



The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

האוניברסיטה העברית בירושלים
The Hebrew University of Jerusalem



המרכז למחקר בכלכלה חקלאית
The Center for Agricultural
Economic Research

המחלקה לכלכלה חקלאית ומנהל
The Department of Agricultural
Economics and Management

Discussion Paper No. 1.10

Uncertain Climate Policy and the Green Paradox

by

Sjak Smulders, Yacov Tsur and Amos Zemel

Papers by members of the Department
can be found in their home sites:

מאמרים של חברי המחלקה נמצאים
גם באתרי הבית שלהם:

<http://departments.agri.huji.ac.il/economics/indexe.html>

P.O. Box 12, Rehovot 76100

ת.ד. 12, רחובות 76100

Uncertain climate policy and the Green Paradox

Sjak Smulders* Yacov Tsur[◇] Amos Zemel[✱]

January 31, 2010

Abstract

Unintended consequences of announcing a climate policy well in advance of its implementation have been studied in a variety of situations. We show that a phenomenon akin to the so-called “Green-Paradox” holds also when the policy implementation date is uncertain. Governments are compelled, by international and domestic pressure, to demonstrate an intention to reduce greenhouse gas emissions. Taking actual steps, such as imposing a carbon tax on fossil energy, is a different matter altogether and depends on a host of political considerations. As a result, economic agents often consider the policy implementation date to be uncertain. We show that in the interim period between the policy announcement and its actual implementation the emission of green-house gases increases vis-à-vis business-as-usual.

“.....If you have to shoot, shoot, don’t talk!” – Tuco in *The Good, the Bad and the Ugly*.

Keywords: Climate policy, carbon tax, uncertainty, green paradox.

*Department of Economics and CentER, Tilburg University, PO Box 90153, 5000 LE Tilburg, The Netherlands (J.A.Smulders@uvt.nl).

[◇]Department of Agricultural Economics and Management, The Hebrew University of Jerusalem, P.O. Box 12 Rehovot 76100, Israel (tsur@agri.huji.ac.il).

[✱]Corresponding author: Department of Solar Energy and Environmental Physics, The Jacob Blaustein Institutes for Desert Research, Ben Gurion University of the Negev, Sede Boker Campus 84990, Israel (amos@bgu.ac.il).

1 Introduction

An increasing body of economic literature suggests that the very large potential damage due to emissions-induced climate change calls for effective regulation measures to limit the accumulation of atmospheric pollution. The costly measures would be justified only if the response they entail actually advances the desired goal of reduced emissions. Recent studies reveal, however, that this is not always the case, and climate policies may paradoxically give rise to more emissions relative to the laissez-faire scenario. For example, partial participation in an international emission reduction program may introduce a leakage effect, whereby the response of the non-participating parties more than offsets the reduction activities of the participants. The resulting “Green Paradox” is analyzed, for example, by Sinn (2008) and by Eichner and Pethig (2009). A similar paradoxical outcome may stem from the regulator’s wish to allow the parties prepare in advance to the proposed policy measures and spread their adjustment efforts over time. A model based on this mechanism has been developed by Di Maria et al. (2008) who study the response of coal or oil fields owners to an advance announcement of an anticipated climate policy and find that the inelastic supply of the non-renewable resources might induce them to lower prices prior to the policy implementation, encouraging enhanced emissions.

At the core of the mechanisms driving these results lies a finite resource stock that owners wish to exploit before the announced policy interrupts their supply activities. In a recent contribution, Smulders et al. (2009) show that scarcity is not the sole driver of such effects and obtain the paradoxical outcome in a model with an unlimited supply of fossil energy. Introducing regulation via a carbon tax, which effectively raises the price of fossil energy, and assuming that the regulator announces the plan to levy the tax well in advance, they show that the early announcement distorts resource allocation processes in a number of ways. In particular, it reduces consumption and increases saving, thus giving rise to a larger capital stock. The larger capital stock, in turn, enhances the demand for fossil energy by firms that use capital, energy and labor as factors of production. Thus, announcing a policy aimed at reducing the use of fossil energy well in advance gives rise to the opposite effect until the policy is actually realized. The result holds both when the regulation policy involves a mild tax rate which reduces fossil use but does not induce the use of alternative, clean (solar) energy as well as when the tax rate is high enough to trigger a transition to solar energy.

In this work we extend the results of Smulders et al. (2009) by consider-

ing uncertainty as yet another driver of paradoxical effects. We incorporate uncertainty into the model by assuming that the government announces the intention to levy the carbon tax, but the date of implementation depends on political conditions and is therefore uncertain. The distinction appears to be important as it affects the underlying mechanism that drives the paradox. In particular, the continuity of the consumption process plays a key role in deriving the early announcement effect when the implementation date is known in advance. In contrast, under uncertain implementation date, the consumption path undergoes a discontinuous jump at the (random) time when the policy is implemented. Nevertheless, we establish the “green paradox” also under uncertainty, and show that it is driven by the same economic forces: anticipating that the tax will reduce energy use in the future induces households to enhance saving today in order to accumulate more capital that can substitute for the lower energy input. Prior to implementation of the tax policy, the increased capital stock is associated with increased energy input, hence the paradoxical outcome. Indeed, since uncertainty regarding implementation appears to be a common feature characterizing climate policies, the negative effect of the paradox may be significant.

Of course, the saving efforts must come at the expense of consumption, and the realization of the effect depends on a condition relating the production elasticity of capital to the elasticity of marginal utility of consumption. As explained by Smulders et al. (2009), this condition would be satisfied in any empirically relevant calibration, and the paradoxical nature of the uncertainty effect appears to be robust.

2 Setup

We begin with a brief summary of the unregulated case on which the early announcement analysis is based.

2.1 The unregulated economy

Early responses to expectations regarding the future introduction of a climate policy are studied in the framework of Tsur and Zemel (2009) who analyzed the penetration of solar technologies into competitive energy markets. We outline briefly the main components of this model and the results that drive the present analysis. The economy consists of a final good sector, an energy sector, and capital owning households. The final goods are produced using

energy x and capital k as inputs. We employ the Cobb-Douglas production technology

$$y(k, x) = Fk^\alpha x^\gamma \quad (2.1)$$

with $\alpha + \gamma < 1$ and $F > 0$.¹ The energy sector consists of fossil energy firms that supply energy at the price ζ and of solar energy firms that invest in solar infrastructure (capital) s . Once the latter has been installed, the generation of solar energy entails no additional cost but is limited by the available stock s of solar capital. The two sources of energy are perfect substitutes, hence

$$x = x^f + bs \quad (2.2)$$

where x^f is fossil energy and $b > 0$ is an efficiency parameter measuring how much solar power can be delivered from one unit of solar capital. Solar energy is supplied at the going market price and the forward-looking solar firms base their investment decisions on their forecast regarding the evolution of future energy demand. The solar stock, then, evolves according to

$$\dot{s} = \iota - \delta s \quad (2.3)$$

where ι is the investment rate and $\delta > 0$ is the capital depreciation rate.

Household have a concave utility function $u(\cdot)$ over consumption c of final goods and seek to maximize the present-value utility stream over an infinite horizon

$$\int_0^\infty u(c(t))e^{-\rho t} dt \quad (2.4)$$

subject to the budget constraint

$$\dot{k} = y(k, x^f + bs) - \zeta x^f - \iota - \delta k - c, \quad (2.5)$$

where ρ is the pure (utility) rate of discount.

Absent market failures, the competitive equilibrium processes are determined by finding nonnegative $\{c(t), x^f(t), \iota(t)\}$ that maximize (2.4) subject to (2.3), (2.5), $k(0) = k_0 > 0$ and $s(0) = 0$.

The competitive allocation is characterized in Tsur and Zemel (2009) in terms of the critical price

$$\zeta^c = (\rho + \delta)/b \quad (2.6)$$

and three conditions:

¹All quantities are given in per capita terms, hence the labor input is omitted. The CD specification is not essential for our analysis, but it allows for a simple and transparent derivation.

1. The condition for fossil energy use, equating its price to the marginal product of energy

$$y_x = F\gamma k^\alpha x^{\gamma-1} = \zeta \quad (2.7)$$

yielding

$$x = \left(\frac{F\gamma}{\zeta} \right)^{1/(1-\gamma)} k^{\alpha/(1-\gamma)}. \quad (2.8)$$

2. A steady state (Ramsey) condition,

$$y_k = F\alpha k^{\alpha-1} x^\gamma = \rho + \delta, \quad (2.9)$$

yielding

$$x = \left(\frac{\rho + \delta}{F\alpha} \right)^{1/\gamma} k^{(1-\alpha)/\gamma}. \quad (2.10)$$

3. A simultaneous growth condition, equating the marginal product for both types of capital

$$y_k = by_x \quad (2.11)$$

yielding

$$x = (b\gamma/\alpha)k. \quad (2.12)$$

Tsur and Zemel (2009) establish the following characterization:

Proposition 1. (i) When the fossil energy price ζ falls short of ζ^c , no investment in solar ever takes place, $s(\cdot) \equiv 0$, and the competitive processes converge to a steady state (\hat{k}, \hat{x}) determined by conditions (2.7) and (2.9). (ii) When the fossil energy price ζ exceeds ζ^c the competitive processes converge to an exclusively solar steady state with (\check{k}, \check{x}) determined by conditions (2.9) and (2.11), where $\check{x}^f = 0$ and $\check{s} = \check{x}/b$.

Economies satisfying condition (i) are referred to as fossil-based economies, while those satisfying condition (ii) are called solar-based. These terms describe long term behavior. In the interim, when the initial capital stock k_0 is small, energy is derived exclusively from fossil sources and investment in solar capital is delayed (or avoided if the economy is fossil-based), while fossil energy use is determined by (2.8).

2.2 Regulation

The discussion so far has focused on the economic and technological aspects of the distinction between fossil and solar technologies, ignoring the externalities associated with the use of the former, due, e.g. to the polluting emissions

it entails. A common policy addressing such externalities entails imposing Pigouvian taxes on emissions. In our setting, such a policy is equivalent to increasing the fossil price ζ . If the “carbon tax” τ is imposed abruptly, the parties will respond promptly by switching from the competitive processes corresponding to the initial (low) price ζ^l to the higher price $\zeta^h = \zeta^l + \tau$. Imposing such a policy by surprise entails discontinuities in the consumption and saving processes, which may raise political opposition. Support-seeking regulators, thus, may choose to announce the tax policy well ahead of its actual implementation in order to allow agents to adjust gradually to the forthcoming changes. The early announcement effects of this policy were shown by Smulders et al. (2009) to give rise to a ‘green paradox’, whereby the use of fossil energy will actually increase, rather than decrease, during the intermediate period between the announcement of the tax policy and its actual implementation. This result holds both when the tax rate leaves the originally fossil-based economy at the same type classification (albeit less energy intensive) and when τ is large enough to bring ζ^h well above the critical price ζ^c of (2.6), turning the economy into a solar-based type. In both cases, agents know the implementation date precisely and adjust their behavior so as to ensure a smooth consumption process, even though this entails results that diametrically oppose the regulator’s original aim.

Here we extend the analysis to situations where the regulator announces the intention to levy the tax, but is unable or unwilling to commit to a specific date of implementing it. When the policy actually takes place, it implies a prompt adjustment to the higher fossil energy price and discontinuous disruptions cannot be avoided. The agents’ response, therefore, differs from that following a pre-specified (known) implementation date. We refer to this scenario as ‘uncertain announcement’ and investigate whether it can also give rise to paradoxical outcomes. We restrict attention to the case of a mild tax rate which leaves the economy as a fossil-based type also after the tax is imposed. Higher tax rates implying a transition to solar-type economies entail a more tedious analysis, but the paradoxical effects are expected to be driven by the same mechanism, as in Smulders et al. (2009).

2.3 Allocation dynamics

The analysis is based on a comparison of the competitive processes following an uncertain announcement to those corresponding to a fixed low price ζ^l free of regulation. Here we characterize the latter processes. Employing the

energy input at its demand (cf. (2.8)) gives the output

$$y = F \left(\frac{F\gamma}{\zeta} \right)^{\gamma/(1-\gamma)} k^{\alpha/(1-\gamma)} \quad (2.13)$$

and implies

$$\zeta x = y_x x = F\gamma k^\alpha x^\gamma = \gamma y.$$

Net production, then, can be expressed as a function of capital only:

$$y - \zeta x = (1 - \gamma)y = F(1 - \gamma) \left(\frac{F\gamma}{\zeta} \right)^{\gamma/(1-\gamma)} k^{\alpha/(1-\gamma)} \equiv A(\zeta)k^\beta, \quad (2.14)$$

where

$$\beta \equiv \alpha/(1 - \gamma) < 1 \quad (2.15)$$

is the effective capital share and

$$A(\zeta) \equiv F(1 - \gamma) \left(\frac{F\gamma}{\zeta} \right)^{\gamma/(1-\gamma)} \quad (2.16)$$

decreases in the fossil price ζ . Fossil based economies with different fossil prices follow the same dynamics, differing only in the parameter $A(\zeta)$. The optimization problem (2.4), thus, reduces to a single state (k) and single control (c) problem whose solution is governed by the pair of dynamic equations

$$\dot{k} = A(\zeta)k^\beta - \delta k - c \quad (2.17)$$

and

$$\dot{c} = c\sigma(c)[A(\zeta)\beta k^{\beta-1} - (\rho + \delta)], \quad (2.18)$$

where

$$\sigma(c) = -u'(c)/[u''(c)c] \quad (2.19)$$

is the intertemporal elasticity of substitution.

The steady state (\hat{k}, \hat{c}) of this system is given by the relations

$$A(\zeta)\beta \hat{k}^{\beta-1} = \rho + \delta \quad (2.20)$$

and

$$\hat{c} = A(\zeta)\hat{k}^\beta - \delta \hat{k} = \hat{k}[(\rho + \delta)/\beta - \delta] \equiv r_\infty \hat{k}, \quad (2.21)$$

where

$$r_\infty = (\rho + \delta)/\beta - \delta \quad (2.22)$$

is independent of ζ . The steady state consumption-capital relation coincides with the straight line $\hat{c} = r_\infty \hat{k}$ for all values of the fossil price below the critical price ζ^c .

For the autonomous system at hand we can write $c = c(k)$, hence $\dot{c} = c'(k)\dot{k}$ and equations (2.17)-(2.18) imply

$$c'(k) = \frac{\sigma(c(k))c(k)}{k} \frac{A(\zeta)\beta k^\beta - (\rho + \delta)k}{A(\zeta)k^\beta - \delta k - c(k)}. \quad (2.23)$$

Combined with the boundary condition $c(\hat{k}) = \hat{c}$, equation (2.23) determines consumption for every positive capital stock:²

Proposition 2. *If $\beta\sigma(c) < 1$ for all c then the $c(\cdot)$ curve lies **above** the straight line $c = r_\infty k$ for all $k \in (0, \hat{k})$ and it lies **below** this straight line for all $k > \hat{k}$.³*

Proof. At $k = \hat{k}$, $c(\hat{k}) = r_\infty \hat{k}$ and equation (2.23) cannot be used directly to determine c' because both numerator and denominator vanish. However, $c'(\hat{k})$ can be obtained by applying l'Hôpital's rule, yielding the quadratic equation

$$\Theta(c') \equiv c'^2 - \rho c' - r_\infty \sigma(\hat{c})[\rho + \delta](1 - \beta) = 0 \quad (2.24)$$

with $\Theta(0) < 0$, while $\Theta(r_\infty) = r_\infty(r_\infty + \delta)(1 - \beta)(1 - \beta\sigma(\hat{c})) > 0$ hence the positive root $c'(\hat{k})$ of (2.24) is smaller than r_∞ . Just below \hat{k} , then, the $c(\cdot)$ curve lies above the straight line $c = r_\infty k$. Suppose that the two curves cross at some state $0 < \tilde{k} < \hat{k}$ where $c(\tilde{k}) = r_\infty \tilde{k}$. Then $c'(\tilde{k}) \geq r_\infty$. However, at \tilde{k} we can use (2.22) and (2.23) to obtain

$$c'(\tilde{k}) = \sigma(r_\infty \tilde{k})r_\infty \frac{A(\zeta)\beta \tilde{k}^\beta - (\rho + \delta)\tilde{k}}{A(\zeta)\tilde{k}^\beta - (\delta + r_\infty)\tilde{k}} = \beta\sigma(r_\infty \tilde{k})r_\infty < r_\infty, \quad (2.25)$$

and the curves cannot cross. The relation at $k > \hat{k}$ is established in a symmetric manner. \square

²Strictly speaking, (2.23) corresponds to the market solution only for $k \leq \hat{k}$. For our purpose, however, it turns out expedient to characterize the properties of its formal solutions also at larger capital stocks.

³Symmetric considerations show that if $\beta\sigma(c) > 1$ for all c then the relation between $c(\cdot)$ and the straight line $c = r_\infty k$ is reversed. In this work we maintain the condition $\beta\sigma(c) < 1$ cited in the Proposition, because it corresponds to any empirically relevant calibration.

2.4 Different fossil energy prices

Next we compare two unregulated $c(\cdot)$ curves corresponding to different fossil prices. We consider the prices $\zeta^h > \zeta^l$ and use the superscripts h and l to denote all quantities associated with the high and low price, respectively. We assume that even the higher price ζ^h is insufficient to induce the economy to use solar energy, hence the dynamics of the previous subsection hold for both processes. Observe that r_∞ is independent of ζ and the steady-states corresponding to both fuel prices lie on the straight line $c = r_\infty k$. According to (2.20), $\hat{k}^l > \hat{k}^h$ and therefore \hat{c}^l is proportionately larger than \hat{c}^h .

According to Proposition 2, $c^l(\hat{k}^h) > r_\infty \hat{k}^h = c^h(\hat{k}^h)$, hence the low-price consumption curve lies above its high-price counterpart at $k = \hat{k}^h$. We establish now that this property holds for all capital stocks.

Proposition 3. *If $\beta\sigma(c) < 1$ for all c then the $c^l(\cdot)$ curve lies above the $c^h(\cdot)$ curve for all $k > 0$.*

Proof. The Proposition holds for $k = \hat{k}^h$. Suppose that the two curves cross at some point (\tilde{k}, \tilde{c}) with $\tilde{k} \in (0, \hat{k}^h)$. It follows that $dc^l(\tilde{k})/dk \geq dc^h(\tilde{k})/dk$. Using (2.23) we find

$$\frac{A(\zeta^l)\beta\tilde{k}^\beta - (\rho + \delta)\tilde{k}}{A(\zeta^l)\tilde{k}^\beta - \delta\tilde{k} - \tilde{c}} \geq \frac{A(\zeta^h)\beta\tilde{k}^\beta - (\rho + \delta)\tilde{k}}{A(\zeta^h)\tilde{k}^\beta - \delta\tilde{k} - \tilde{c}}. \quad (2.26)$$

All terms of (2.26) are positive, because both k and c increase below their corresponding steady states. Thus,

$$(\rho + \delta)\tilde{k}A(\zeta^h) + \beta(\delta\tilde{k} + \tilde{c})A(\zeta^l) \leq (\rho + \delta)\tilde{k}A(\zeta^l) + \beta(\delta\tilde{k} + \tilde{c})A(\zeta^h).$$

or

$$\beta(\delta\tilde{k} + \tilde{c})[A(\zeta^l) - A(\zeta^h)] \leq (\rho + \delta)\tilde{k}[A(\zeta^l) - A(\zeta^h)].$$

Now, $A(\zeta^l) > A(\zeta^h)$, yielding

$$\beta(\delta\tilde{k} + \tilde{c}) \leq (\rho + \delta)\tilde{k}$$

or, using (2.22)

$$\tilde{c} \leq r_\infty \tilde{k},$$

violating Proposition 2. It follows that the two consumption curves do not meet in the interval $(0, \hat{k}^h]$.

At $k > \hat{k}^h$ the inequality (2.26) and the signs of its terms are reversed, but a crossing of the consumption curves can be ruled out via the same considerations, recalling that the curves lie below the straight line $c = r_\infty k$ when the capital stock k exceeds their respective steady states. \square

Proposition 3 lies at the core of the early announcement effects studied in Smulders et al. (2009). We proceed now to investigate how the analysis can be extended to study uncertain announcements.

3 Uncertain implementation date

Suppose that implementation of the carbon tax τ , under which the price of fossil energy increases from ζ^l to $\zeta^h = \zeta^l + \tau$, is considered to take place at some unknown future date T . The realization of T may depend on the successful ratification and implementation of some international treaty, or on other developments in the global arena, and is taken as exogenous to the economy under consideration. Thus, from the vantage point of the economy, the hazard rate π corresponding to the random T is constant. The payoff, conditional on T , is

$$\int_0^T u(c(t))e^{-\rho t}dt + e^{-\rho T}v(k(T)|\zeta^h),$$

where $v(k|\zeta)$ represents the value given a constant fossil price ζ :

$$v(k|\zeta) = \max_{\{c(t)\}} \int_0^\infty u(c(t))e^{-\rho t}dt \quad (3.1)$$

subject to (2.17), given $k(0) = k$. Note that $dv(k|\zeta^h)/dk = \lambda^h(k) = u'(c^h(k))$, where λ^h is the current-value shadow price of capital under the optimal policy corresponding to $v(k|\zeta^h)$.

A constant hazard π implies that T is exponentially distributed and the expected payoff is

$$E_T \left\{ \int_0^T u(c(t))e^{-\rho t}dt + e^{-\rho T}v(k(T)|\zeta^h) \right\} = \int_0^\infty [u(c(t)) + \pi v(k(t)|\zeta^h)]e^{-(\rho+\pi)t}dt.$$

The allocation problem with uncertain carbon tax date T becomes

$$v^\pi(k_0|\zeta^l, \zeta^h) = \max_{\{c(t)\}} \int_0^\infty [u(c(t)) + \pi v(k(t)|\zeta^h)]e^{-(\rho+\pi)t}dt \quad (3.2)$$

subject to (2.17) with $\zeta = \zeta^l$, given $k(0) = k_0$. We compare the emission path corresponding to $v(k_0|\zeta^l)$, under which no carbon tax is contemplated, with that corresponding to $v^\pi(k_0|\zeta^l, \zeta^h)$, under which a carbon tax τ will be imposed at an uncertain time T .

The capital process $k^\pi(\cdot)$ corresponding to $v^\pi(k_0|\zeta^l, \zeta^h)$ follows (2.17) with $\zeta = \zeta^l$ (the prevailing price until the tax is imposed) while equation (2.18) becomes

$$\dot{c}^\pi(t) = \sigma(c^\pi(t))c^\pi(t) [A(\zeta^l)\beta k^\pi(t)^{\beta-1} - (\rho + \delta) + P(k^\pi(t))], \quad (3.3)$$

where

$$P(k) \equiv \pi \left(\frac{u'(c^h(k))}{u'(c^\pi(k))} - 1 \right). \quad (3.4)$$

Comparing (3.3) with (2.18), we see that the uncertainty in T , with $\pi > 0$, is represented by the $P(k)$ term, the sign of which depends on the relative magnitudes of $c^h(k)$ and $c^\pi(k)$. We turn now to study the effects of this term.

3.1 The consumption-capital trajectory

We consider the capital dependence of consumption under the π regime. Equation (2.23) becomes

$$\frac{dc^\pi(k)}{dk} = \sigma(c^\pi(k))c^\pi(k) \frac{A(\zeta^l)\beta k^{\beta-1} - (\rho + \delta) + P(k)}{A(\zeta^l)k^\beta - \delta k - c^\pi(k)}, \quad (3.5)$$

with the steady state values \hat{k}^π and \hat{c}^π , given by

$$A(\zeta^l)(\hat{k}^\pi)^\beta - \delta \hat{k}^\pi - \hat{c}^\pi = 0 \quad (3.6)$$

and

$$\beta A(\zeta^l)(\hat{k}^\pi)^{\beta-1} - (\rho + \delta) + P(\hat{k}^\pi) = 0. \quad (3.7)$$

We compare these steady state values with their regulation-free counterparts.

From (2.20) and (3.7) we obtain

$$A(\zeta^l)\beta[(\hat{k}^l)^{\beta-1} - (\hat{k}^\pi)^{\beta-1}] = P(\hat{k}^\pi). \quad (3.8)$$

According to (3.4), $P(\hat{k}^\pi)$ is small when π is small, hence \hat{k}^π is close to \hat{k}^l and (3.6) implies that

$$c^\pi(\hat{k}^\pi) = \hat{c}^\pi \approx \hat{c}^l = c^l(\hat{k}^l) \approx c^l(\hat{k}^\pi) > c^h(\hat{k}^\pi).$$

With $u''(\cdot) < 0$, it follows that $u'(c^\pi(\hat{k}^\pi)) < u'(c^h(\hat{k}^\pi))$ and $P(\hat{k}^\pi) > 0$. Turning again to (3.8) and recalling that $\beta - 1 < 0$, we find that $\hat{k}^\pi > \hat{k}^l$ when the hazard rate π is small. We show that this relation between the steady states extends to arbitrary positive values of π . Consider the steady state \hat{k}^π as a function of π and assume that at some π value this function crosses the

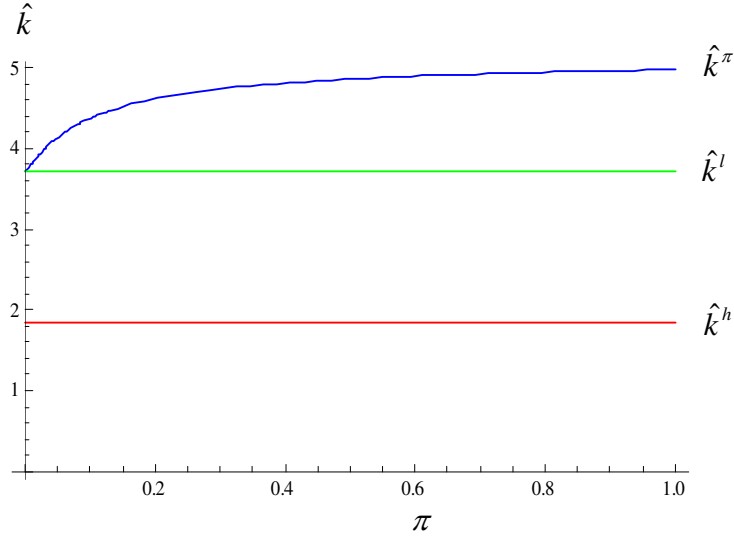


Figure 1: The steady state capital \hat{k}^π as a function of the hazard rate π . The upper and lower horizontal lines indicate \hat{k}^l and \hat{k}^h , respectively. The curves in all figures were derived under the above functions specifications and the parameter values: $\alpha = \gamma = 1/3$, $F = 1$, $\sigma = 1$, $\rho = \delta = 5\%$ annually, $\zeta^l = 1$ and $\zeta^h = 2$.

constant \hat{k}^l so that the left hand side of (3.8) vanishes. However, (3.6) holds for both $c^\pi(\cdot)$ and $c^l(\cdot)$ hence $c^\pi(\hat{k}^\pi) = c^l(\hat{k}^\pi) > c^h(\hat{k}^\pi)$. According to (3.4) $P(\hat{k}^\pi) > 0$ hence the right hand side of (3.8) is positive, while the left hand side vanishes. Thus, the crossing cannot occur. We conclude, therefore that

$$\hat{k}^\pi > \hat{k}^l \quad \forall \pi > 0, \quad (3.9)$$

as Figure 1 illustrates.

Next we compare the complete consumption curves by relating $c^\pi(k)$ to $c^l(k)$. Since \hat{k}^l represents the steady state for the $k^l(\cdot)$ process, it follows that $\dot{k}^l(t) = 0$ at this state. However, the steady state \hat{k}^π of $k^\pi(\cdot)$ exceeds \hat{k}^l , hence $\dot{k}^\pi(t) > 0$ when $k^\pi(t) = \hat{k}^l$. Thus, (2.17) implies $c^l(\hat{k}^l) > c^\pi(\hat{k}^l)$. We show that this relation cannot reverse at other capital states. Suppose otherwise, that $c^l(k^*) = c^\pi(k^*)$ (hence $P(k^*) > 0$) at some capital state $k^* < \hat{k}^l$ but $c^l(k) > c^\pi(k) \quad \forall k \in (k^*, \hat{k}^l]$. It follows that $dc^l(k^*)/dk \geq dc^\pi(k^*)/dk$. However, we can write (3.5) as

$$\frac{dc^\pi(k^*)}{dk} = \frac{dc^l(k^*)}{dk} + \frac{\sigma(c^l(k^*))c^l(k^*)P(k^*)}{A(\zeta^l)k^{*\beta} - \delta k^* - c^l(k^*)} > \frac{dc^l(k^*)}{dk},$$

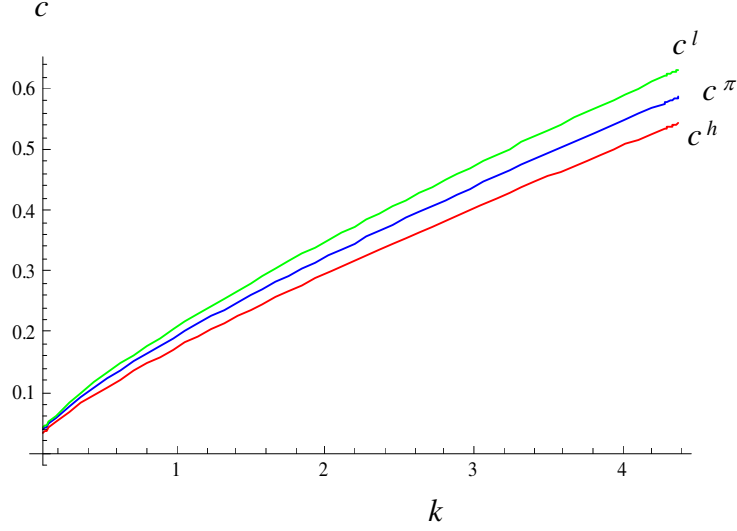


Figure 2: Consumption curves as functions of capital under uncertain T (c^π), low fossil energy price (c^l) and high fossil energy price (c^h). In this and the following figures we use the value $\pi = 0.1$ corresponding to $E\{T\} = 10$ years.

because the denominator of the second term is also positive at k^* . A crossing of the consumption curves (with $dc^l(k^*)/dk \leq dc^\pi(k^*)/dk$) can be ruled out also for $k^* > \hat{k}^l$ using the same argument, since the denominator is negative above \hat{k}^l . Thus,

$$c^\pi(k) < c^l(k) \quad \forall k > 0.$$

We wish to compare the uncertain consumption curve also to its high price counterpart, $c^h(\cdot)$. We use (3.9) to deduce from (3.8) that $P(\hat{k}^\pi) > 0$ hence $c^h(\hat{k}^\pi) < c^\pi(\hat{k}^\pi)$. To establish the same relation for smaller capital stocks, we assume otherwise, that $c^h(\tilde{k}) = c^\pi(\tilde{k})$ at some stock $\tilde{k} < \hat{k}^\pi$, where $dc^h(\tilde{k})/dk \leq dc^\pi(\tilde{k})/dk$ but $P(\tilde{k}) = 0$. This, however, implies (2.26) which can be ruled out via the same arguments used to establish Proposition 3. We summarize these considerations in Figure 2 and in

Proposition 4. *If $\beta\sigma(c) < 1 \quad \forall c$, then $c^h(k) < c^\pi(k) < c^l(k) \quad \forall k \in (0, \hat{k}^\pi]$.*

Uncertainty, then, reduces consumption but not by as much as would be implied by a prompt implementation of the tax.

3.2 The “Green Paradox”

The time trajectories of k^l and k^π are given, respectively, by the implicit solutions of (2.17):

$$t = \int_{k_0}^{k^l(t)} \frac{dk}{A(\zeta^l)k^\beta - \delta k - c^l(k)},$$

and

$$t = \int_{k_0}^{k^\pi(t)} \frac{dk}{A(\zeta^l)k^\beta - \delta k - c^\pi(k)}.$$

Thus, the relation $c^l(k) > c^\pi(k)$ implies that

$$k^l(t) < k^\pi(t) \quad \forall t > 0,$$

as indicated in Figure 3. Indeed, this result provides the manifestation of the “Green Paradox” effect in the case of uncertain T . Since both $k^l(\cdot)$ and $k^\pi(\cdot)$ proceed under the same price of fossil energy and with the same production technology, the larger $k^\pi(\cdot)$ process entails enhanced energy use at each point of time (until implementation), in contrast to the original purpose of the announcement. As in the case of a certain early announcement, preparing for the anticipated tax consists of accumulating a larger capital stock so that when the tax is eventually levied, the larger capital stock will partly compensate for the reduced energy use implied by the tax.

Interestingly, a comparison of the corresponding consumption time trajectories does not display the same simple pattern in time: With a higher steady state consumption, $c^\pi(t)$ must exceed $c^l(t)$ at large time (but prior to actual implementation). This relation between the consumption processes, however, cannot extend all the way back to $t = 0$ (when the capital stock equals k_0 under both regimes) because if it did, the relation between the capital processes displayed in Figure 3 would be reversed. The two consumption processes, therefore, must cross at some finite time, as shown in Figure 4. Efforts to prepare for the tax (in terms of reduced consumption) are concentrated at the early stages of the growth process, while at later times, parts of the fruits of the oversized capital (relative to the prevailing low fossil energy price) are used again to finance enhanced consumption.

4 Concluding comments

The model presented in this work suggests yet another mechanism to produce “paradoxical” outcomes of climate policies without resorting to the

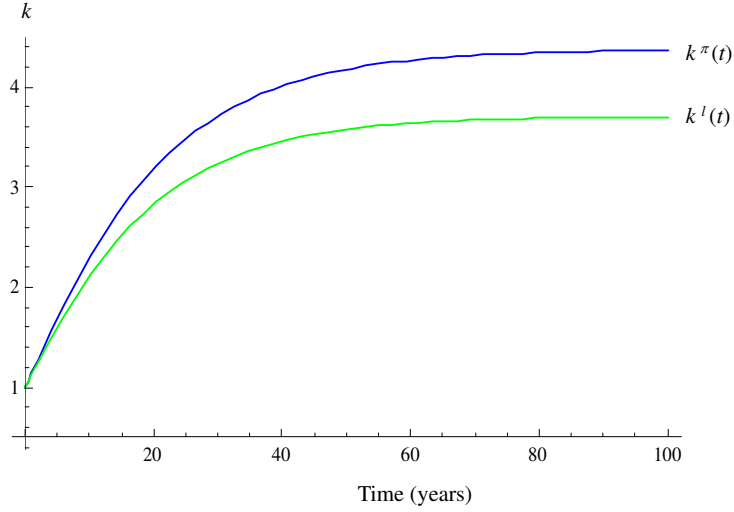


Figure 3: Capital time trajectories under uncertain T (k^π) and low fossil energy price (k^l).

scarcity of the fossil resource. Here, the effects are due to uncertainty regarding the timing of introducing the carbon tax. While the economic forces at work are similar to those driving the early announcement model of Smulders et al. (2009), the two mechanisms operate differently because in the present model economic agents cannot predict the tax implementation date at which they must ensure a smooth transition of the consumption process. In fact, consumption will undergo a discontinuous jump on this date and the adopted processes are tuned so as to minimize the expected utility loss associated with the jump. The solution involves delicate tradeoffs as manifested by the crossing of the time profiles of the consumption processes displayed in Figure 4. Nevertheless, the “paradoxical” effect of increased fossil energy use persists at all times until the tax policy is realized.

For brevity and simplicity of exposition, the results are presented in terms of the simplest specification of a Cobb-Douglas technology, constant hazard rate and a mild tax rate which does not imply a transition to a solar-based economy. As indicated by Smulders et al. (2009), none of these assumptions is essential and the “paradoxical” effect can be obtained in a more general setting, albeit at the cost of more tedious derivations.

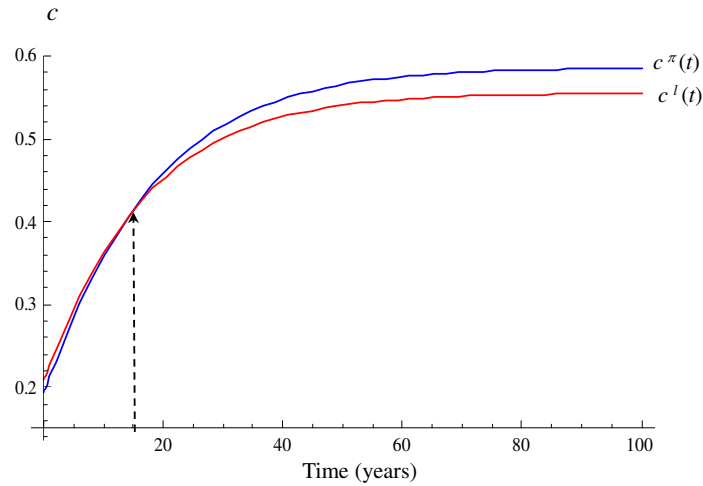


Figure 4: Consumption time trajectories under uncertain T (c^{π}) and low fossil energy price (c^l). The arrow indicates the time when the trajectories cross.

References

- Di Maria, C., Smulders, S. and van der Werf, E.: 2008, Absolute abundance and relative scarcity: Announced policy, resource extraction and carbon emissions. Fondazione Eni Enrico Mattei Working Paper 2008.92.
- Eichner, Th. and Pethig, R.: 2009, Carbon leakage, the Green Paradox and perfect future markets. CESifo Working Paper 2542.
- Sinn, H.-W.: 2008, Public policies against global warming, *International Tax and Public Finance* **15**, 360–394.
- Smulders, S., Tsur, Y. and Zemel, A.: 2009, Announcing climate policy: Can a Green Paradox arise without scarcity? CESifo Area Conference on Energy and Climate Economics, Munich.
- Tsur, Y. and Zemel, A.: 2009, Market structure and the penetration of alternative energy technologies. The Center for Agricultural Economic Research Discussion Paper 2.09.
URL: <http://ageconsearch.umn.edu/bitstream/47174/2/yacov-zemel.pdf>

PREVIOUS DISCUSSION PAPERS

- 1.01 Yoav Kislev - Water Markets (Hebrew).
- 2.01 Or Goldfarb and Yoav Kislev - Incorporating Uncertainty in Water Management (Hebrew).
- 3.01 Zvi Lerman, Yoav Kislev, Alon Kriss and David Biton - Agricultural Output and Productivity in the Former Soviet Republics.
- 4.01 Jonathan Lipow & Yakir Plessner - The Identification of Enemy Intentions through Observation of Long Lead-Time Military Preparations.
- 5.01 Csaba Csaki & Zvi Lerman - Land Reform and Farm Restructuring in Moldova: A Real Breakthrough?
- 6.01 Zvi Lerman - Perspectives on Future Research in Central and Eastern European Transition Agriculture.
- 7.01 Zvi Lerman - A Decade of Land Reform and Farm Restructuring: What Russia Can Learn from the World Experience.
- 8.01 Zvi Lerman - Institutions and Technologies for Subsistence Agriculture: How to Increase Commercialization.
- 9.01 Yoav Kislev & Evgeniya Vaksin - The Water Economy of Israel--An Illustrated Review. (Hebrew).
- 10.01 Csaba Csaki & Zvi Lerman - Land and Farm Structure in Poland.
- 11.01 Yoav Kislev - The Water Economy of Israel.
- 12.01 Or Goldfarb and Yoav Kislev - Water Management in Israel: Rules vs. Discretion.
- 1.02 Or Goldfarb and Yoav Kislev - A Sustainable Salt Regime in the Coastal Aquifer (Hebrew).
- 2.02 Aliza Fleischer and Yacov Tsur - Measuring the Recreational Value of Open Spaces.
- 3.02 Yair Mundlak, Donald F. Larson and Rita Butzer - Determinants of Agricultural Growth in Thailand, Indonesia and The Philippines.
- 4.02 Yacov Tsur and Amos Zemel - Growth, Scarcity and R&D.
- 5.02 Ayal Kimhi - Socio-Economic Determinants of Health and Physical Fitness in Southern Ethiopia.
- 6.02 Yoav Kislev - Urban Water in Israel.
- 7.02 Yoav Kislev - A Lecture: Prices of Water in the Time of Desalination. (Hebrew).

- 8.02 Yacov Tsur and Amos Zemel - On Knowledge-Based Economic Growth.
- 9.02 Yacov Tsur and Amos Zemel - Endangered aquifers: Groundwater management under threats of catastrophic events.
- 10.02 Uri Shani, Yacov Tsur and Amos Zemel - Optimal Dynamic Irrigation Schemes.
- 1.03 Yoav Kislev - The Reform in the Prices of Water for Agriculture (Hebrew).
- 2.03 Yair Mundlak - Economic growth: Lessons from two centuries of American Agriculture.
- 3.03 Yoav Kislev - Sub-Optimal Allocation of Fresh Water. (Hebrew).
- 4.03 Dirk J. Bezemer & Zvi Lerman - Rural Livelihoods in Armenia.
- 5.03 Catherine Benjamin and Ayal Kimhi - Farm Work, Off-Farm Work, and Hired Farm Labor: Estimating a Discrete-Choice Model of French Farm Couples' Labor Decisions.
- 6.03 Eli Feinerman, Israel Finkelshtain and Iddo Kan - On a Political Solution to the Nimby Conflict.
- 7.03 Arthur Fishman and Avi Simhon - Can Income Equality Increase Competitiveness?
- 8.03 Zvika Neeman, Daniele Paserman and Avi Simhon - Corruption and Openness.
- 9.03 Eric D. Gould, Omer Moav and Avi Simhon - The Mystery of Monogamy.
- 10.03 Ayal Kimhi - Plot Size and Maize Productivity in Zambia: The Inverse Relationship Re-examined.
- 11.03 Zvi Lerman and Ivan Stanchin - New Contract Arrangements in Turkmen Agriculture: Impacts on Productivity and Rural Incomes.
- 12.03 Yoav Kislev and Evgeniya Vaksin - Statistical Atlas of Agriculture in Israel - 2003-Update (Hebrew).
- 1.04 Sanjaya DeSilva, Robert E. Evenson, Ayal Kimhi - Labor Supervision and Transaction Costs: Evidence from Bicol Rice Farms.
- 2.04 Ayal Kimhi - Economic Well-Being in Rural Communities in Israel.
- 3.04 Ayal Kimhi - The Role of Agriculture in Rural Well-Being in Israel.
- 4.04 Ayal Kimhi - Gender Differences in Health and Nutrition in Southern Ethiopia.
- 5.04 Aliza Fleischer and Yacov Tsur - The Amenity Value of Agricultural Landscape and Rural-Urban Land Allocation.

- 6.04 Yacov Tsur and Amos Zemel – Resource Exploitation, Biodiversity and Ecological Events.
- 7.04 Yacov Tsur and Amos Zemel – Knowledge Spillover, Learning Incentives And Economic Growth.
- 8.04 Ayal Kimhi – Growth, Inequality and Labor Markets in LDCs: A Survey.
- 9.04 Ayal Kimhi – Gender and Intrahousehold Food Allocation in Southern Ethiopia
- 10.04 Yael Kachel, Yoav Kislev & Israel Finkelshtain – Equilibrium Contracts in The Israeli Citrus Industry.
- 11.04 Zvi Lerman, Csaba Csaki & Gershon Feder – Evolving Farm Structures and Land Use Patterns in Former Socialist Countries.
- 12.04 Margarita Grazhdaninova and Zvi Lerman – Allocative and Technical Efficiency of Corporate Farms.
- 13.04 Ruerd Ruben and Zvi Lerman – Why Nicaraguan Peasants Stay in Agricultural Production Cooperatives.
- 14.04 William M. Liefert, Zvi Lerman, Bruce Gardner and Eugenia Serova - Agricultural Labor in Russia: Efficiency and Profitability.
- 1.05 Yacov Tsur and Amos Zemel – Resource Exploitation, Biodiversity Loss and Ecological Events.
- 2.05 Zvi Lerman and Natalya Shagaida – Land Reform and Development of Agricultural Land Markets in Russia.
- 3.05 Ziv Bar-Shira, Israel Finkelshtain and Avi Simhon – Regulating Irrigation via Block-Rate Pricing: An Econometric Analysis.
- 4.05 Yacov Tsur and Amos Zemel – Welfare Measurement under Threats of Environmental Catastrophes.
- 5.05 Avner Ahituv and Ayal Kimhi – The Joint Dynamics of Off-Farm Employment and the Level of Farm Activity.
- 6.05 Aliza Fleischer and Marcelo Sternberg – The Economic Impact of Global Climate Change on Mediterranean Rangeland Ecosystems: A Space-for-Time Approach.
- 7.05 Yael Kachel and Israel Finkelshtain – Antitrust in the Agricultural Sector: A Comparative Review of Legislation in Israel, the United States and the European Union.
- 8.05 Zvi Lerman – Farm Fragmentation and Productivity Evidence from Georgia.
- 9.05 Zvi Lerman – The Impact of Land Reform on Rural Household Incomes in Transcaucasia and Central Asia.

- 10.05 Zvi Lerman and Dragos Cimpoeas – Land Consolidation as a Factor for Successful Development of Agriculture in Moldova.
- 11.05 Rimma Glukhikh, Zvi Lerman and Moshe Schwartz – Vulnerability and Risk Management among Turkmen Leaseholders.
- 12.05 R.Glukhikh, M. Schwartz, and Z. Lerman – Turkmenistan's New Private Farmers: The Effect of Human Capital on Performance.
- 13.05 Ayal Kimhi and Hila Rekah – The Simultaneous Evolution of Farm Size and Specialization: Dynamic Panel Data Evidence from Israeli Farm Communities.
- 14.05 Jonathan Lipow and Yakir Plessner - Death (Machines) and Taxes.
- 1.06 Yacov Tsur and Amos Zemel – Regulating Environmental Threats.
- 2.06 Yacov Tsur and Amos Zemel - Endogenous Recombinant Growth.
- 3.06 Yuval Dolev and Ayal Kimhi – Survival and Growth of Family Farms in Israel: 1971-1995.
- 4.06 Saul Lach, Yaacov Ritov and Avi Simhon – Longevity across Generations.
- 5.06 Anat Tchetchik, Aliza Fleischer and Israel Finkelshtain – Differentiation & Synergies in Rural Tourism: Evidence from Israel.
- 6.06 Israel Finkelshtain and Yael Kachel – The Organization of Agricultural Exports: Lessons from Reforms in Israel.
- 7.06 Zvi Lerman, David Sedik, Nikolai Pugachev and Aleksandr Goncharuk – Ukraine after 2000: A Fundamental Change in Land and Farm Policy?
- 8.06 Zvi Lerman and William R. Sutton – Productivity and Efficiency of Small and Large Farms in Moldova.
- 9.06 Bruce Gardner and Zvi Lerman – Agricultural Cooperative Enterprise in the Transition from Socialist Collective Farming.
- 10.06 Zvi Lerman and Dragos Cimpoeas - Duality of Farm Structure in Transition Agriculture: The Case of Moldova.
- 11.06 Yael Kachel and Israel Finkelshtain – Economic Analysis of Cooperation In Fish Marketing. (Hebrew)
- 12.06 Anat Tchetchik, Aliza Fleischer and Israel Finkelshtain – Rural Tourism: Development, Public Intervention and Lessons from the Israeli Experience.
- 13.06 Gregory Brock, Margarita Grazhdaninova, Zvi Lerman, and Vasilii Uzun - Technical Efficiency in Russian Agriculture.

- 14.06 Amir Heiman and Oded Lowengart - Ostrich or a Leopard – Communication Response Strategies to Post-Exposure of Negative Information about Health Hazards in Foods
- 15.06 Ayal Kimhi and Ofir D. Rubin – Assessing the Response of Farm Households to Dairy Policy Reform in Israel.
- 16.06 Iddo Kan, Ayal Kimhi and Zvi Lerman – Farm Output, Non-Farm Income, and Commercialization in Rural Georgia.
- 17.06 Aliza Fleishcer and Judith Rivlin – Quality, Quantity and Time Issues in Demand for Vacations.
- 1.07 Joseph Gogodze, Iddo Kan and Ayal Kimhi – Land Reform and Rural Well Being in the Republic of Georgia: 1996-2003.
- 2.07 Uri Shani, Yacov Tsur, Amos Zemel & David Zilberman – Irrigation Production Functions with Water-Capital Substitution.
- 3.07 Masahiko Gemma and Yacov Tsur – The Stabilization Value of Groundwater and Conjunctive Water Management under Uncertainty.
- 4.07 Ayal Kimhi – Does Land Reform in Transition Countries Increase Child Labor? Evidence from the Republic of Georgia.
- 5.07 Larry Karp and Yacov Tsur – Climate Policy When the Distant Future Matters: Catastrophic Events with Hyperbolic Discounting.
- 6.07 Gilad Axelrad and Eli Feinerman – Regional Planning of Wastewater Reuse for Irrigation and River Rehabilitation.
- 7.07 Zvi Lerman – Land Reform, Farm Structure, and Agricultural Performance in CIS Countries.
- 8.07 Ivan Stanchin and Zvi Lerman – Water in Turkmenistan.
- 9.07 Larry Karp and Yacov Tsur – Discounting and Climate Change Policy.
- 10.07 Xinshen Diao, Ariel Dinar, Terry Roe and Yacov Tsur – A General Equilibrium Analysis of Conjunctive Ground and Surface Water Use with an Application To Morocco.
- 11.07 Barry K. Goodwin, Ashok K. Mishra and Ayal Kimhi – Household Time Allocation and Endogenous Farm Structure: Implications for the Design of Agricultural Policies.
- 12.07 Iddo Kan, Arie Leizarowitz and Yacov Tsur - Dynamic-spatial management of coastal aquifers.
- 13.07 Yacov Tsur and Amos Zemel – Climate change policy in a growing economy under catastrophic risks.

- 14.07 Zvi Lerman and David J. Sedik – Productivity and Efficiency of Corporate and Individual Farms in Ukraine.
- 15.07 Zvi Lerman and David J. Sedik – The Role of Land Markets in Improving Rural Incomes.
- 16.07 Ayal Kimhi – Regression-Based Inequality Decomposition: A Critical Review And Application to Farm-Household Income Data.
- 17.07 Ayal Kimhi and Hila Rekah – Are Changes in Farm Size and Labor Allocation Structurally Related? Dynamic Panel Evidence from Israel.
- 18.07 Larry Karp and Yacov Tsur – Time Perspective, Discounting and Climate Change Policy.
- 1.08 Yair Mundlak, Rita Butzer and Donald F. Larson – Heterogeneous Technology and Panel Data: The Case of the Agricultural Production Function.
- 2.08 Zvi Lerman – Tajikistan: An Overview of Land and Farm Structure Reforms.
- 3.08 Dmitry Zvyagintsev, Olga Shick, Eugenia Serova and Zvi Lerman – Diversification of Rural Incomes and Non-Farm Rural Employment: Evidence from Russia.
- 4.08 Dragos Cimpoeies and Zvi Lerman – Land Policy and Farm Efficiency: The Lessons of Moldova.
- 5.08 Ayal Kimhi – Has Debt Restructuring Facilitated Structural Transformation on Israeli Family Farms?.
- 6.08 Yacov Tsur and Amos Zemel – Endogenous Discounting and Climate Policy.
- 7.08 Zvi Lerman – Agricultural Development in Uzbekistan: The Effect of Ongoing Reforms.
- 8.08 Iddo Kan, Ofira Ayalon and Roy Federman – Economic Efficiency of Compost Production: The Case of Israel.
- 9.08 Iddo Kan, David Haim, Mickey Rapoport-Rom and Mordechai Shechter – Environmental Amenities and Optimal Agricultural Land Use: The Case of Israel.
- 10.08 Goetz, Linde, von Cramon-Taubadel, Stephan and Kachel, Yael - Measuring Price Transmission in the International Fresh Fruit and Vegetable Supply Chain: The Case of Israeli Grapefruit Exports to the EU.
- 11.08 Yuval Dolev and Ayal Kimhi – Does Farm Size Really Converge? The Role Of Unobserved Farm Efficiency.
- 12.08 Jonathan Kaminski – Changing Incentives to Sow Cotton for African Farmers: Evidence from the Burkina Faso Reform.
- 13.08 Jonathan Kaminski – Wealth, Living Standards and Perceptions in a Cotton Economy: Evidence from the Cotton Reform in Burkina Faso.

- 14.08 Arthur Fishman, Israel Finkelshtain, Avi Simhon & Nira Yacouel – The Economics of Collective Brands.
- 15.08 Zvi Lerman - Farm Debt in Transition: The Problem and Possible Solutions.
- 16.08 Zvi Lerman and David Sedik – The Economic Effects of Land Reform in Central Asia: The Case of Tajikistan.
- 17.08 Ayal Kimhi – Male Income, Female Income, and Household Income Inequality in Israel: A Decomposition Analysis
- 1.09 Yacov Tsur – On the Theory and Practice of Water Regulation.
- 2.09 Yacov Tsur and Amos Zemel – Market Structure and the Penetration of Alternative Energy Technologies.
- 3.09 Ayal Kimhi – Entrepreneurship and Income Inequality in Southern Ethiopia.
- 4.09 Ayal Kimhi – Revitalizing and Modernizing Smallholder Agriculture for Food Security, Rural Development and Demobilization in a Post-War Country: The Case of the Aldeia Nova Project in Angola.
- 5.09 Jonathan Kaminski, Derek Headey, and Tanguy Bernard – Institutional Reform in the Burkinabe Cotton Sector and its Impacts on Incomes and Food Security: 1996-2006.
- 6.09 Yuko Arayama, Jong Moo Kim, and Ayal Kimhi – Identifying Determinants of Income Inequality in the Presence of Multiple Income Sources: The Case of Korean Farm Households.
- 7.09 Arie Leizarowitz and Yacov Tsur – Resource Management with Stochastic Recharge and Environmental Threats.
- 8.09 Ayal Kimhi - Demand for On-Farm Permanent Hired Labor in Family Holdings: A Comment.
- 9.09 Ayal Kimhi – On the Interpretation (and Misinterpretation) of Inequality Decompositions by Income Sources.
- 10.09 Ayal Kimhi – Land Reform and Farm-Household Income Inequality: The Case of Georgia.
- 11.09 Zvi Lerman and David Sedik – Agrarian Reform in Kyrgyzstan: Achievements and the Unfinished Agenda.
- 12.09 Zvi Lerman and David Sedik – Farm Debt in Transition Countries: Lessons for Tajikistan.
- 13.09 Zvi Lerman and David Sedik – Sources of Agricultural Productivity Growth in Central Asia: The Case of Tajikistan and Uzbekistan.
- 14.09 Zvi Lerman – Agricultural Recovery and Individual Land Tenure: Lessons from Central Asia.

- 15.09 Yacov Tsur and Amos Zemel – On the Dynamics of Competing Energy Sources.
- 16.09 Jonathan Kaminski – Contracting with Smallholders under Joint Liability.
- 1.10 Sjak Smulders, Yacov Tsur and Amos Zemel – Uncertain Climate Policy and the Green Paradox