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# The macroeconomics of TANSTAAFL

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ABSTRACT

Market imperfections may lead to underinvestment in dynamic general equilibrium models. An interesting but unexplored question is whether policy interventions which attenuate underinvestment gaps necessarily imply that consumption will initially decline. By employing a calibrated version of a standard R&D-based growth model, we show that raising the R&D subsidy rate may not only close the R&D underinvestment gap but also raise consumption per capita at all times ("intertemporal free lunch"). We also discuss the general mechanics of such an intertemporal free lunch in both one-sector and multi-sector growth models and further examples.



## 1. Introduction

The saying *There ain't no such thing as a free lunch*, popularized in economics by Milton Friedman (1975), expresses the insight that every benefit comes at a cost. There is one general exception to this rule. If resources are being used inefficiently, it is possible to get "something for nothing". There are some examples of static free lunches, like the gains from trade when opening up goods market from autarky or efficiency gains after addressing static externalities by policy interventions.

To assess the welfare effects of policy interventions in dynamic models, one must take the entire transition path into account. Comparing steady states only may lead to drastically misleading results, especially if the speed of convergence is low. In addition, it would be interesting to know whether a policy intervention could implement a reallocation of resources in a decentralized economy such that per capita consumption increases for some periods and does not decline for any period. Such a possibility may be referred to as *intertemporal free lunch*.

In a dynamic context, it is natural to focus on an intertemporal free lunch associated with investment distortions. The macroeconomics literature on this issue has dealt with the phenomenon of dynamic inefficiency (e.g. Phelps, 1966; Cass, 1972; Abel et al., 1989). Dynamic inefficiency is typically said to occur when a production factor is *over*accumulated in the sense that less investment into that factor than in market equilibrium would lead to an intertemporal free lunch. For instance, as is well-known, the Solow model exhibits dynamic inefficiency if the saving rate lies above its golden rule level

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such that capital is overaccumulated. In an overlapping-generations context, dynamic inefficiency may result since current generations do not take changes in the future interest rate into account when deciding on their saving rate (Weil, 2008).

By contrast, this paper examines the question whether an intertemporal free lunch is possible if a production factor is *under*accumulated in long run market equilibrium. We explore if a policy intervention in a decentralized economy targeted to increase investment of the underaccumulated factor can lead to a reallocation of resources such that an intertemporal free lunch is realized. To the best of our knowledge, the previous literature has not dealt with this possibility. A priori, one may think that, in a closed economy, higher investment would always imply consumption losses in the short run, even under investment inefficiencies. In fact, if there is a single investment good, higher investment necessarily means lower consumption in the short run (i.e. for given income) in macroeconomic equilibrium.

We employ calibrated versions of the model by Romer (1990), Barro (1974) where growth is fully endogenous, and the semi-endogenous growth model by Jones (1995) to show that an intertemporal free lunch may be possible due to multiple investment possibilities. As first demonstrated by Jones and Williams (2000) in a calibrated version of the semi-endogenous growth model, in the long run, a social planner would like to allocate more resources towards R&D than is the case in decentralized equilibrium. The reason is that positive R&D externalities like an intertemporal knowledge spillover outweigh possible negative R&D externalities under empirically motivated calibrations. We show that, by raising the current R&D subsidy rate in a situation with underinvestment, households immediately decrease their saving rate due to their expectation of future productivity advances when labor is reallocated towards R&D in response to the policy intervention. Thus, the accumulation of physical capital slows down in the initial transition phase to the new steady state while more resources are devoted to knowledge accumulation. The decrease in the rate of investment in physical capital then enables an intertemporal free lunch despite a drop in initial per capita income. In our calibrated economy, only for large increases in the R&D subsidy rate, possibly beyond the socially optimal *long run* rate, per capita consumption drops initially.

As we calibrate our economy to the US and deliberately analyze a widely-accepted, standard growth set ups, our results suggest that an intertemporal free lunch is more than a theoretical anomaly and may be realized in advanced economies. We start out with the semi-endogenous growth model of Jones (1995), in which the long run growth rate is independent of the R&D subsidy. That an intertemporal free lunch even occurs in such a framework may thus be considered as a strong argument to raise the R&D subsidy from its current level. In view of some criticisms of semi-endogenous growth theory (e.g. (Laincz and Peretto, 2006, p. 268f.), we also examine the seminal framework of Romer (1990) to support and compare our main result in an alternative framework.

From a more general point of view, we show that a necessary condition for an intertemporal free lunch to occur in a situation with underinvestment is that at least two allocation variables can be affected independently by a policy intervention. In the Romer-Jones model, an increase in the R&D subsidy rate induces a reallocation of labor towards the R&D sector. This requires a first allocation variable to be set freely. For an intertemporal free lunch to be feasible, i.e. for consumption not to decrease initially, capital accumulation has to decelerate, which requires a second degree of freedom. This response to the R&D policy intervention allows for consumption smoothing in the presence of a substantial positive wealth effect. We discuss analogous considerations for one-sector and multi-sector growth models.

Technically, to identify an intertemporal free lunch and its underlying causes in sophisticated endogenous growth models requires to numerically compute the entire transition path to the new steady state after a policy shock in non-linear, highly dimensional, saddle-point stable, differential-algebraic systems. Simulating such a dynamic model is all but trivial. The growth literature has used the techniques of linearization, time elimination, or backward integration. Linearization delivers bad approximations if the deviation from the steady state is large, time elimination does not work if there are non-monotonic adjustments, and backward integration fails in case of stiff differential equations. Typically, all of these problems are present in our context. We employ a recent procedure, called relaxation algorithm (Trimborn et al., 2008), which can deal with these conceptual difficulties.

In line with seminal papers in growth theory, we focus on the standard assumption of an infinite planning horizon. As formalized by Barro (1974), the assumption may capture intertemporal utility of short-lived individuals with dynastic bequest motives. For evaluating the dynamic impact of policy interventions, it is thus important to know whether an intertemporal free lunch is conceivable or if instantaneous utility necessarily falls for some periods in response to the policy intervention. In fact, for a long time, scholars felt uneasy with the idea that present generations should give up consumption for the benefit of future generations, including Rawls (1971). For instance, this utilitarian idea is questioned in the debate on natural resource depletion and climate change, which is often based on infinite horizon models as well. Recently, Long and Martinet (2012) proposed a new approach to intertemporal natural resource allocation problems which serves as a different alternative to a utilitarian treatment of different generations: in addition to standard intertemporal welfare, a social planner should ensure that certain minimum thresholds for consumption and resource stocks are met, which is accomplished by introducing an "index of rights" in the objective function (Martinet, 2011). More generally, applied to policy interventions in a dynamic context like ours, this could mean that addressing underinvestment should be (and in a democratic society may be) supported only if the instantaneous change in per capita consumption is nonnegative. The knowledge of whether or not an intertemporal free lunch is feasible therefore could be a crucial information for policy makers.

The focus of our paper is hence very different from the literature on optimal growth policy which maximizes steady state welfare or seeks to identify the policy reform which maximizes the gain in intertemporal welfare which results from it. For instance, Grossmann et al. (2010) propose a comprehensive semi-endogenous growth model to derive the optimal tax deductions for capital costs, R&D expenditure and human capital expenditure. Grossmann et al. (2013) show that