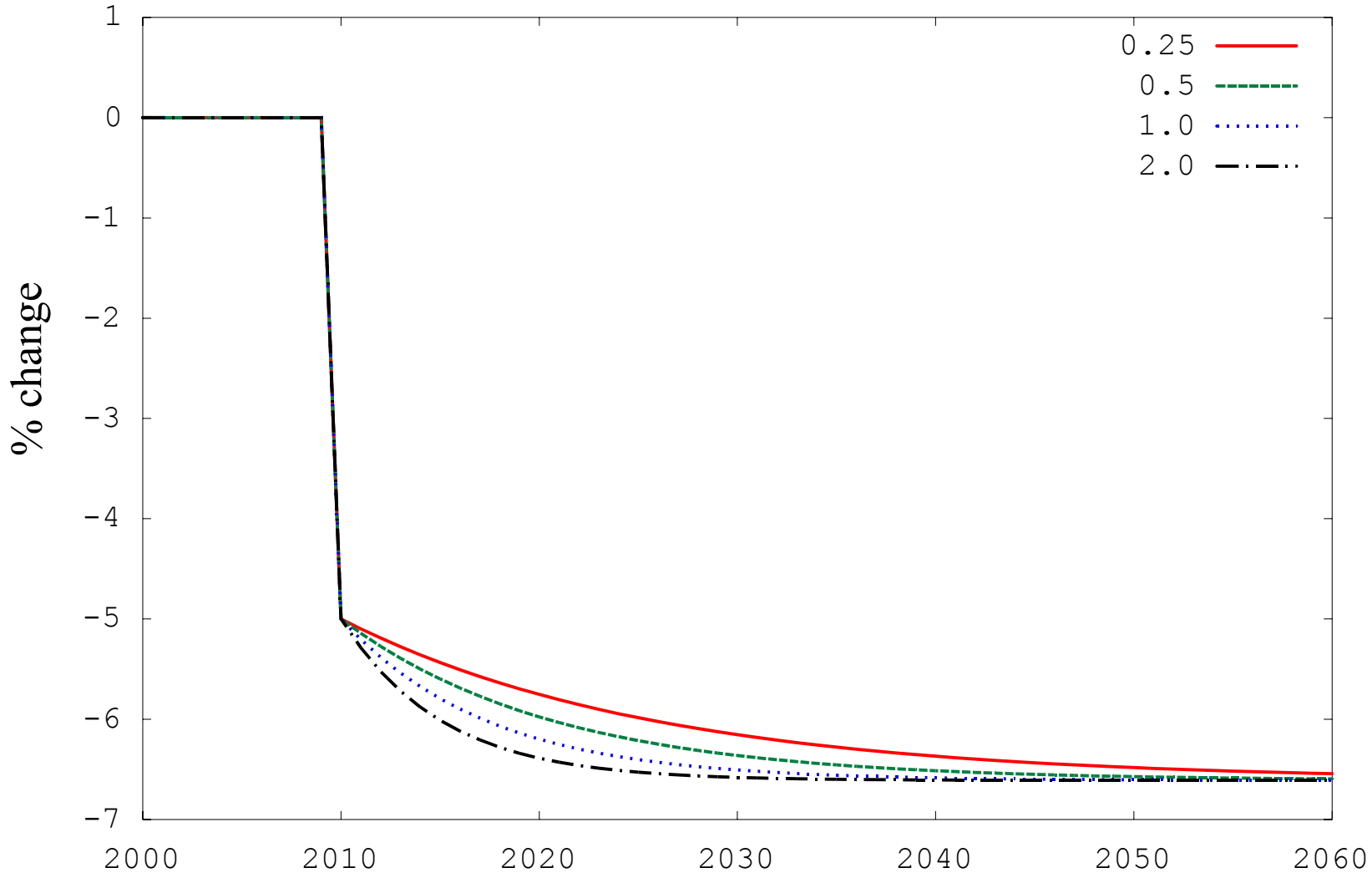
4. Discounted consumption has the virtue of simplicity. When presenting costs to congressional aides, we can avoid subtlties such as cardinal versus ordinal utility. We can instead simply stick to dollars, something to which congress can relate.

5. GDP impacts are not a very good approximation of equivalent variation in income because these depend on induced changes in investment as well as consumption.

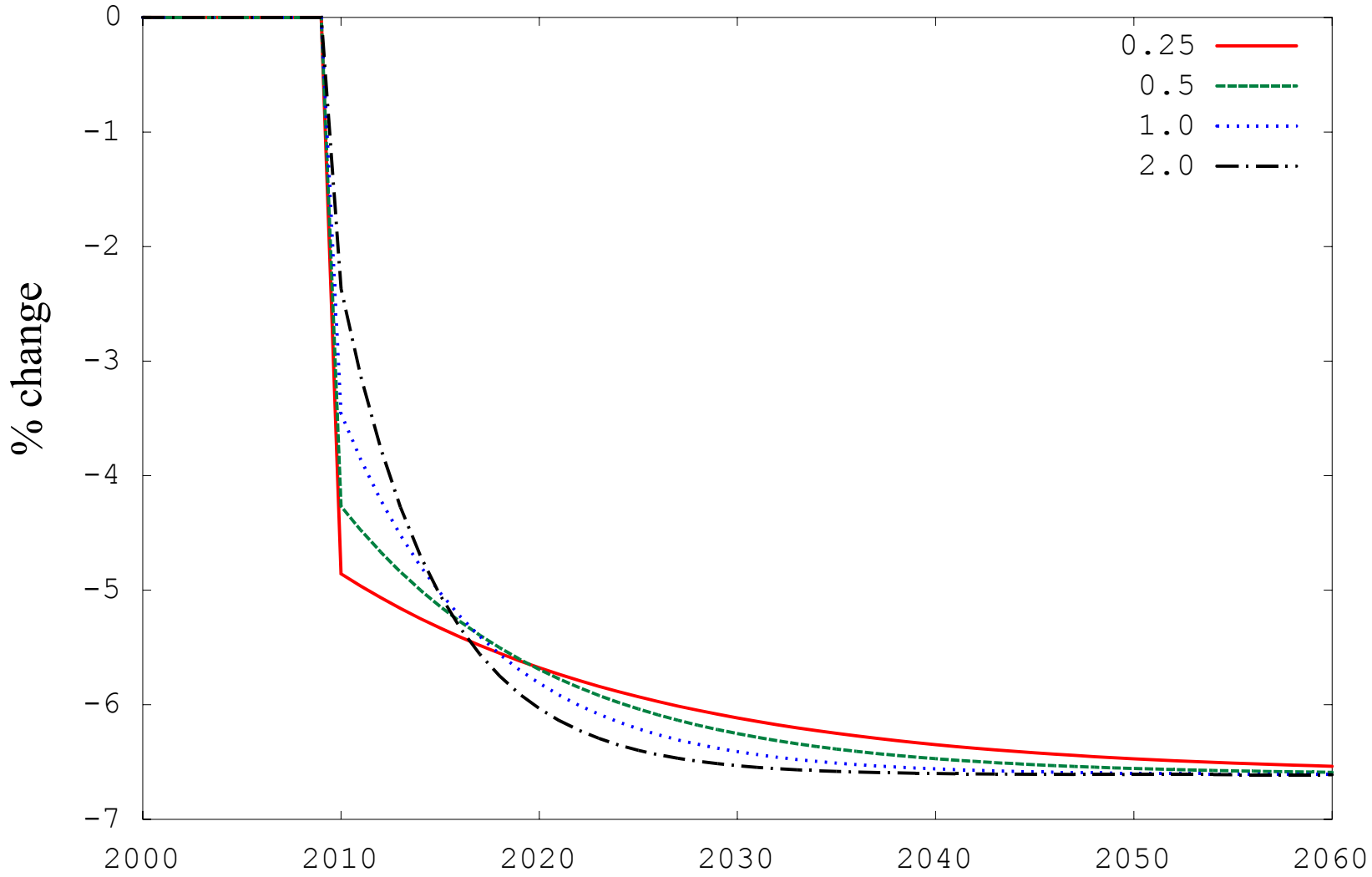
Applying an Economic Shock in a Ramsey Model

- Simple Cobb-Douglas production structure in which capital and labor are combined to produce output.
- Output is either consumed or invested.
- Intertemporal utility is isoelastic.
- A 10% adverse productivity shock occurs in 2010, the 10th year of the model.
- Investment is subject to an upper bound at the baseline level. This upper bound prevents consumption and GDP *increases* during the ten years prior to the adverse shock.
- Future consumption becomes relatively expensive, so a higher elasticity of intertemporal substitution cause a larger shift in consumption from the future to the present.

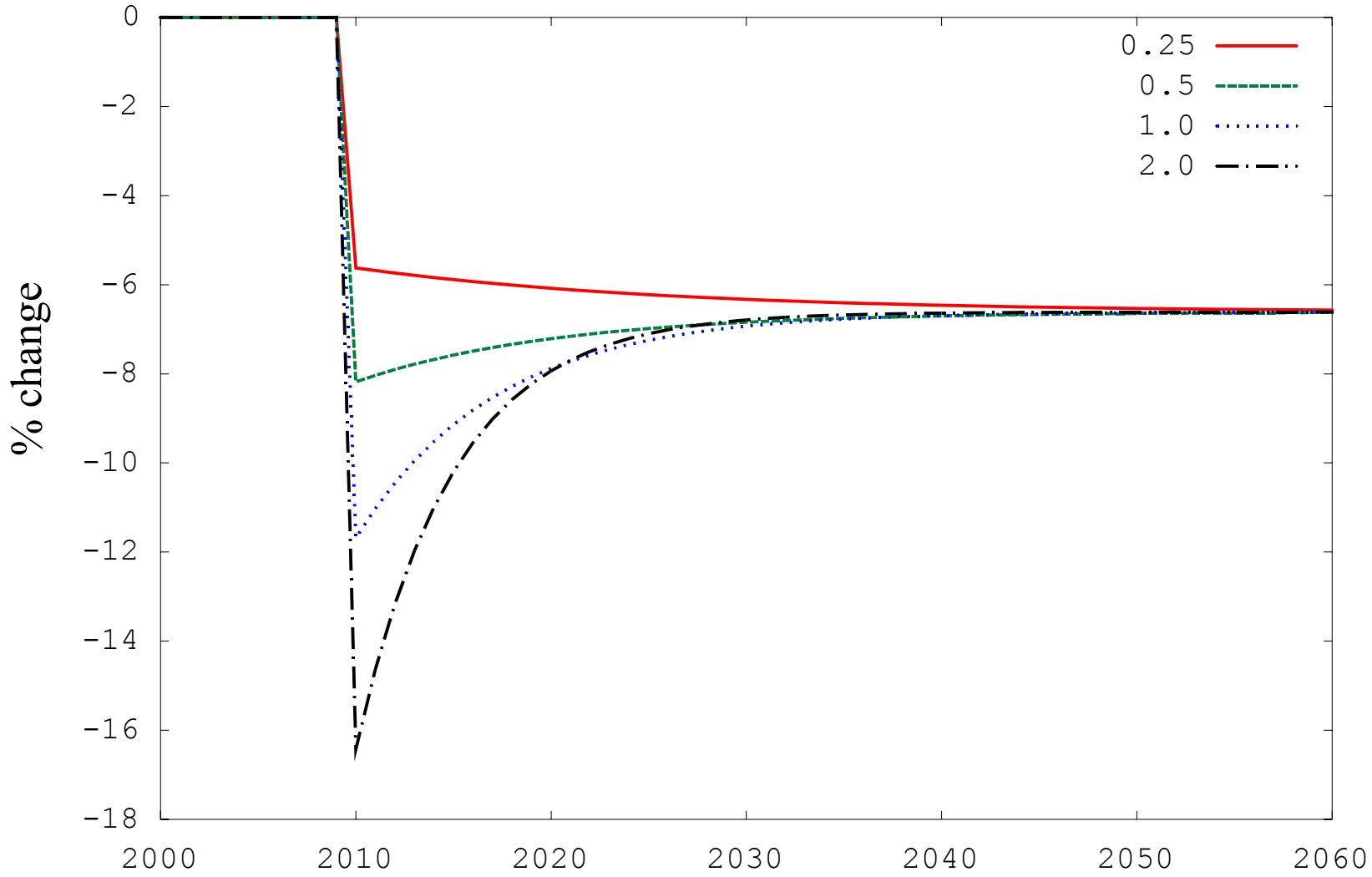
GDP Impacts -- Alternative σ_T



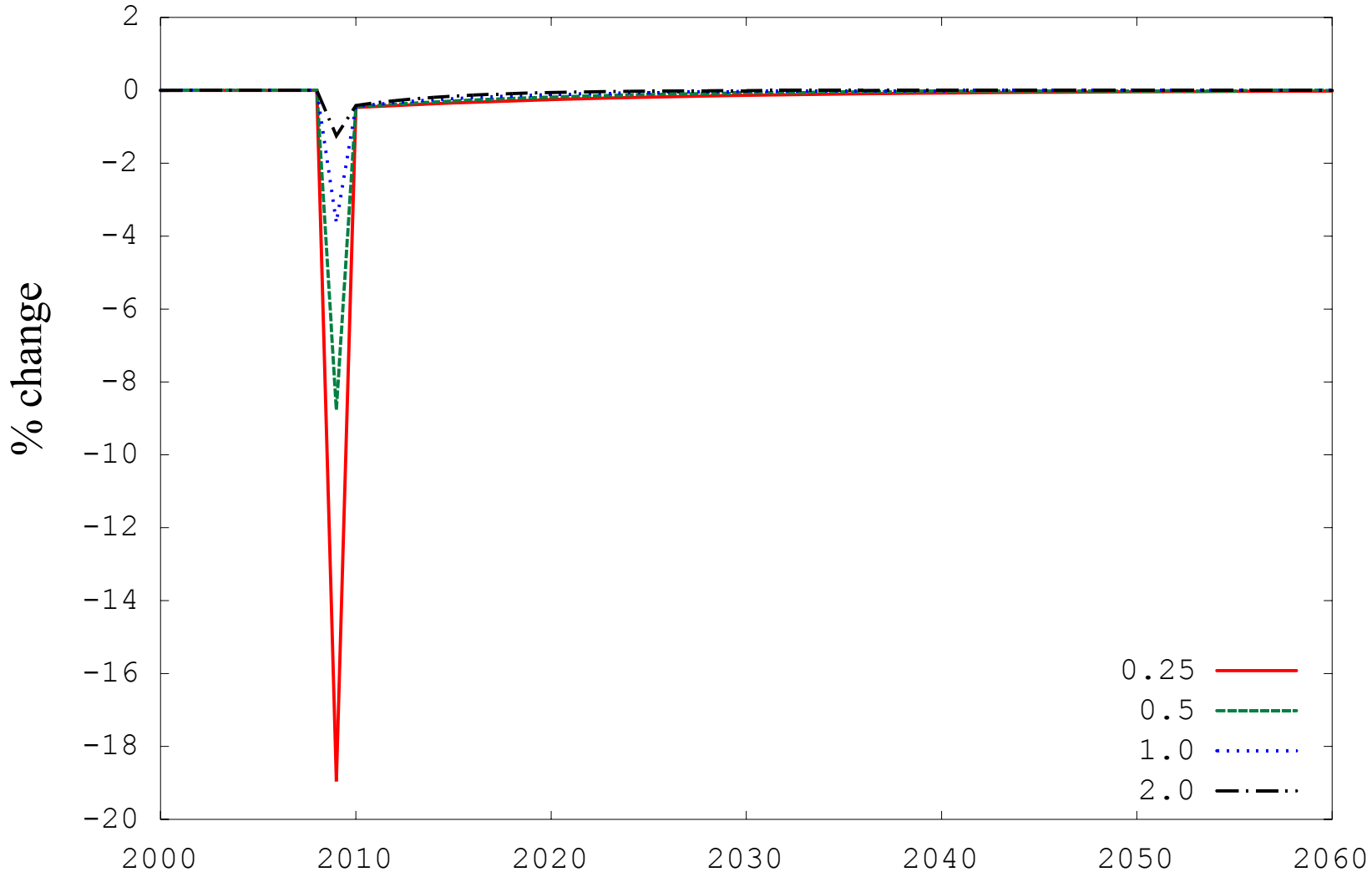
Consumption – Alternative σ_T



Investment – Alternative σ_T



Interest Rate Impacts – Alternative σ_T



Alternative Measures of Economic Cost

- The following slide compares alternative scalar metrics of economic cost.
- The horizon axis measures the hypothetical time horizon. While all calculations are based on results from a 200-year model, and we use these values as though they were provided by a model truncated at year T
- This analysis does *not* compare alternative methods of producing a finite horizon approximation of the infinite horizon equlibrium growth path. Instead we ask: what is the closest estimate of economic cost which could be obtained from a model with horizon *T* if that model where to precisely represent the 200-year equilibrium growth path.

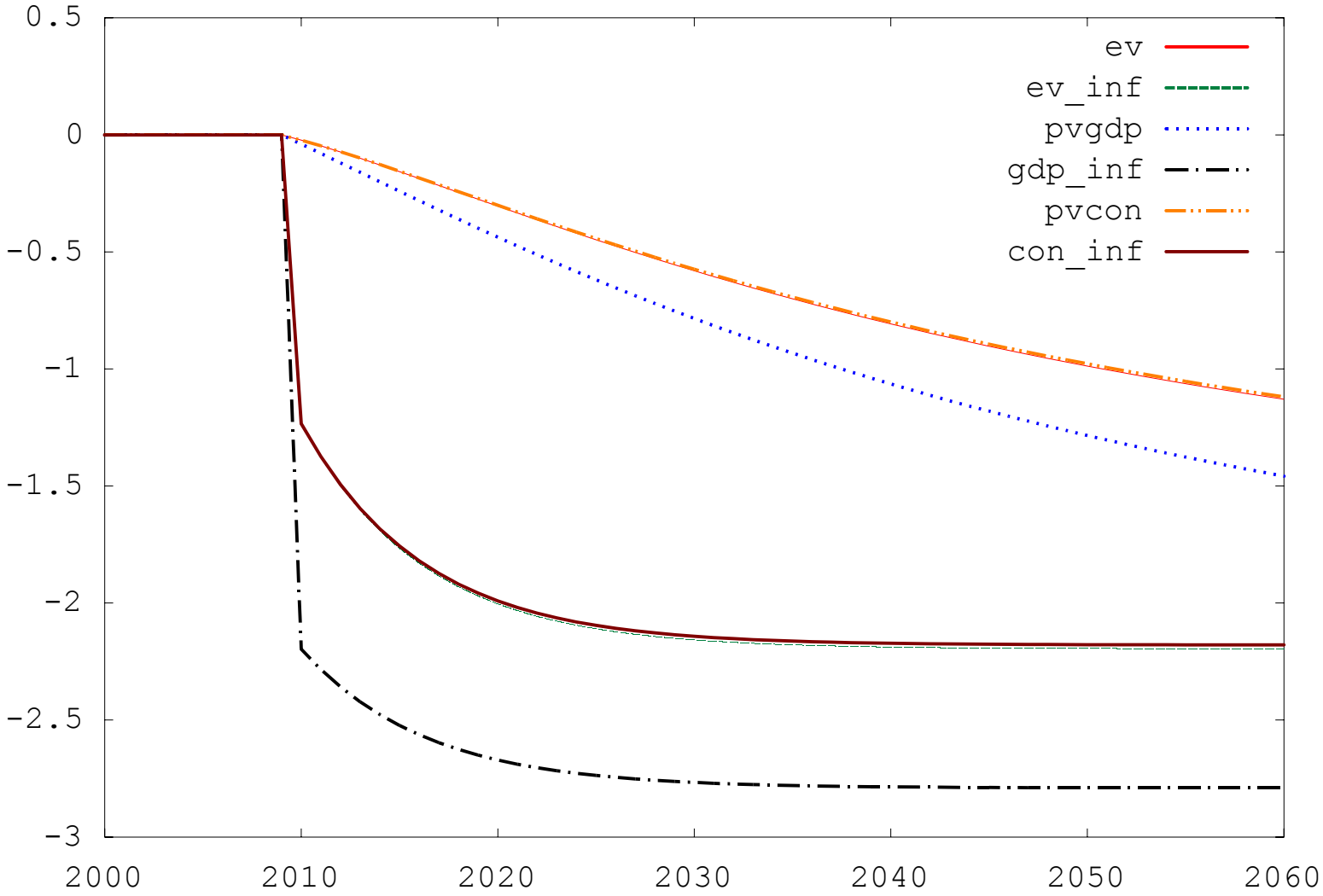
Alternative Measures of Economic Cost:

- **ev** relates the equivalent variation in income based on consumption changes through a given horizon.
- **ev_inf** presents an approximation to infinite-horizon equivalent variation in income, based on consumption from 2000 to 2000 + T with a geometric summation multiplier applied to the terminal period consumption index.
- **gdp** presents discounted GDP losses from a model truncated a horizon indicated on the horizontal axis.
- **gdp_inf** presents discounted GDP losses for an infinite horizon, based on an model running through a horizon indicated on the horizontal axis and assuming constant steady-state growth thereafter.
- **pvcon** presents the discounted present value of consumption losses from a model truncated at the horizon indicated on the horizon axis (ignoring consumption changes in the post-terminal period)
- **pvcon_inf** presents discounted consumption losses for an infinite horizon, based on a model running through the horizon indicated on the horizontal axis and assuming constant steady-state growth thereafter.

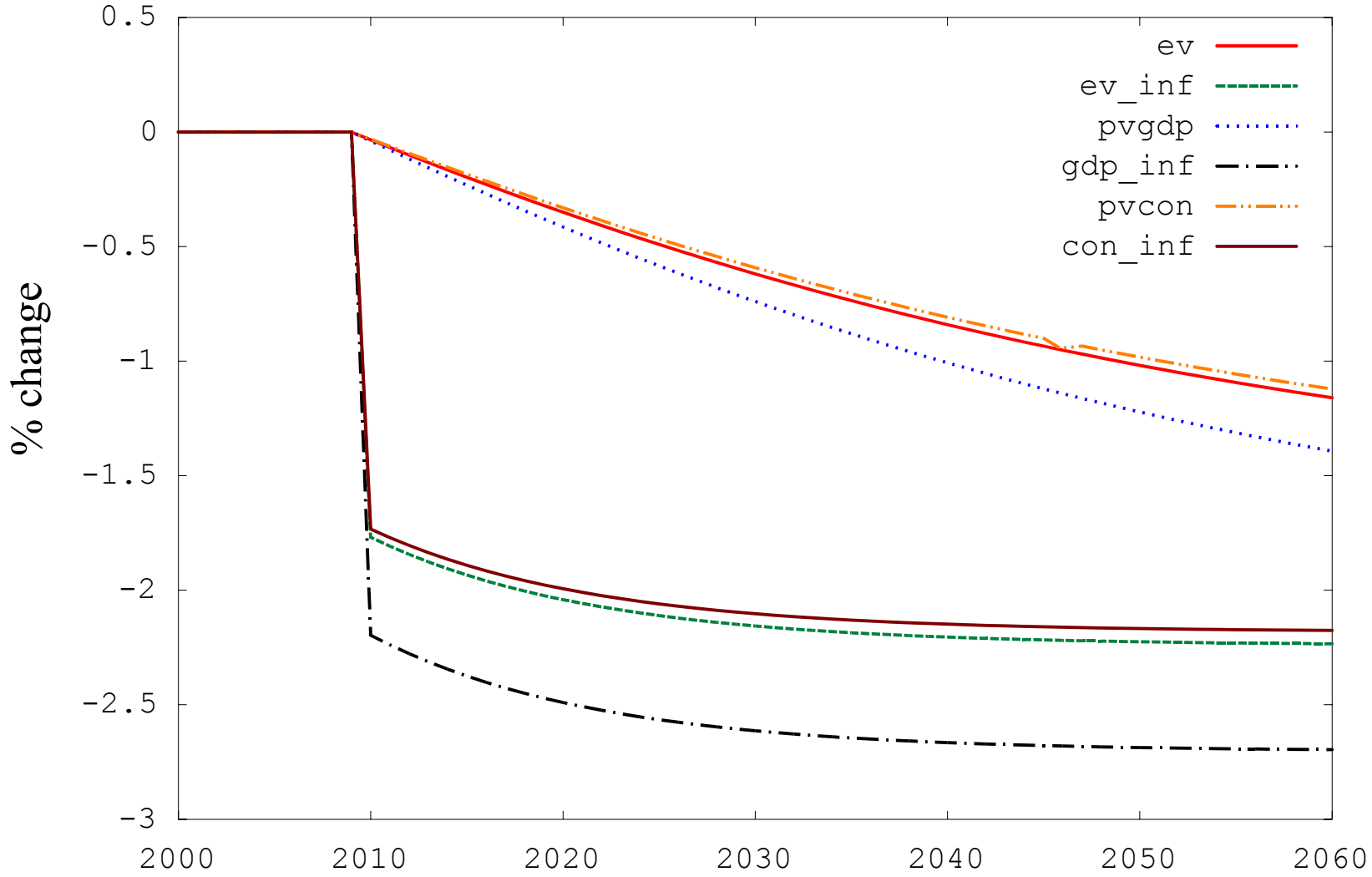
Results:

- When we consider finite horizon results we find that present value consumption losses and equivalent variation in income are virtually identical.
- Likewise, infinite horizon approximations based on discounted consumption and equivalent variation are very close.
- Both infinite horizon consumption and welfare impacts converge quickly to a stationary value, within a period of 25 to 30 years.
- GDP impacts are considerably larger than discounted consumption and equivalent variation in income, both in the truncated, finite-horizon measures and in the infinite horizon approximatinos..
- As would be expected based on a simple indifference curve diagram, when intertemporal elasticities are low (σ_T=0.25), there is a noticible (but small) differenceS between discounted consumption and equivalent variation. When intertemporal elasticities are high (σ_T=2), the EV and the discounted consumption measures are virtually identical.

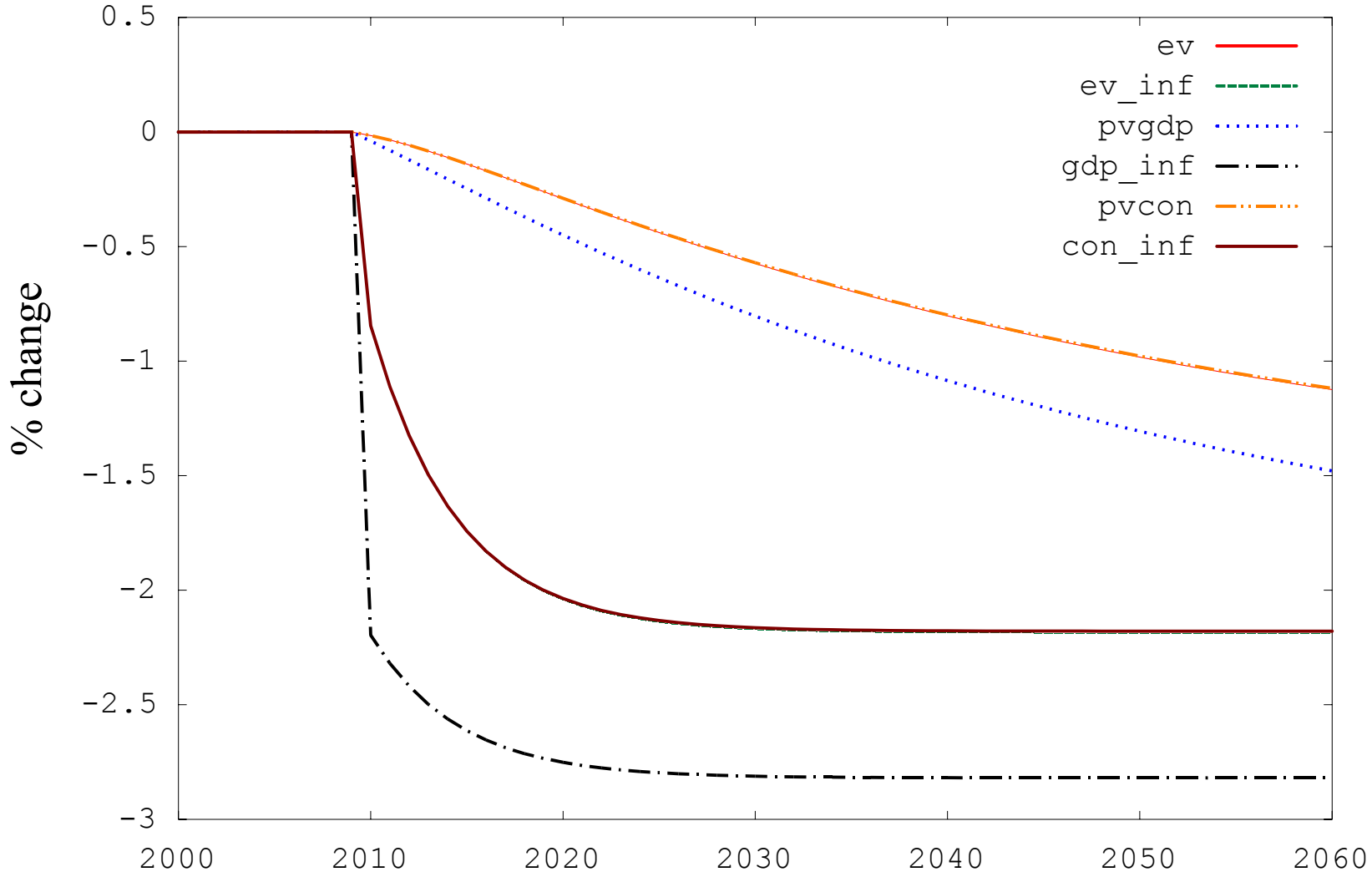
Alternative Measures of Cost – σ_T=1



Alternative Measures of Cost – σ_T=0.25



Alternative Measures of Cost – σ_T=2



A Three Factor Model

- Simple extension of the single-sector Ramsey model:

```
y = f(K,L,E) = C + I + ec  E.
```

- GDP is measured as `y - ec E`
- We consider three alternative specifications for f(K,L,E):
  - Cobb-Douglas

```
f = phi * K**kvs * L**lvs * E**evs
```

  - Merge

```
f = phi * (alpha * K**(rho*kvs) *  L**(rho*(1- kvs))
+ (1-alpha) * E**rho )**(1/rho)
```

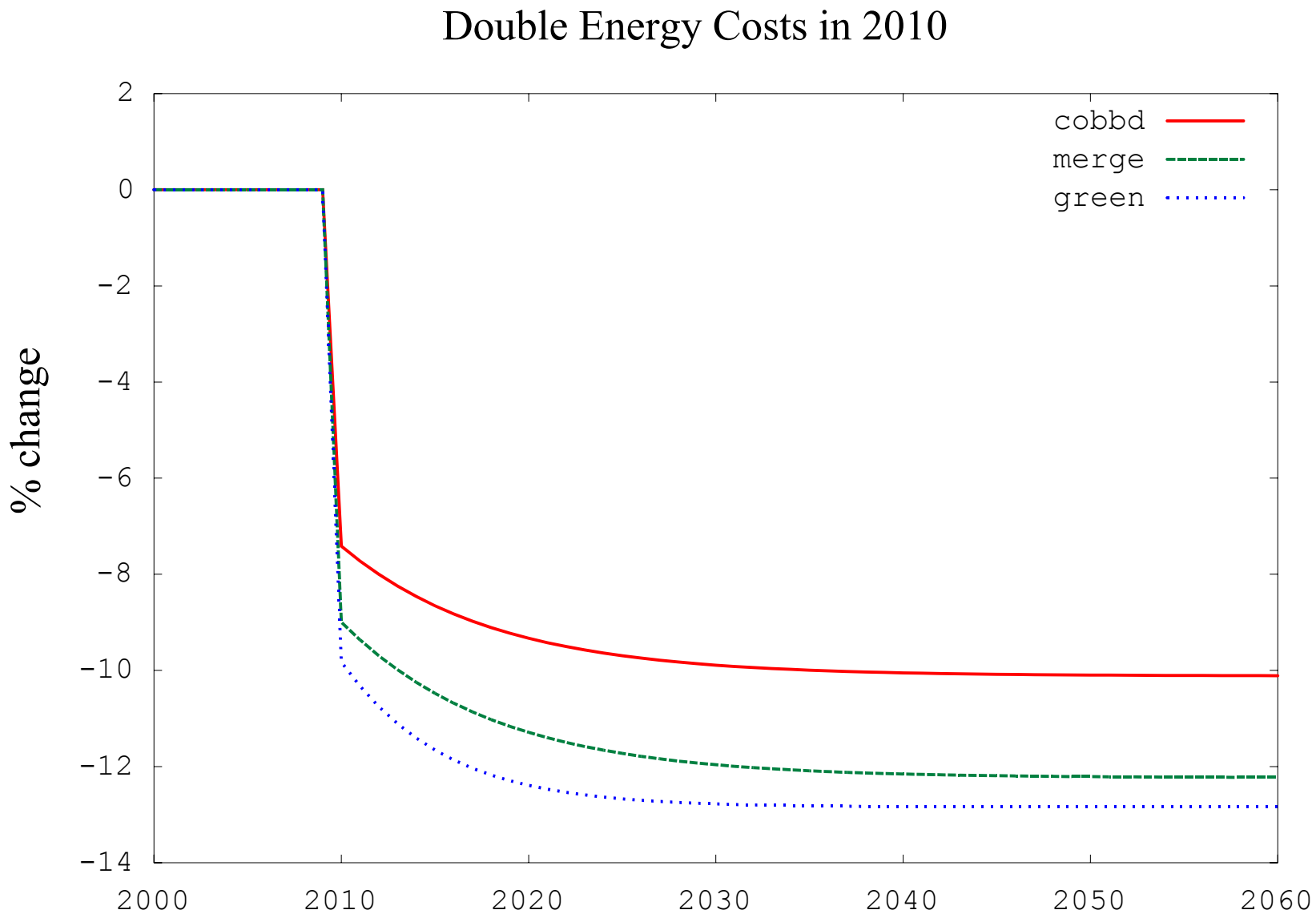
  - Green

```
 f = phi * (L**beta * (beta * K**gamma
+ (1-beta) * E**gamma)**((1-beta)/gamma))**(1/gamma)
```

Economic Shock

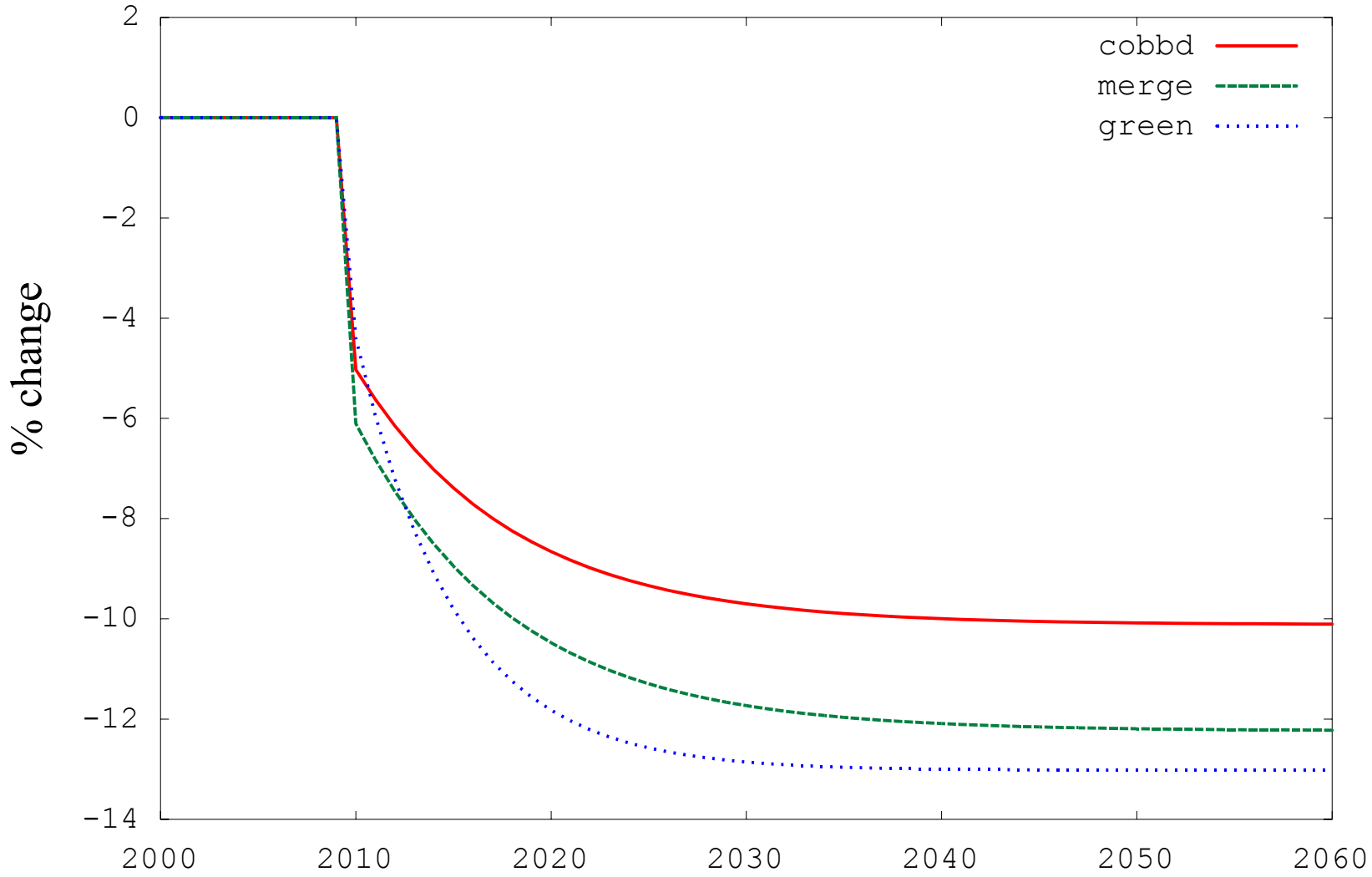
- Doubling of energy costs beginning in 2010
- Upper bound on investment in the first ten years.
- A common intertemporal utility function for all three models with an intertemporal elasticity of substitution equal to unity.
- GDP impacts are largest in the Green model where capital and energy are net complements in production – a decrease in energy demand produces a decrease in the long-run capital stock and investment.
- GDP impacts are larger in the Merge model than in the Cobb-Douglas model because of lower scope for substitution away from energy toward labor and capital.

GDP Impacts in Alternative Models

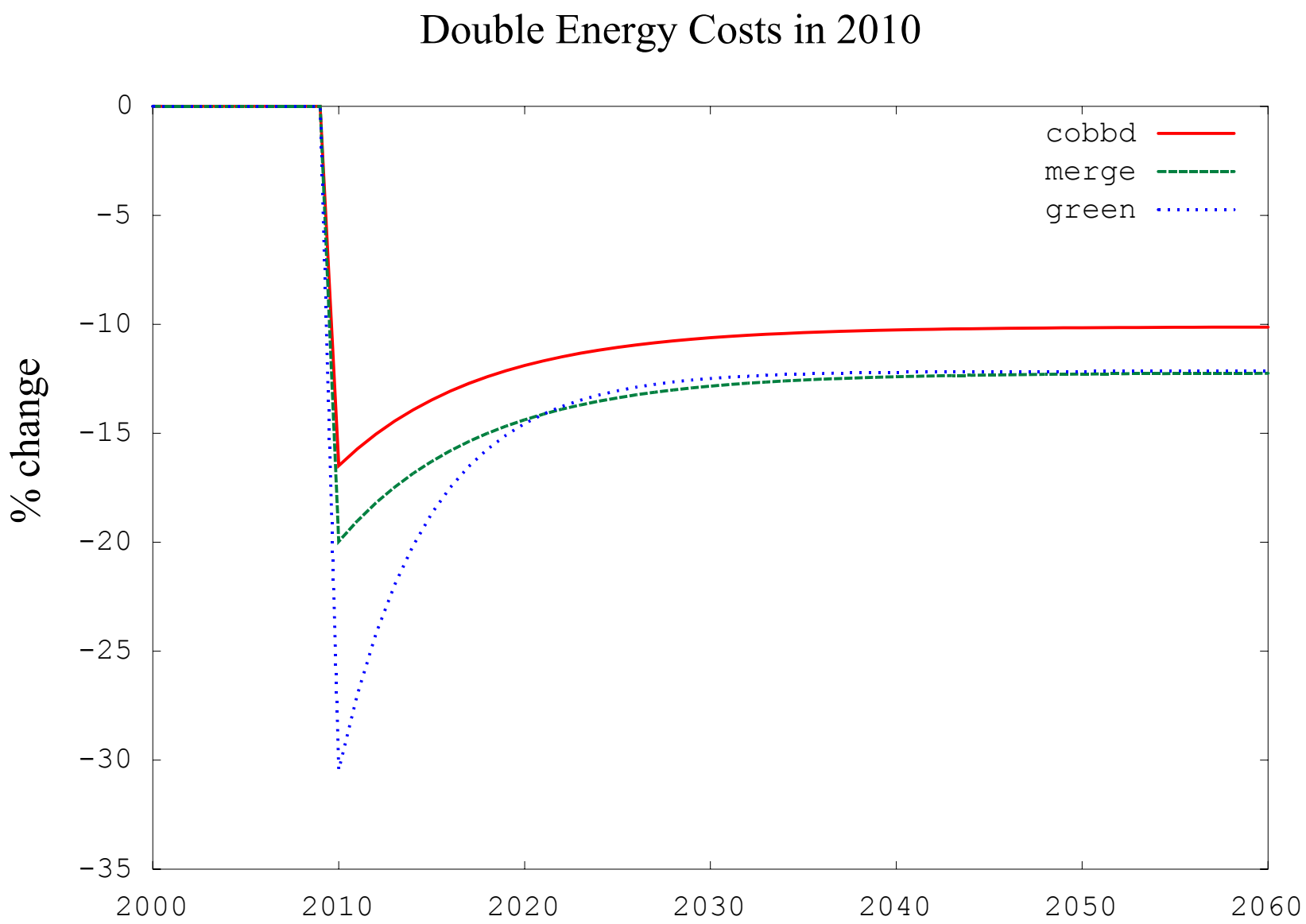


Consumption Impacts in Alternative Models

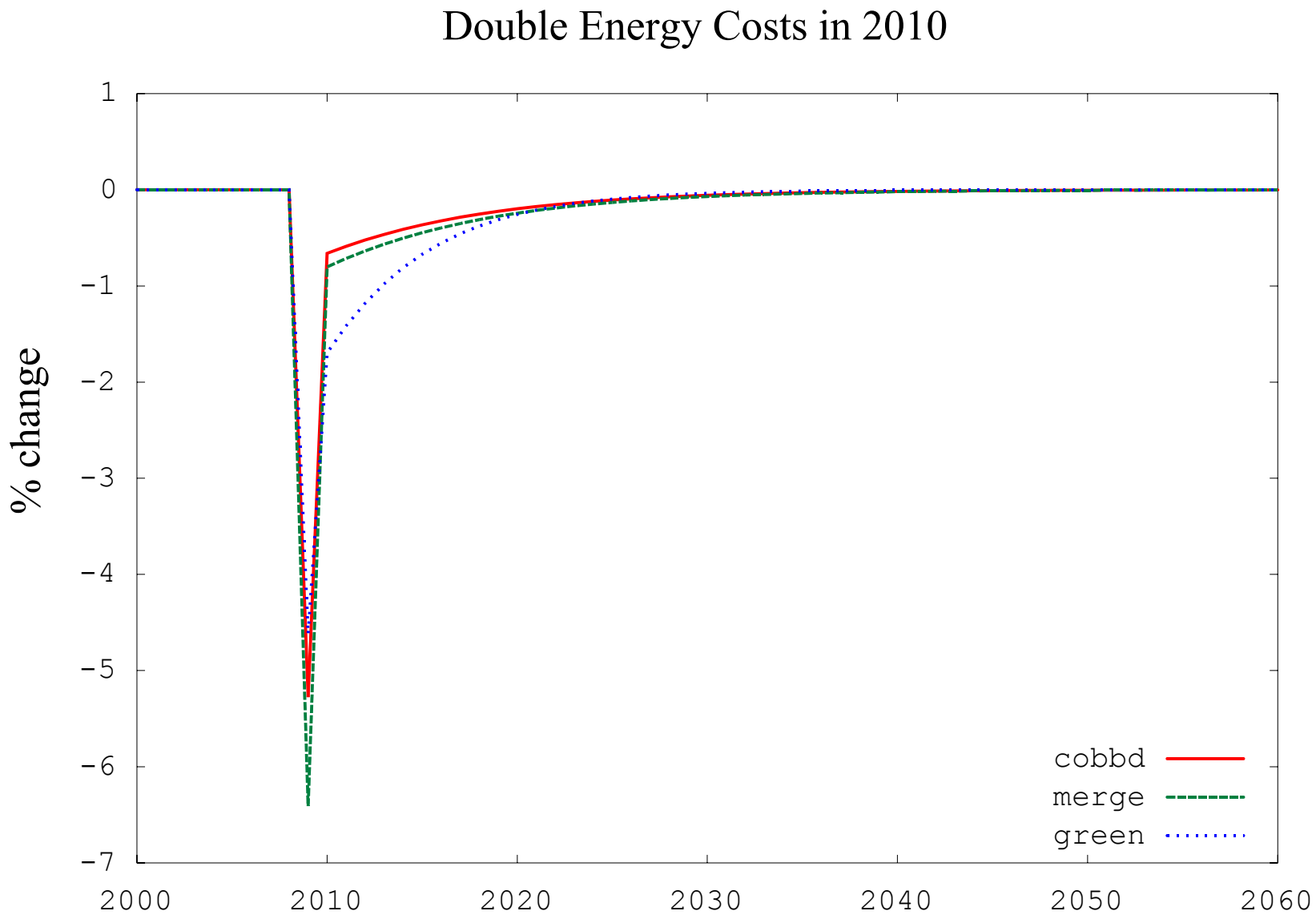
Double Energy Costs in 2010



Investment Impacts in Alternative Models



Interest Rate Impacts in Alternative Models

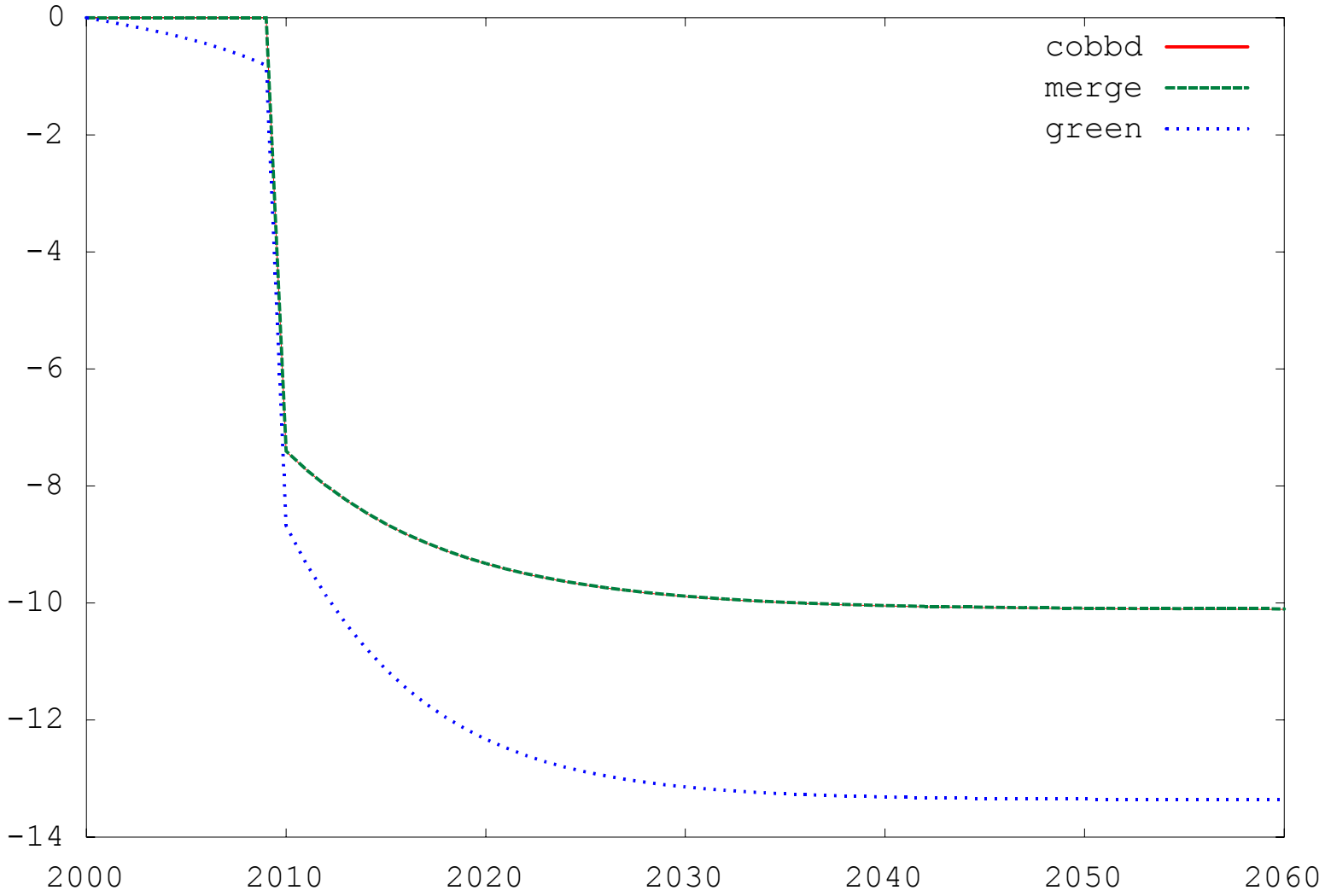


GDP Impacts Depend on Factors other than the Structure of Intertemporal Welfare

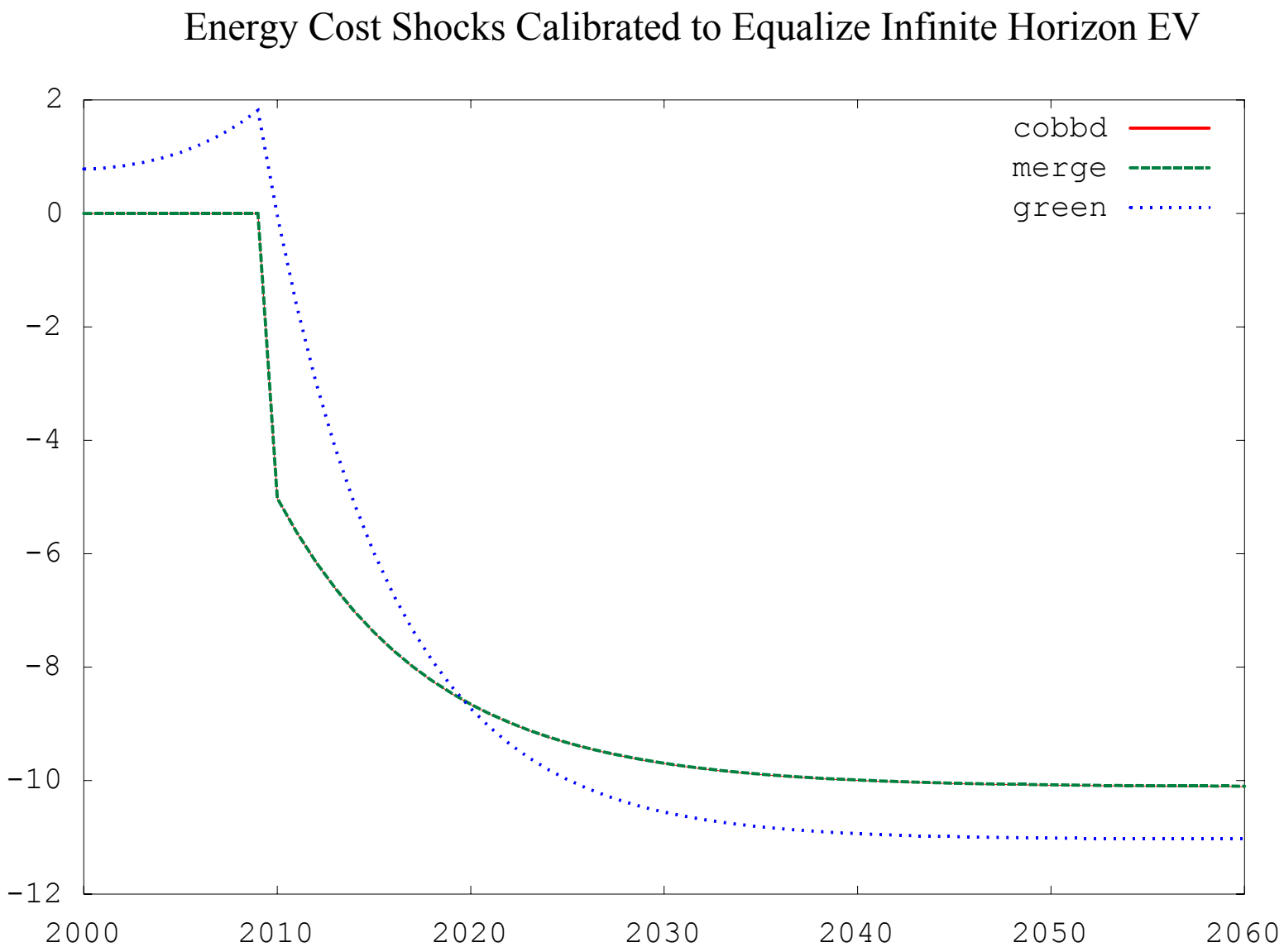
- In the initial experiment we compare results from an identical shock using three alternative production functions. Due to differences in substitution possiblities, we find considerable differences the economic cost of an energy cost increase.
- In order to clearly illustrate differences in the GDP impacts across different models we differentiate energy cost shocks so that the infinite horizon welfare is identical in each model
- The cost increase in the Cobb-Douglas model is set equal to 2 (energy costs are doubled). The cost increase in the Merge and Green models are both set to 1.8. This results in an identical infinite horizon EV.
- In the Green model, an increase in energy costs leads to a decrease in the demand for capital. Investment therefore falls in the early periods and consumption rises. This is distinct from the Cobb-Douglas and Merge models where increased energy cost lead to an increase in the demand for capital as a substitute for energy.

GDP Impacts in Alternative Models

Energy Cost Shocks Calibrated to Equalize Infinite Horizon EV



Consumption Impacts in Alternative Models



Investment Impacts in Alternative Models

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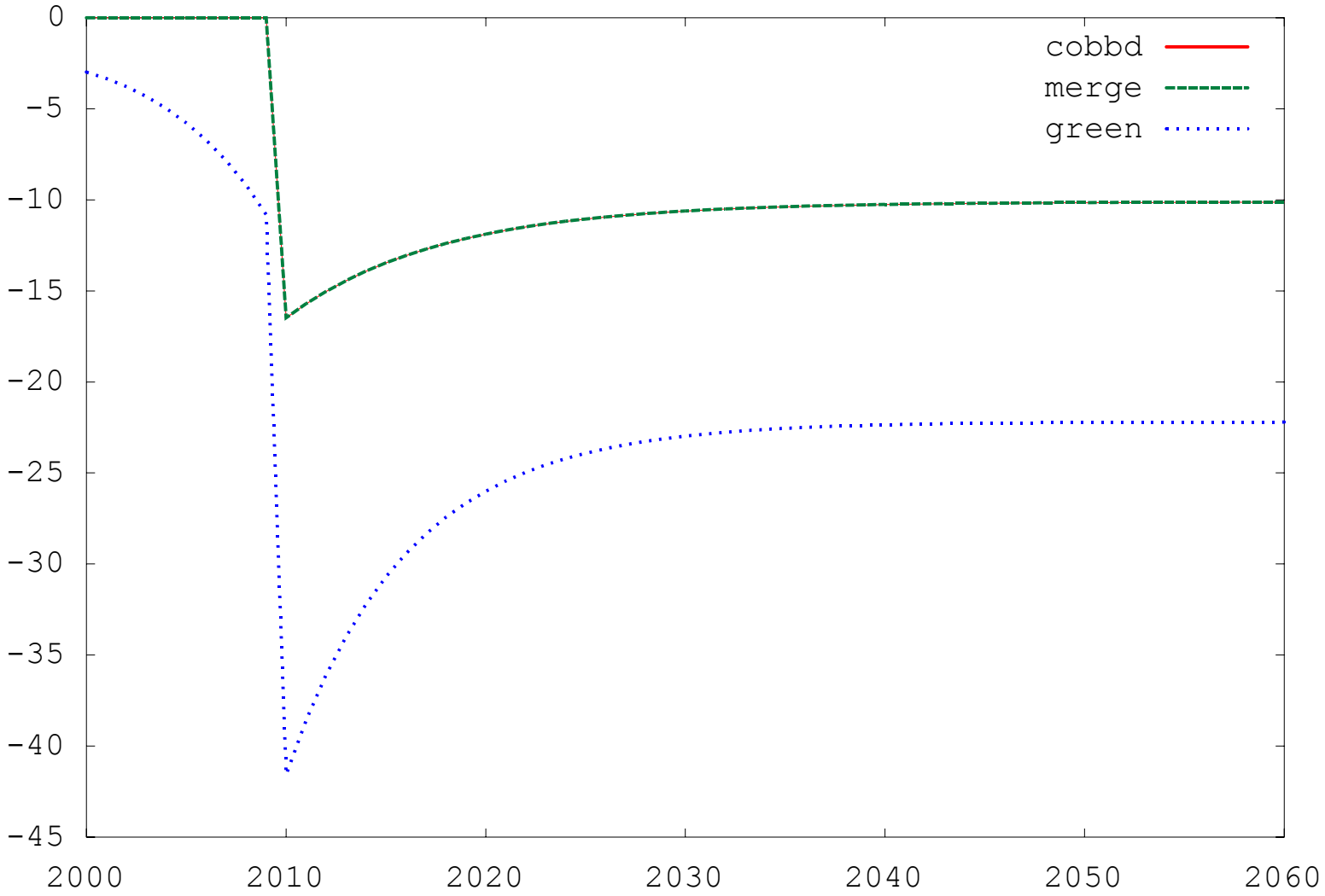

Interest Rate Impacts in Alternative Models

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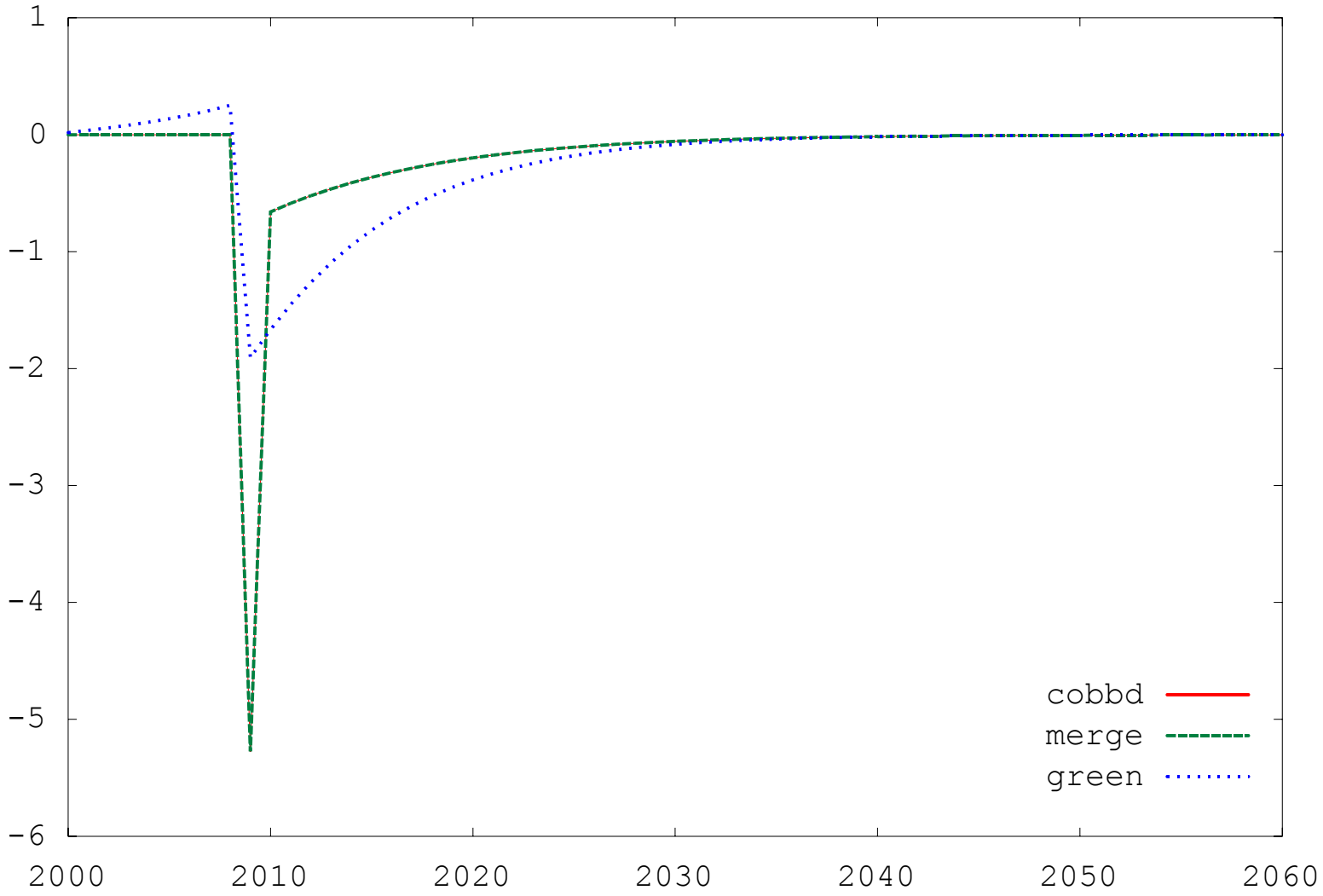
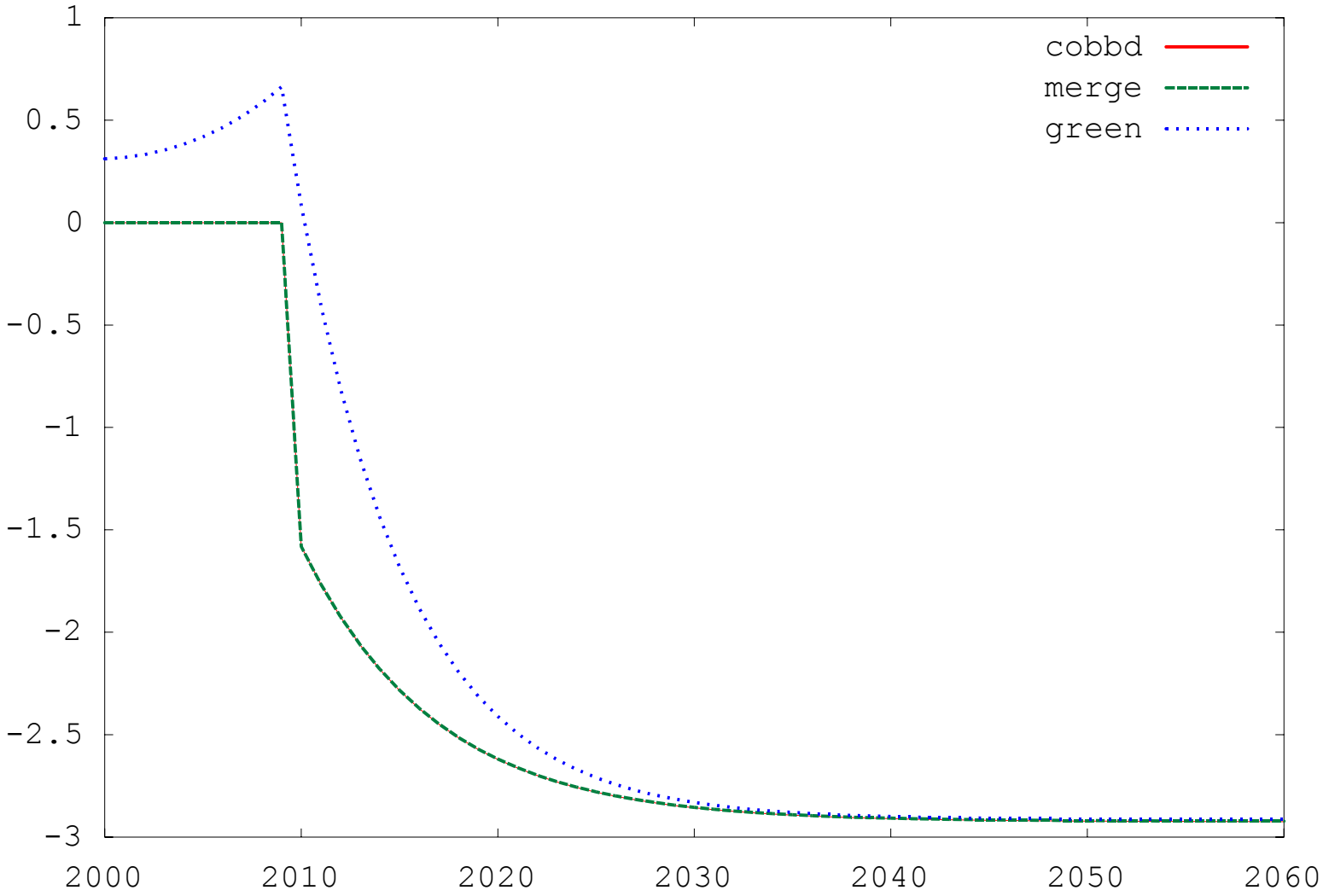


Alternative Welfare Metrics

- In these calculations infinite horizon EV is the same for all three models.
- Consumption rises in the near-term in the Green model.
- Approximations to infinite horizon EV are stable from 2030 onward. The economic shock could therefore be measured in a model with as few as 30 years.

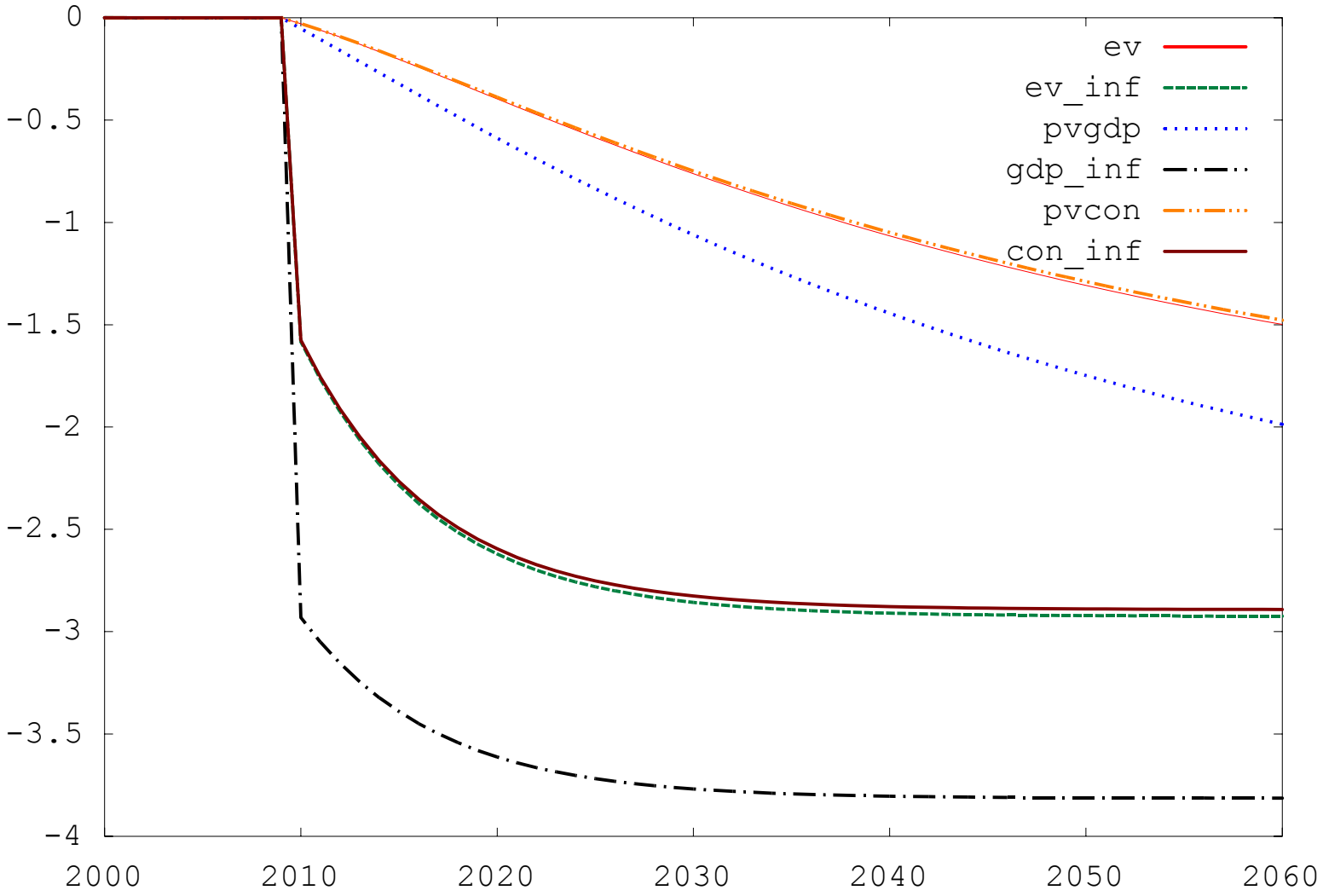
Equivalent Variation Impacts in Alternative Models

Energy Cost Shocks Calibrated to Equalize Infinite Horizon EV

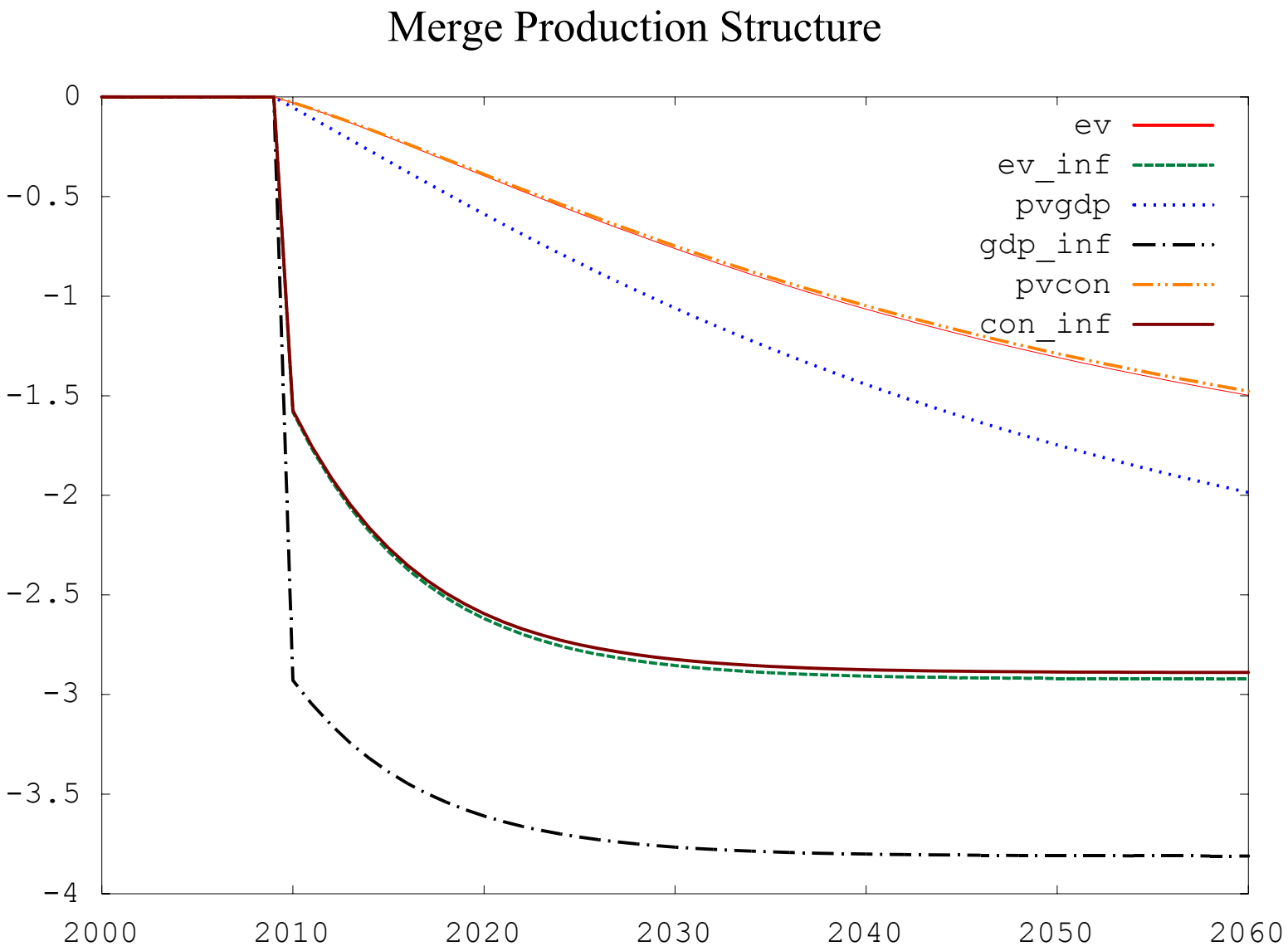


Alternative Measures of Economic Cost

Cobb Douglas Production Structure



Alternative Measures of Economic Cost



Alternative Measures of Economic Cost