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Integrating Investment and Annual Planning

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Abstract

This article illustrates (1) how to determine an efficient division of output between aggregate consumption and aggregate investment in a way that is democratic and participatory, and (2) how annual and investment planning can be integrated to improve outcomes as more accurate information becomes available. The article is of general relevance to the literature on economic planning, but is of particular interest to a post-capitalist "model" known as "participatory economics."

JEL Classification: P21, B51

Keywords

democratic planning, investment planning, socialist planning

1. Introduction

How participatory *annual* planning can be done has been explained in great detail in numerous publications (Albert and Hahnel 1991, 1992a, 1992b, 2002, and Hahnel 2000, 2005, 2012a, 2012b, 2015, and 2017). This article goes on to explain: (a) how participatory *investment* planning might be done, and (b) how participatory investment and annual planning can be coordinated to take advantage of new information as it becomes available to update investment plans and improve outcomes.

Section 2 describes a simple, one-good economy which operates over three years sufficient for present purposes. Section 3 assumes that all necessary information is known to an omniscient planner at the beginning of the first year, and demonstrates how she could calculate an optimal production, saving/investment, and consumption plan for the three years. Section 4 explains why planning *cannot* be done this way because critical information regarding consumer preferences, productive technologies, and the supply of labor in years two and three cannot be available to planners at the beginning of year one. But more importantly, Section 4 explains why planning *should not* be done this way because it would be authoritarian and undemocratic to do so. Section 5 explains how participatory investment planning can be done based on: (a) accurate information available from annual planning about preferences, technologies, and labor supply for year 1, and

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(b) *assumptions* about what preferences, technologies, and labor supplies will be in years 2 and 3. Section 6 describes relevant features of participatory annual planning, and explains why participatory investment planning and participatory annual planning must be carefully sequenced and integrated. Section 7 uses our simple model to demonstrate how new information from annual planning can be used to update the initial investment plan to increase welfare.

2. A Simple Model

There are three years, t = 1, 2, 3, after which planners know the world ends.[1]

There is a single good, corn, which is both the sole consumption good, and, together with homogeneous labor, an input into the production of corn.

The amount of homogeneous labor available each year, l(t), is exogenous.

There are no primary inputs from nature used in production.

The amount of corn available at the beginning of year 1, corn(1), is given. For convenience we assume corn(1) cannot be consumed, but can only be used as an input into the production of corn during year 1.

To be used in production during a year, corn must be available at the beginning of the year. Corn produced during any year cannot be used for production during the same year it is produced. All corn used in production in a year disappears during production. In traditional terms, corn is both the sole consumption good, and also a *capital* good, not an *intermediate* good. But it is a capital good which depreciates entirely in the year after it became available.

All corn produced during a year, x(t), is either consumed that year, c(t), or saved and invested, s/i(t). Therefore, in year 1 the amount of corn available for production is corn(1). In year 2 the amount of corn available for production is s/i(1). And in year 3 the amount of corn available for production is s/i(2).

Because the world ends after year 3, in an optimal plan s/i(3)* = 0, and therefore x(3)* = c(3)* where * indicates the optimal value for a variable.

Utility each year is a function of the amount of corn consumed that year, U(t)[c(t)].

The production function for corn, F(t), is a function of how much corn is used and how much labor is used during the year: x(t) = F(t)[corn(t),l(t)].

For convenience, we assume that social welfare, SW, is simply the sum of utility in the three years: SW = ΣU(t) (t = 1,2,3), i.e., that the social rate of time discount is zero.

It should be noted that because there is only one good, corn, which is both the consumption good and the investment or capital good, this model is not suitable for exploring many important investment decisions. Because there is only one good, decisions about how much of *different* investment, or capital goods to produce, and how to allocate capital goods to *different* industries do not arise, and therefore cannot be addressed. These important investment issues are explored in a multi-good model in Hahnel and Kerkhoff (2020), and in part 6 of Hahnel (2020). However, the single-good model is suitable for exploring how much of production should be saved and invested each year, s/i(t), rather than consumed each year, c(t).

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[1]Two reviewers pointed out that any real-world application would presumably differ considerably from the simple model we explore in this article. To be clear: we are not suggesting that planning for the future be limited to three years. In real-world settings investment plans should probably cover at least five years. And manpower, or educational planning, environmental planning, and international strategic economic planning all require much longer planning horizons—in some cases as many as fifty years. Also, as reviewers pointed out, revising *all* long-term plans *every* year should improve results compared to the more limited revision procedure we explore here—although this would also entail more time consumed in planning which has a cost to be considered. However, an investment plan spanning only three years is sufficient to illustrate how *any* longer-term plan can be updated based on information from subsequent shorter-term plans to improve outcomes. Our priority was to demonstrate this important insight in the simplest possible setting.

3. An Omniscient Planner

We assume that an omniscient planner knows:

(a) the utility functions for each year. For simplicity we assume these are the same for all three years: $U(t)[c(t)] = \sqrt{c(t)}$, t = 1, 2, 3.

Note that U(t) increases as c(t) rises, but at a diminishing rate because $dU(t)[c(t)]/dc(t) = 1/[2\sqrt{c(t)}]$.

(b) the production function for each year. Again, we begin by assuming these are the same for all three years: $x(t) = F(t)[corn(t),l(t)] = \sqrt{corn(t)l(t)}$ t = 1,2,3.

Note that x(t) rises whenever either corn(t) or l(t) rises, but at a decreasing rate because $\delta F(t)[corn(t),l(t)]/\delta corn(t) = \sqrt{l(t)}/[2\sqrt{corn(t)}]$ and $\delta F(t)[corn(t),l(t)]/\delta l(t) = \sqrt{corn(t)}/[2\sqrt{l(t)}]$.[2]

We begin by assuming that the amount of corn available at the beginning of year 1, corn(1), is 4 units, and the amount of labor that becomes available for use at the beginning of each year is the same for all three years: l(t) = 8, t = 1, 2, 3.

Armed with all this information an omniscient planner can calculate an optimal plan—a production, saving/investment, consumption plan for all three years—which maximizes SW.

The first thing the omniscient planner will do is maximize production in year 1 by using all of corn(1) = 4 and all of l(1) = 8: $x(1)^* = \sqrt{(4)(8)} = 5.65685$.

After this, the planner must calculate how to divide x(1) between c(1) and s/i(1), and how to divide x(2) between c(2) and s/i(2). Once s/i(1)* is decided, this will determine x(2)* since corn(2) = s/i(1)* and l(2) = 8. And once s/i(2)* is decided, this will determine x(3)* since corn(3) = s/i(2)* and l(3) = 8, which also determines c(3)* since s/i(3)* = 0 as explained. Our omniscient planner will do this by requiring the optimal plan to satisfy the following two first order conditions for maximizing $SW = \sqrt{c(1)} + \sqrt{c(3)} + \sqrt{c(3)}$:

(A) the last unit of corn consumed in year 1 increases utility in year 1 by the same amount as the last unit of corn saved/invested in year 1 increases corn production in year 2, *times* the amount the last unit of corn consumed in year 2 increases utility in year 2:

$$dU(1)\left[c(1)\right]/dc(1) = \left\{\delta F(2)\left[corn(2),l(2)\right]/\delta corn(2)\right\}\left\{dU(2)\left[c(2)\right]/dc(2)\right\}$$

A. $$1/\left[2\sqrt{c(1)}\right] = \left\{\sqrt{l(2)}/\left[2\sqrt{corn(2)}\right]\right\}\left\{1/\left[2\sqrt{c(2)}\right]\right\}$$

(B) the last unit of corn consumed in year 2 increases utility in year 2 by the same amount as the last unit of corn saved/invested in year 2 increases corn production in year 3, *times* the amount the last unit of corn consumed in year 3 increases utility in year 3:

$$dU(2)\left[c(2)\right]/dc(2) = \left\{\delta F(3)\left[corn(3),l(3)\right]/\delta corn(3)\right\}\left\{dU(3)\left[c(3)\right]/dc(3)\right\}$$

[2] $\delta F(t)[corn(t),l(t)]/\delta corn(t): = \delta/\delta corn(t)\ \{corn(t)l(t)\}^{1/2} = (1/2)\ \{corn(t)l(t)\}^{-1/2}\ [l(t)] = l(t)/[2\sqrt{corn(t)l(t)}] = \sqrt{l(t)}\sqrt{l(t)}/[2\sqrt{corn(t)}\sqrt{l(t)}] = \sqrt{l(t)}/[2\sqrt{corn(t)}]$. The derivation is similar for $\delta F(t)[corn(t),l(t)]/\delta l(t) = \sqrt{corn(t)}/[2\sqrt{l(t)}]$.

$$\text{B.}\quad 1/\left[2\sqrt{c(2)}\right] = \left\{\sqrt{1(3)}/\left[2\sqrt{\text{corn}(3)}\right]\right\}\left\{1/\left[2\sqrt{c(3)}\right]\right\}$$

We know:

$$c(1) = x(1) - s/i(1) = \left[5.65685 \text{ - } s/i(1)\right]$$

$$\text{corn}(2) = s/i(1) \text{ and } \text{corn}(3) = s/i(2)$$

And for l(2) = l(3) = 8 we have:

$$x(2) = F(2)\left[\text{corn}(2), 1(2)\right] = \sqrt{8s/i(1)} = 2.82843\sqrt{s/i(1)}$$

$$c(2) = x(2) - s/i(2) = \left[2.82843\sqrt{s/i(1)} - s/i(2)\right]$$

$$x(3) = c(3) = F(3)\left[\text{corn}(3), 1(3)\right] = \sqrt{8s/i(2)} = 2.82843\sqrt{s/i(2)}$$

Substituting all this into equations A and B yields two equations in two unknowns, s/i(1) and s/i(2)—the amount we should save and invest in years 1 and 2 respectively:

$$1/\left\{2\sqrt{\left[5.65685 - s/i(1)\right]}\right\} = \left\{\sqrt{8}/\left[2\sqrt{s/i(1)}\right]\right\}\left\{1/\left\{2\sqrt{\left[2.82843\sqrt{s/i(1)} - s/i(2)\right]}\right\}\right\} \tag{A}$$

$$1/\left\{2\sqrt{\left[2.82843\sqrt{s/i(1)} - s/i(2)\right]}\right\} = \left\{\sqrt{8}/\left[2\left[\sqrt{s/i(2)}\right]\right]\right\}\left\{1/\left\{2\sqrt{\left[2.82843\sqrt{s/i(2)}\right]}\right\}\right\} \tag{B}$$

Using www.wolframalpha.com to solve these two equations in two unknowns yields the optimal values for saving/investment in years 1 and 2:[3]

$$s/i(1)^* = 2.36628;\ s/i(2)^* = 1.56968$$

This gives the following optimal production, saving/investment, and consumption plan for all three years, and the maximum social welfare:

$$t = 1\text{: } x(1)^* = 5.65685,\ s/i(1)^* = 2.36628,\ c(1)^* = 3.29057$$

$$t = 2\text{: } x(2)^* = 4.35089,\ s/i(2)^* = 1.56968,\ c(2)^* = 2.78121$$

$$t = 3\text{: } x(3)^* = 3.54365,\ s/i(3)^* = 0.00000,\ c(3)^* = 3.54365$$

$$\begin{aligned} SW(\max)^* &= U(1)\left[c(1)^*\right] + U(2)\left[c(2)^*\right] + U(3)\left[c(3)^*\right] = \sqrt{c(1)^*} + \sqrt{c(2)^*} + \sqrt{c(3)^*} = \\ &\sqrt{3.29057} + \sqrt{2.78121} + \sqrt{3.54365} = 1.81399 + 1.66770 + 1.88246 = 5.36415 \end{aligned}$$

[3] We named our key variables s/i(1) and s/i(2) in order to emphasize that what we are solving for is the amount of corn to be saved and invested in year 1 and year 2. However, unfortunately this notation confuses Wolfram. In order to replicate our results readers should use x for s/i(1) and y for s/i(2) before entering equations A and B into Wolfram.

4. Why Investment Planning Cannot and Should Not Be Done This Way

While it has long been tempting for economists to think about investment planning this way, it is *impractical* because investment planners are not omniscient. It is impossible for planners to know what technologies and preferences will be in years 2 and 3. Nor is there any way to know for certain what the supply of labor will be in future years. But what about preferences, technologies, and the supply of labor in year 1? Clearly, along with the initial supply of corn, the supply of labor in year 1 can be known to planners at the beginning of year 1. And, as we have demonstrated elsewhere, our participatory annual planning procedure can induce consumers and producers to truthfully reveal their preferences and technological capabilities for year 1 as well. But obtaining accurate information about future preferences, technologies, and labor availabilities is another matter. The practical take-away is that when an investment plan is created it must be based on *estimates* of what preferences, technologies, and the supply of labor will be in years 2 and 3.

However, even if our planner were omniscient and benevolent, it would be politically undesirable to allow a planner, or central planning agency, to create our investment plan for us. The calculations our omniscient planner performed in section 3 did not involve workers and consumers in deciding what *they* would produce, consume, save, and invest in any way whatsoever. This is how authoritarian, central planning functions, and certainly not a model for how participatory, democratic planning should be done.

There is a long tradition of dismissing central planning on practical grounds. The "tacit knowledge" critique of Von Mises and Hayek is now often treated as "common knowledge," and many others have pointed out that when central planners in the Soviet Union and Eastern European countries tried to obtain information from production units they often created perverse incentives for units to disguise their true capabilities. Interested readers should see chapter 9 in Hahnel and Albert (1990) for a thorough evaluation of whether central planning could, *in theory*, overcome the *practical* problem that planners are not omniscient, and avoid perverse incentives for enterprise managers by using any of a variety of price-guided, quantity-guided, gradient, and mixed procedures to elicit information about technologies from production units developed by economic theorists during the late 1960s and early 1970s. Geoffrey Heal (1973) rigorously examined the properties of many of these procedures in chapters 4, 5, 6, 7, 8, and 9. But even though the "information critique" of central planning has been grossly overexaggerated, the main point is that despite the fact that there may be creative ways to eliminate perverse incentives for enterprise managers, central planning remains undesirable nonetheless because it is inherently undemocratic.

Moreover, it turns out that *because* it is highly undemocratic, and *because* those who work and consume have so little opportunity to participate in meaningful decision making, comprehensive authoritarian planning eventually ceases to be sufficiently innovative. Even had the Soviet Union adopted the clever mechanisms designed largely by Western economic theorists in the 1960s and 1970s, this would only have postponed its eventual defeat by a rival economic system which does stimulate innovation despite its many other failings.

5. Participatory Investment Planning

How do we propose to overcome the practical problem that investment planning must be initiated before future preferences, technologies, and labor supplies can be known? How do we propose to make investment planning democratic and participatory?

5.1. The Missing Information Problem

There is no getting around the problem that future preferences, technologies, and labor supplies must be estimated in order to do investment planning. That is, investment planning must be based on *guesses* about the future. And this is true whether or not investment planning is done democratically or autocratically.[4]

To illustrate, what if our investment planner in section 3 estimated *incorrectly* that future labor supplies in year 2 and 3 were going to be 9 units each year? Using equations A and B with $\sqrt{l(2)} = \sqrt{l(3)} = \sqrt{9} = 3$ instead of $\sqrt{l(2)} = \sqrt{l(3)} = \sqrt{8} = 2.828427$, the planner would decide to save and invest 2.43603 units of corn in year 1 (instead of 2.36628 units), and 1.70747 units of corn in year 2 (instead of 1.56968 units). When actual future labor supplies in years 2 and 3 turn out to be 8 instead of 9, this mistake to oversave and overinvest in years 1 and 2 will result in a loss of 0.00169 units of social welfare over the three years compared to what social welfare could have been had investment planners correctly anticipated future labor availabilities and not overinvested.

Inaccurate estimates of future preferences, U(t) t = 2,3, or future technologies, F(t) t = 2,3, would result in similar losses of potential welfare because the investment plan would invest either too little or too much in years 1 and 2. In section 7 we explore: (a) what will happen if planners fail to anticipate that while $F(1) = \sqrt{corn(1)l(1)}$ in year 1, technologies will improve in years 2 and 3 and become $F(2) = \sqrt{2corn(2)l(2)}$ and $F(3) = \sqrt{2corn(3)l(3)}$; and (b) how to mitigate welfare losses by updating the investment plan based on information revealed by annual planning for year 1. In sum, the goal is to make *best guesses* about future parameters during initial investment planning, and then to take advantage of opportunities to update investment plans when more accurate information is revealed by the results from annual plans.

5.2. Making Investment Planning Democratic and Participatory

How do we propose to make investment planning democratic and participatory, and enhance the accuracy of initial estimates of parameters? Our simple, one-good corn model is useful for exploring how we propose to decide how much of production each year should be devoted to consumption rather than saved and invested. But, as we have just seen, we need to formulate estimates of how consumer preferences are likely to change in the future in order to do this efficiently. Who better than the National Federation of Consumer Councils, NFCC, to estimate how future U(t)[c(t)]s may change. This consumer federation will be overseeing R&D activity concerning new products and services, so the NFCC will be in charge of finding out what kinds of new products consumers want. Combining information from that work with data on historic trends in consumption patterns, the NFCC is ideally suited to estimate changes in consumer preferences once it is provided with an estimate of likely increases in economic productivity and therefore average incomes.

As explained, we also need to estimate what F(t)[corn(t),l(t)] t = 2, 3 will be. Who better to estimate likely improvements in technology than the National Federation of Worker Councils, NFWC. Since the NFWC oversees a large R&D department researching new technologies, this federation is best situated to provide the best guess in this regard. We have proposed elsewhere that R&D focused on developing *new products* be overseen by the national federation of *consumer* councils, but that the national federation of *worker* councils be in charge of R&D having to do with developing *new technologies*.[5] Of course the NFWC can call on industry federations of Worker councils for help since they will also oversee R&D for their individual industries. But this issue is better explored in a multi-good model where industries produce *different* goods, and

[4]The necessity of basing investment decisions on guesses applies to market economies as well. But in the case of market systems investors must also make guesses about what competitors are deciding to do. In other words, investment decisions in market economies are based on a great deal *more* uncertainty.

[5]In capitalist economies both kinds of research are usually carried out by producers despite perverse incentives that are seldom noted that result from putting producers in charge of research about new products for consumers.

saving/investing takes the form of producing *different* capital goods (see Hahnel and Kerkhoff forthcoming, and Hahnel 2020). In any case, this division of research labor seems to us to be the best way to take advantage of who is likely to have access to the information most critical to each problem.[6]

Since the business of these two national federations is conducted by recallable, elected delegates from all neighborhood consumer councils and from worker councils in all industries, we believe this procedure for formulating estimates of changes in consumer preferences and productive technologies is democratic as well as effective. Once we have these best guesses about future U(t)s and F(t)s, as well as best guesses about future l(t)s,[7] how should participatory investment planning proceed?

At the aggregate level under consideration here, investment planning is about the trade-off between more consumption now versus more saving and investment now, and therefore more consumption later. Between years which are not far apart this is mostly a tradeoff between present and future consumption for the same people. However, for years farther apart this is a trade-off between well-being for different generations of people. Unfortunately, future generations are not available to participate when we draw up investment plans, so their interests must somehow be represented by somebody else.

Up to now we have implicitly assumed that the utility functions U(1), U(2), and U(3) represent the utilities of the same people—which may change somewhat over time in ways that people may not anticipate. But we can highlight problems that different generations create by assuming people are born and die in a single year, so those whose utilities we express as U(1), U(2), and U(3) are the utilities of different people, or generations.

Since only the first generation will be present when we do investment planning, the first question is: who will speak for and protect the interests of the second and third generations of consumers? If those present during investment planning, the first generation, take only their own interests into account, they will choose $s/i(1) = 0$ to maximize c(1) and U(1), which will render x(2), x(3), c(2), c(3), U(2), and U(3) all zero. *How do we propose to prevent this?*

The second issue is that, depending on how productive saving and investment turns out to be, the most efficient investment plan, i.e., the plan that maximizes SW for given preferences, technologies, labor supplies, and initial corn stock, may be ethically unacceptable because it unfairly advantages one generation over another. For example, if saving/investment is extremely productive—say $F(2) = \sqrt{100\text{corn}(2)l(2)}$, and therefore the marginal productivity of saving and investing in year 1, $[5\sqrt{l(2)}]/[\sqrt{s/i(1)}]$, is extremely high—the optimal plan will call for a very high s/i(1)* and consequently c(1)* may be so low it almost starves the first generation. Or, if saving/investment is very *un*productive—say $F(2) = \sqrt{0.01\text{corn}(2)l(2)}$, and therefore the marginal productivity of saving and investing in year 1, $[0.05\sqrt{l(2)}]/[\sqrt{s/i(1)}]$, is extremely low—the optimal plan will call for a very low s/i(1)* and consequently c(2)* may be so low it almost starves the second generation. In other words, for some production functions, even if we assume the utility functions

[6]Note that what investment planners need to know is the likely increase in productivity that will result simply from improvements in technologies—in our simple model changes in F(t)[corn(t),l(t)] t = 2, 3. While this is one reason per capita productivity and therefore per capita income increases over time, increases in per capita productivity and income will also come from capital deepening. But the optimal trajectory for capital deepening is precisely what investment planning will determine based on estimates of changes in technology, preferences, and future labor supplies.

[7]This article is concerned only with investment planning and its relationship to annual planning. Elsewhere we propose ways to carry out education planning, environmental planning, and strategic international economic planning (Hahnel 2020). Education planning changes future supplies of different kinds of labor from "givens" which investment planners must estimate, into dependent variables which education planning solves for, and then makes available to, investment planners. Similarly, environmental planning changes future supplies of different kinds of natural resources from givens into dependent variables.

are the same for all generations and the social welfare function weighs utility of all generations equally, we may find that the "efficient" saving/investment plan is morally unacceptable. *What do we propose to do about that?*

5.3. A Generational Equity Constraint

We propose to solve both problems by placing limits on how much any c(t) can deviate from any c(t+1). For example suppose we stipulate: c(t+1) < 1.βc(t) *and* c(t) < 1.βc(t+1) for all t. This generational equity constraint prevents consumption in any adjacent years from differing by more than β percent. As John Rawls (1971) famously taught, ideally we would like to have everyone vote on β behind a *veil of ignorance* which prevents people from knowing what generation they will be part of when they vote. So admittedly, having people *knowing they are in the first generation* vote on β is not ideal. Nonetheless it seems reasonably satisfactory. The first constraint prevents the first generation from being unfairly disadvantaged even if the marginal productivity of saving and investing is extremely high. The second constraint prevents later generations from being unfairly disadvantaged even if the marginal productivity of saving and investing is extremely low.

Requiring the present generation to vote on a percentage β to be used in the generational equity constraint prevents them from being able to ignore the interests of future generations. Absent the constraint, if they were selfish the present generation could conceivably place a zero in front of U(2) and U(3) in SW so that s/i(1), c(2), and c(3) would all be zero, and c(1) = x(1) would be at a maximum. However, if the present generation tried to ignore the well-being of future generations in this way the constraint would require c(1) < (1.β)c(2) = (1.β)(0) = 0. The present generation cannot do any better than 1.β times however well the next generation does.[8] But if the present generation chooses a high β they run the risk that if the productivity of investment is very low they will end up 1.β worse off than the next generation. For the same reason, the generational equity constraint makes it risky for the present generation at the NFCC to downplay how much satisfaction future generations will get from consumption. We proposed putting the NFCC in charge of estimating future U(t)s because it is in the best position to collect and evaluate information about preference change. The generational equity constraint helps make the present generation honest brokers, so to speak.

Once β is chosen there are two possibilities:

(1) For the actual U(t)s, F(t)s, l(t)s, and corn(1) in the economy, neither constraint is binding. In this case, consumption in adjacent years differs by less than β percent, and the investment plan which maximizes SW is also morally acceptable.

(2) For the actual U(t)s, F(t)s, l(t)s, and corn(1) in the economy, one of the two constraints is binding. In this case, consumption in adjacent years differs by exactly β percent because one of the two generational equity constraints prevents any larger deviation. In this case, the investment plan that emerges yields a value for SW that is somewhat less than SW(max), but the plan is morally acceptable.

[8]Arguably, present generations have long ignored the immense negative consequences of climate change on future generations. I thank Professor Mark Klinedinst for pointing out in his review of this article that the generational equity constraint serves as a strong disincentive for present generations to continue this practice.

5.4. The Participatory Investment Planning Procedure

As explained, the NFCC, aided by the R&D department under its control, seems best informed to estimate what future preferences will be.[9] And the generational equity constraint should reduce—although admittedly not eliminate—any perverse incentive for the NFCC to either underestimate how much satisfaction future generations get from consumption, or overdiscount the well-being of future generations because average consumption rises over time. Also as explained, the NFWC, aided by its R&D arm, seems best informed to estimate future changes in production technologies, which will affect how fast average consumption rises over time.

Who is the natural "voice" to argue the case for more consumption in years 1 and 2? And who is the natural "voice" to argue the case for more saving and investment in years 1 and 2? Clearly today's consumers have an interest in arguing for more consumption in year 1, next year's consumers have a like interest in arguing the merits of more consumption in year 2, and consumers in year 3 have an interest in advocating for more consumption in year 3. But if future consumers in years 2 and 3 cannot be present when decisions must be made, we must improvise.

The generational equity constraint is our first step to improvise and limit perverse incentives for the only generation present when we make investment decisions to prioritize its own interest both unfairly and inefficiently at the expense of future generations. But that does not solve the problem of who will speak forcefully for the value of saving and investment. Our second attempt to improvise is to take advantage of any "can do" tendency which producers in Worker councils may have. All other things being equal, presumably worker councils would like to have more and better capital goods to work with, which in our present context translates into a higher level of saving and investment.

One might well ask why? In a planned economy where Worker councils are charged for the social cost of producing any capital goods they use, why would they care if they get more or fewer capital goods to expand their productive capabilities? Particularly if we remember that what we are considering in this article is saving and investing more corn *for all Worker councils*, rather than allocating more capital goods to one worker council rather than another, it may seem that Worker councils as a whole, as represented by the NFWC, has no material interest in a higher or lower level of saving and investment. However, while they may not be as strong an advocate for more saving and investment as future consumers, at least the NFWC has no material disincentive to call for less saving and investment than is socially optimal, and may have a psychological inclination to be optimistic about its value. And in a more realistic setting than considered in this article, a setting where individual Worker councils do have an incentive to present a forceful case for why they can put more capital goods to better use than other Worker councils can, Worker councils should be more motivated spokespersons for the benefits of investment. All of which, given the absence of future generations at the discussion table, leaves us with the NFWC as the best available "voice" to present the "case" for saving and investing more corn.

Consider the debate over how much to save and invest in year 1, which is a debate over what level of saving and investment, s/i(1), satisfies equation A:[10]

$$\mathrm{dU}(1)\left[\mathrm{c}(1)\right]/\mathrm{dc}(1) = \left\{\delta\mathrm{F}(2)\left[\mathrm{corn}(2),\mathrm{l}(2)\right]/\delta\mathrm{corn}(2)\right\}\left\{\mathrm{dU}(2)\left[\mathrm{c}(2)\right]/\mathrm{dc}(2)\right\}$$

If the NFWC wants to make a convincing case that more should be saved and invested in year 1, it must argue that at the level of saving and investment currently under consideration the right

[9]As already explained, because of limitations of a one-good model the description of the participatory investment planning procedure here is incomplete See Hahnel and Kerkhoff (2020) and Hahnel (2020) for how to do participatory investment planning in a multi-good model.

[10]The same reasoning applies to the debate over how much to save and invest in year 2, so we needn't repeat what follows.

side is greater than the left side in equation A. Regarding equation A: the NFWC has no influence over U(1)[c(1)], and therefore dU(1)[c(1)]/dc(1), because U(1)[c(1)] is revealed by the previous annual planning process. Nor does the NFWC have any influence over U(2)[c(2)], and therefore dU(2)[c(2)]/dc(2), since U(2)[c(2)] will be estimated by the NFCC as explained above, not by the NFWC. So the only way the NFWC could agitate for more saving and investment than is socially optimal would be to pretend that δF(2)[corn(2),l(2)]/δcorn(2) is greater than it truly believes it will be. Therefore the crucial questions regarding any perverse incentive for the NFWC to overexaggerate the benefits of saving and investment in year 1 during the participatory investment planning process are: (a) will any overestimation of how productive saving and investing truly is be subsequently revealed as an overexaggeration? And (b) would the NFWC be sufficiently punished if an overexaggeration were revealed to prevent the NFWC from being tempted to exaggerate its enthusiasm to win more investment for Worker councils? We return to these questions shortly.

If the NFCC wants to make a convincing case that more should be consumed and less saved and invested in year 1, it must argue that at the level of saving and investment currently proposed the left side is greater than the right side in equation A. The NFCC has no influence over U(1)[c(1)], and therefore dU(1)[c(1)]/dc(1), for the same reason the NFWC has no influence—because U(1)[c(1)] is revealed by the previous annual planning process. Nor does the NFCC have any influence over F(2)[corn(2),l(2)] and therefore δF(2)[corn(2),l(2)]/δcorn(2), because the NFWC is charged with estimating what those functions will be. So the only way for the NFCC to agitate for more consumption in year 1 than is socially optimal, and therefore less saving and investment than is socially optimal in year 1, would be to underestimate how much satisfaction future consumers will get from consumption, i.e., to underestimate U(2)[c(2)], and therefore dU(2)[c(2)]/dc(2) in equation A. Again, the crucial questions regarding any perverse incentive for the NFCC during the participatory investment planning process are: (a) will any underestimation of how much satisfaction in year 2 consumers get from consumption be subsequently revealed? And (b) would the NFCC be sufficiently punished if an underestimation were revealed to prevent the NFCC from being tempted to lie in order to win less saving and investment, and therefore more consumption in year 1? We are now ready to address these questions about perverse incentives for the NFWC and NFCC.

The good news is that mistaken estimations will be revealed, and the investment plan can be revised accordingly. In section 7 we demonstrate concretely: (a) how results from the annual plan for year 2 will reveal if assumptions about δF(2)[corn(2),l(2)]/δcorn(2) made during investment planning are accurate, and (b) how the investment plan can then be revised to mitigate welfare losses. So if the NFWC attempts to exaggerate how productive saving and investing will be, this deception is revealed and appropriate corrections can be made. Similarly, results from annual planning: (a) reveal if the NFCC has underestimated future consumers' ability to gain satisfaction from consumption, and (b) how to revise the investment plan accordingly.

The bad news is that designing penalties for misestimation is less straightforward. How can one effectively penalize the NFWC or NFCC? Remember who and what the NFWC and NFCC are. As national federations they represent *all* members of *all* worker councils, and *all* members of *all* neighborhood consumer councils. Clearly "collective punishment" for all workers or all consumers is neither desirable nor possible in this case. However, the work of these federations is carried out by elected and recallable delegates. If it is revealed that the delegates at the NFWC overestimated future productivity gains, which led to overinvestment, or that the delegates at the NFCC underestimated future consumer preferences, which led to underinvestment, it is possible to replace them, bar them from ever serving as delegates again, or even punish delegates personally if it can be proved that a delegate engaged in a deliberate deception rather than made an honest mistake.

6. Coordinating Participatory Investment and Annual Planning

The sequencing of participatory annual planning and participatory investment planning is important for two reasons:

(1) Annual plans require inputs provided by the results of investment plans. Most broadly, and for the purposes of this article, those engaged in annual planning must know the division of output between consumption and investment before creating a plan for the year. More specifically, those engaged in annual planning must be told the amounts of different capital goods which must be produced during the year.
(2) Information from annual planning in years subsequent to drawing up a multi-year investment plan reveal how investment planners initially erred because their estimates of certain data were off the mark. This new information can be used to update and modify the investment plan for years still to come and thereby mitigate welfare losses.

We have explained how participatory annual planning works elsewhere (see chapter 14 in Hahnel (2012b) and chapter 5 in Albert and Hahnel (1991)). But the relevant aspects for present purposes are that the procedure: (a) induces worker councils to reveal their productive capabilities in any given year, and (b) generates accurate estimates of the social opportunity costs of using all inputs when the optimal production plan is carried out in any given year. In our present context this means annual planning reveals the true production functions, F(t)[corn(t),l(t)], and accurate values for δF(t)[corn(t)*,l(t)*]/δcorn(t)* and δF(t)[corn(t)*,l(t)*]/δl(t)* for t = 1, 2, 3. Bearing this in mind, the timing and sequencing of investment planning, annual planning, and modifications of investment planning can be arranged as follows for investment plans, which cover three years.

(1) Every third year participatory investment planning takes place during November, to create an investment plan covering the next three calendar years.
(2) Participatory annual planning takes place during December every year, to determine an annual plan to be carried out from January through December of the calendar year that follows.
(3) On December 31 we receive the results of what happened during the previous year, which for convenience we assume become immediately available.
(4) Every three-year initial investment plan is revised twice: it is revised for the first time in January after the first year is over and the actual results of what happened in the economy during the first year of the three-year investment plan are available. After that, an expedited version of participatory annual planning takes place in February using the new values from the updated investment plan, which yields a revised annual plan for year 2 to be implemented starting on March 1.
(5) The initial investment plan is revised for a second time in January after the second year is over and the actual results of what happened in the economy during the second year of the three-year investment plan are available. After which an expedited version of participatory annual planning takes place in February using the new values from the updated investment plan, which yields a revised annual plan for year 3 to be implemented starting on March 1.

How does this schedule work under the simplifying assumptions of this article, namely that: (a) there is only one good, corn, which can either be consumed or saved and invested; and (b) there are only three years, after which investment planners know the world will end? [11] We assume the

[11] We understand that both these simplifying assumptions introduce some bizarre features. As already noted, the single-good assumption eliminates some of the most important issues which real participatory investment planning must decide, namely how much of *different* capital goods should be produced, and how they should be allocated to *different* firms in *different* industries. Also, knowing the world comes to an end on December 31 of year 3 means that the optimal amount of saving and investment in year 3 is zero. We chose in this article to ignore the problem that any finite planning horizon must deal with the "truncation problem." Interested readers should see chapter 11 in Heal (1973) for an exhaustive treatment of the pros and cons of different ways to eliminate undesirable consequences of the practical consequences of truncation. Nonetheless, a single-good, three-year world is sufficient to allow us to explore key issues in sequencing and integrating participatory annual planning and participatory investment planning.

economy producing only corn has been running for a number of years, but now planners know the economy will function for three more years, after which the world will end on December 31 of the third year. It is November 1 of the year prior to year 1, which we call year zero, and implementation of the annual plan for year zero, which was revised somewhat in February of year zero, is drawing to a close. The last three-year investment plan covered the two years prior to year zero and year zero, so we no longer have an investment plan going forward after December 31 of year zero. What must we do?

During November in year zero we need to engage in participatory investment planning to come up with a new three-year investment plan for years 1, 2, and 3. That plan decides what s/i(1)*, s/i(2)*, and s/i(3)* will be. Since planners know the world will end on December 31 of year 3, the optimal choice for s/i(3)* is zero, and there will never be any need to revise this choice. It is also impossible to revise s/i(1)* because it will have been implemented before we discover that we may have wished to revise it. But there will be both motive and opportunity to revise the second year of the investment plan, s/i(2)* after results from the economy are known on December 31 of year 1.[12]

Then, during December in year zero we need to engage in participatory annual planning to come up with an annual plan for year 1, to be implemented starting January 1 of year 1. Notice that in a more realistic multi-good world where there are many different capital goods, when participatory annual planning takes place in December of year zero we know the amount of all capital goods which must be produced during year 1 because that has already been determined by the investment planning process that took place in November. However, in our one-good world it is simply s/i(1)*, the amount of corn which must be saved and invested that has been decided by the investment plan, which annual planners now take as a "given" when formulating the annual plan for year 1 during December of year zero.

From January 1 through November 30 of year 1 no more planning takes place, the annual plan for year 1 is launched, and what actually happens will presumably differ in some respects from what the annual plan called for, and various adjustments will be made so that what actually happens will differ to some extent from what was initially planned for year 1. But in any case, the results of what actually occurred during year 1 are known and available on December 31 of year 1.

Starting on December 1 of year 1, even before these results are known, participatory annual planning for year 2 takes place and is completed by December 31 of year 1. In our one-good world it is the amount of corn which must be saved and invested in year 1, s/i(1)*, as well as the amount which must be saved and invested in year 2, s/i(2)*, which was determined by the initial investment plan (s/i(3)* = 0). However, there is now an opportunity to revise the amount of corn to be saved and invested during year 2, s/i(2)*, in light of evidence from actual outcomes in year 1.

During January of year 2, the three-year investment plan will be revised and corrected in light of actual results during year 1. In our one-good, three-year model it is s/i(2)* that we have the opportunity to revise. And since the adjustment will be known by February 1 of year 2 there is still time to repeat an expedited version of participatory annual planning for year 2 using the revised amount for s/i(2)*, and this version of an annual plan for year 2 can begin to be implemented starting on March 1.

Starting on December 1 of year 2, participatory annual planning for year 3 takes place and is completed by December 31 of year 2. This time there is no need to revise s/i(3)* because s/i(3)* = 0 is still optimal given the fact that planners know the world will end on December 31 of year 3. If this were not the case we would take advantage of the fact that there is a second opportunity

[12] In a real-world version of participatory investment planning, each investment plan would cover more years and revisions would take place for every year except the first. However, the three-year/world-ends model is sufficient to demonstrate how revision works since revisions can be made for the second year of the investment plan.

to revise s/i(3)* in a second revision of the three-year investment plan during January of year 3 based on the actual results in the economy during year 2.

7. Calculating Welfare Gains from Updating Investment Plans

This section explores how to adjust for assumptions about future increases in productivity that prove to be inaccurate. However, the same reasoning applies to inaccurate assumptions about future preferences or labor supplies. In other words, when subsequent annual plans reveal that assumptions about future preferences and labor supplies made during investment planning were inaccurate, we could update the investment plan to mitigate welfare losses in these cases as well.

Suppose investment planners *underestimate* technological improvements in years 2 and 3 when drawing up the initial investment plan. Suppose technological change actually increases economic productivity in years 2 and 3 compared to year 1 as follows: $F(1) = \sqrt{corn(1)l(1)}$, $F(2) = \sqrt{2corn(2)l(2)}$, and $F(3) = \sqrt{2corn(3)l(3)}$; but investment planners fail to anticipate these improvements in productivity in years 2 and 3, and believe instead that productions functions remain the same in years 2 and 3 as they were in year 1:

$$F(1) = \sqrt{corn(1)l(1)},\ F(2) = \sqrt{corn(2)l(2)},\ \text{and}\ F(3) = \sqrt{corn(3)l(3)}.$$

November year 0. As we calculated in section 3, when participatory investment planning takes place based on what is now *incorrect* information about future productivity, it will arrive at the following production, saving/investment, and consumption plan:

$$t = 1: x(1)^* = 5.65685,\ s/i(1)^* = 2.36628,\ c(1)^* = 3.29057$$

$$t = 2: x(2)^* = 4.35089,\ s/i(2)^* = 1.56968,\ c(2)^* = 2.78121$$

$$t = 3: x(3)^* = 3.54365,\ s/i(3)^* = 0.00000,\ c(3)^* = 3.54365$$

December year 0. When participatory annual planning for year 1 takes place, the annual plan is required to save and invest 2.36628 units of corn out of however much corn is produced in year 1. Assuming participatory annual planning is efficient, it will call for production of $F(1) = \sqrt{corn(1)l(1)} = \sqrt{(4)(8)} = 5.65685$ units of corn, and therefore have $5.65685 - 2.36628 = 3.29057$ units left over for consumption in year 1, which will generate $\sqrt{3.29057} = 1.81399$ units of welfare.

December year 1. When participatory annual planning for year 2 takes place, the annual plan for year 2 will be required to save and invest 1.56968 units of corn out of however much corn is produced in year 2. Because participatory annual planning is designed to induce producers to reveal their true capabilities—which are $\sqrt{2corn(2)l(2)}$ and *not* $\sqrt{corn(2)l(2)}$ as investment planners in November of year 0 believed they would be—the annual plan for year 2 will call for production of $F(2) = \sqrt{2corn(2)l(2)} = \sqrt{(2)(2.36628)(8)} = 6.15309$ units of corn, leaving $6.15309 - 1.56968 = 4.58341$ units of corn for consumption in year 2, which will generate $\sqrt{4.58341} = 2.14089$ units of welfare.

December 31 year 1. At this point when the annual plan for year 2 is complete, it will become apparent that something is amiss because according to the annual plan for year 2 the marginal productivity of corn will be different from the marginal productivity of corn in year 2 according to the initial investment plan. Given the fact that saving and investing corn was actually more productive than investment planners initially anticipated, and therefore the initial investment plan called for too little saving and investment, the marginal product of corn in year 2 will be higher according to the annual plan for year 2 than it was anticipated to be by the initial investment plan.

According to the annual plan for year 2, calculated during December of year 1 where the correct production function is revealed as x(2) = $\sqrt{2[\text{corn}(2)][l(2)]}$, the marginal product of corn in year 2 will be:

$$\delta x(2)/\delta \text{corn}(2) = \sqrt{l(2)}/\left[\sqrt{2\text{corn}(2)}\right] = \sqrt{8}/\sqrt{2\text{s/i}(1)^*} = \sqrt{8}/\sqrt{(2)(2.36628)} = 1.30016.$$

But according to the initial investment plan, calculated during November of year 0 where it was assumed that x(2) = $\sqrt{[\text{corn}(2)][l(2)]}$, the marginal product of corn in year 2 was:

$$\delta x(2)/\delta \text{corn}(2) = \sqrt{l(2)}/\left[2\sqrt{\text{corn}(2)}\right] = \sqrt{8}/\left[2\sqrt{\text{s/i}(1)^*}\right] = \sqrt{8}/(2)\sqrt{(2.36628)} = 0.91935.$$

This discrepancy reveals that when we initially formulated the investment plan, we incorrectly assumed that δx(2)/δcorn(2) was lower than it turned out to be. And since we now know that δx(2)/δcorn(2) = 1.30016 when corn(2) = 2.36628, we know that F(2) must, in truth, be equal to $\sqrt{2[\text{corn}(2)][l(2)]}$ and not $\sqrt{[\text{corn}(2)][l(2)]}$. If we now assume that F(3) is also $\sqrt{2[\text{corn}(3)][l(3)]}$ and not $\sqrt{[\text{corn}(3)][l(3)]}$, we can recalculate a new investment plan for years 2 and 3 to mitigate the welfare loss from our initial underestimation of F(2) and F(3). We designate optimal values for the revised investment plan with a single apostrophe.

January year 1. It is too late to go back and increase s/i(1) = 2.36628, and under our assumptions the optimum choice for s/i(3) remains zero. But it is not too late to change s/i(2) in light of our new information about F(2) and F(3).

We know corn(2) = s/i(1) = 2.36628, and therefore x(2) = $\sqrt{2[\text{s/i}(1)^*][l(2)]} = \sqrt{(2)(2.36628)(8)}$ = 6.15309. This means that c(2) = [6.15309 − s/i(2)]. We also know that because s/i(3) = 0 then c(3) = x(3) = $\sqrt{(2)[\text{s/i}(2)](8)} = \sqrt{16[\text{s/i}(2)]} = 4\sqrt{[\text{s/i}(2)]}$. As always, dU(2)[c(2)]/dc(2) = $1/2\sqrt{c(2)}$ and dU(3)[c(3)]/dc(3) = $1/2\sqrt{c(3)}$. And finally, with F(3) actually equal to $\sqrt{2[\text{corn}(3)][l(3)]} = \sqrt{(2)\text{s/i}(2)(8)} = \sqrt{16\text{s/i}(2)} = 4\sqrt{\text{s/i}(2)}$, we have δF(3)[corn(3),l(3)]/δcorn(3) = $4/2\sqrt{\text{s/i}(2)} = 2/\sqrt{\text{s/i}(2)}$.

Only optimality condition B is relevant or necessary:

$$dU(2)\left[c(2)\right]/dc(2) = \left\{\delta F(3)\left[\text{corn}(3),l(3)\right]/\delta\text{corn}(3)\right\}\left\{dU(3)\left[c(3)\right]/dc(3)\right\}$$

Substituting in two steps:

$$1/2\sqrt{c(2)} = \left\{2/\sqrt{\text{s/i}(2)}\right\}\left\{1/2\sqrt{c(3)}\right\}$$

Substituting c(2) = [6.15309 - s/i(2)] and c(3) = $4\sqrt{\text{s/i}(2)}$ we have:

$$1/\left\{2\sqrt{\left[6.15309 - \text{s/i}(2)\right]}\right\} = \left\{2/\sqrt{\text{s/i}(2)}\right\}\left\{1/\left\{2\sqrt{\left[4\sqrt{\text{s/i}(2)}\right]}\right\}\right\}$$

And finally:

$$1/\left\{2\sqrt{\left[6.15309 - \text{s/i}(2)\right]}\right\} = 1/\left\{2\left[\text{s/i}(2)\right]^{3/4}\right\}$$

Using www.wolframalpha.com to solve this single equation in our single unknown yields s/i(2)′ = 2.4105, our new optimal value for saving and investment in year 2, based on our new more accurate information about how productive saving and investing actually is. Not surprisingly, $s/i(2)' = 2.4105 > 1.56968 = s/i(2)^*$ when planners did not anticipate any increase in productivity in years 2 and 3. Our new, revised plan—which consists of the same plan for year 1 which was too late to change, but adjustments in our plans for years 2 and 3—is now:

$$t = 1: x(1)' = 5.65685, s/i(1)' = 2.36628, c(1)' = 3.29057$$

$$t = 2: x(2)' = 6.15309, s/i(2)' = 2.41050, c(2)' = 3.74259$$

$$t = 3: x(3)' = 6.21031, s/i(3)' = 0.00000, c(3)' = 6.21031$$

The last step is to compare social welfare in three scenarios: (1) how high would SW be if a benevolent, omniscient planner drew up our three-year plan based on accurate information about future productivities? (2) how high would SW be if the initial plan based on incorrect information about F(2) and F(3) were carried out *without adjustment*? And (3) how high will SW be if the initial plan *is adjusted* after year 1 when new information becomes available about what F(2) and F(3) actually are?

We begin with SW(c(1)′, c(2)′, c(3)′) for the adjusted plan we just calculated:

$$SW' = \sqrt{3.29057} + \sqrt{3.74259} + \sqrt{6.21031} = 1.81399 + 1.93458 + 2.49205 = 6.24062$$

What would happen if we did *not* correct for mistaken assumptions about F(2) and F(3) and simply implemented the initial investment plan without adjustment? This would *not* be the same as plan calculated in section 3. While both that plan and this plan were calculated based on the assumption that $F(t) = \sqrt{corn(t)l(t)}$ for t = 1, 2, 3, for the outcome calculated in section 3 that assumption was correct. In this case we apply the same investment plan, $s/i(t)^*$ t = 1, 2, 3 as in section 3, but use the *true* production functions: $F(1) = \sqrt{corn(1)l(1)}$, $F(2) = \sqrt{2corn(2)l(2)}$, and $F(3) = \sqrt{2corn(3)l(3)}$, not the production functions we initially assumed, which in the case of years 2 and 3 turned out to be incorrect. This uncorrected plan is:

$$t = 1: x(1)'' = 5.65685, s/i(1)'' = 2.36628, c(1)'' = 3.29057$$

$$t = 2: x(2)'' = 6.15309, s/i(2)'' = 1.56968, c(2)'' = 4.58341$$

$$t = 3: x(3)'' = 5.01147, s/i(3)'' = 0.00000, c(3)'' = 5.01147$$

In which case we would have:

$$SW'' = \sqrt{3.29057} + \sqrt{4.58341} + \sqrt{5.01147} = 1.81399 + 2.14089 + 2.23863 = 6.19351$$

Clearly making the adjustment—increasing s/i(2) from 1.56968 to 2.41050—was worthwhile since it increased welfare by 6.24062 − 6.19351 = + 0.04711 units.

However, while our adjusted investment plan gives better results than the unadjusted investment plan, the adjusted plan is not as good as the plan that a benevolent, omniscient planner with *correct* information about future production functions would have calculated:[13]

[13] In this case our equations are: (A): $1/\{2\sqrt{[5.65685 - s/i(1)]}\} = \{2/\sqrt{s/i(1)}\}\{1/2[\sqrt{[\sqrt{(16s/i(1))} - s/i(2)]}\}$, and (B): $1/2[\sqrt{[\sqrt{[16s/i(1)]} - s/i(2)]} = 1/[2s/i(2)^{3/4}]$. Using Wolfram: s/i(1)^ = 2.78902 and s/i(2)^ = 2.56710.

$$t = 1 : x(1)\^{} = 5.65685, s/i(1)\^{} = 2.78902, c(1)\^{} = 2.86783$$

$$t = 2 : x(2)\^{} = 6.68014, s/i(2)\^{} = 2.56710, c(2)\^{} = 4.11304$$

$$t = 3 : x(3)\^{} = 6.40887, s/i(3)\^{} = 0.00000, c(3)\^{} = 6.40887$$

In which case we have:

$$SW\^{} = \sqrt{2.86783} + \sqrt{4.11304} + \sqrt{6.40887} = 1.69347 + 2.02806 + 2.53157 = 6.25310$$

Since SW^ = 6.25310 > 6.24062 = SW′ it is clear that an omniscient investment plan would outperform our adjusted investment plan by 0.01248 units of welfare. The reason we cannot do as well even when we update the investment plan as the omniscient planner can is that she is able to increase saving and investment in year 1 as well as year 2 in light of her more accurate information about what F(2) and F(3) will be—while we are stuck with a suboptimal level of saving and investment in year 1 based on our underestimation of future technological capabilities. However, when investment planning is done initially there inevitably are mistaken estimates of important future parameters. So the best that can be done is to identify those mistakes as quickly as possible, update parameters accordingly, and recalculate later years in the investment plan to mitigate welfare losses—as we have just demonstrated can be done. To quote a popular saying, hopefully our proposal proves to be *more than* “good enough for government work!”

8. Conclusion

In numerous previous publications we have explained in great detail: (a) how to carry out comprehensive, annual, economic planning in a democratic and participatory way; and (b) why our annual, participatory planning procedure achieves an efficient plan under certain assumptions. In this article we shed light on two crucial questions regarding investment planning: (a) how can investment planning also be done democratically with maximum participation by workers and consumers? And (b) how can we solve the missing information problem in a way that mitigates welfare loses, since initial investment plans must, necessarily, be based on assumptions about future preferences, technologies, and labor supplies which will inevitably prove to be somewhat inaccurate? In a simple setting we propose: (a) how investment planning can be made participatory, and (b) how participatory investment and participatory annual planning can be integrated so as to reveal and correct for inevitable errors in initial investment plans, and thereby mitigate welfare loses.

We caution readers that this article deals only with the overall saving/investment decision and does not address several other important issues. It does *not* address how to decide how much of *different* capital goods to produce, and which industries and firms within industries to allocate them to. These important aspects of investment planning require a multi-good model and are treated in Hahnel and Kerkhoff (2020) and in part 6 in Hahnel (2020). *Nor* does this article discuss human resource planning, environmental planning, or strategic, international, economic planning—all of which require more complicated models with multiple kinds of labor, multiple inputs from the natural environment, and multiple imports and exports, as explored in part 7 of Hahnel (2020). And finally, this article does *not* address the truncation problem, nor the pros and cons of different ways to deal with it. We refer readers to chapter 11 in Heal (1973) on that issue.

However, the procedure discussed here for updating longer-term plans based on information revealed by subsequent shorter-term plans, and thereby mitigating welfare losses, *is* applicable in these other, more complicated planning situations as well. Just as annual planning can tell us if assumptions made during investment planning, about how productive saving/investment will be, were accurate, annual planning can reveal if assumptions about the marginal social products of different kinds of labor made during manpower/education planning, the marginal social products of different inputs from the natural environment made during environmental planning, and the marginal social products of different imports made during international economic planning were accurate—and how to update those long-term plans to mitigate welfare losses when they are not. These issues are explored at length in part 7 in Hahnel (2020) as well.

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