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(4.49) $\left[\frac{dy_2}{dv_1}\right]_U = \frac{q_1}{p_2}$ where q_1 is the price of factor v_1, p_2 is the price of good y_2

From profit maximization:

(4.50) $\left[\frac{dy_2}{dv_1}\right]_f = \frac{q_1}{p_2}$

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The links and correlations are partly weak and partly suggesting interesting research topics. Certainly much more empirical, not only experimental research is needed. But there is a chance to work in interdisciplinary ways along these lines to formulate and test more specific hypotheses. How individual creativity and other capacities of problem solving can be combined in teams facing the challenge to adapt to a yet unknown future is worthy of the attention of economics, psychology and beyond.

This special issue contains contributions, presented at the 41st annual Economics Seminar in Ottobeuren in September 2011. The articles underwent a conventional refereeing process (without desk rejection.) As organizers we thank the authors, the presenters and their commentators for the lively exchange at the Ottobeuren 2011 event. We also would like to express our gratitude to all who served as referees including graduate students of the Frankfurt School of Finance and Management who handed in additional reports, in particular Philipp Boeing, Niels Detering and Florian Gunsilius. The work of Sarah-Lea Effert deserves particular mentioning.

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Schumpeterian Innovation and Preference Adaptation

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Abstract: If preferences are endogenous can we still maintain cost-benefit analysis based on individual preferences rather than collectivist value judgements ? The answer is "yes" if preference changes are « adaptive » and the projects to be evaluated are "trend" projects.

JEL codes : D60, D61, D11
Keywords: adaptive preferences; cost-benefit analysis; Schumpeterian innovation

1. An Introduction: Adaptive Preferences

This paper is part of a larger project of mine (see von Weizsäcker 2013). In this project I try to tackle the following problem: Traditional welfare economics operates with the assumption that preferences are exogenously given. In that approach preferences are the measuring rod of economic performance: the better individual wants - as defined by these preferences - are fulfilled the better is the performance of the economy. The purpose of the whole exercise was and is the establishment of a theory of economic welfare on an individualistic basis, i.e. a theory which basically tries to avoid collectivist value judgements about the well-being of individuals imposed on them rather *than* chosen by themselves. But agents' preferences *are* influenced by their economic and social environment. Can we still do welfare economics on an individualistic basis, if preferences are influenced by the economic and social environment of the agents' preferences, i.e. if the measuring rod itself changes with the object it is supposed to measure?

I believe the answer is yes – provided certain assumptions about the "laws of motion" of preferences are compatible with the real world. The

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core assumption is that of *adaptive preferences*. I briefly explain this basic concept. For ease of presentation I work with a cardinal concept of utility. But due to a theorem which I will not present here, it is also possible to give a completely ordinal interpretation of the results.

Also, for ease of presentation I concentrate on the case that preferences are only influenced by past consumption. Let *x(t)* be the consumption vector of a person as a function of time t. Then *x(t)* is a non-negative vector in n-dimensional Euclidean space. Let *q(t)* be an exponentially weighted average of past consumption. The vector *q(t)* is an indicator of the prevailing preferences at time *t*. We then have a utility function *u(x;q)*. We assume that preferences *q(t)* follow the following linear vector differential equation

$$\frac{dq}{dt} = \alpha(x(t) - q(t)) \qquad (1)$$

where $\alpha > 0$ is a real number. Observe that for a vector x which is constant through time the vector q converges to x. We introduce the concept of *preferences corresponding to x*. These are the preferences which remain constant through time, if x remains constant through time. Thus, given our differential equation, preferences x are the preferences which correspond to x.

I now introduce the purely ordinal concept of *adaptive preferences*. I introduce the following notation: *y(<;q)x* means: given preferences q basket y is preferred over basket x.

Definition Preferences are adaptive, if the following holds: Let x and y be any two consumption vectors. If *y(>x)x* then *y(>y)x*.

In words, adaptive preferences prevail, if the following holds:
For any two baskets y and x: if y is preferred over x, given preferences which correspond to x then –a fortiori –y is preferred over x, given preferences which correspond to y.

To put it differently: adaptive preferences make any basket x at least as highly esteemed if preferences corresponding to x prevail as when preferences corresponding to another basket prevail.

I believe that I can show that the assumption of adaptive preferences is *realistic*. Take just one example: the well-known endowment effect. People who by accident have obtained object A value A higher than people who by accident don't own such an object.

For cardinal utility functions adaptive preferences can be expressed by the following inequality. Let q and x be two baskets. Then the utility of x

if x prevails is as high as the utility of x under q, i.e., $u(x;x) \geq u(x;q)$. Cardinal utility of any given basket x is highest, when preferences prevail which correspond to that basket. This implies that as long as consumption remains the same through time utility associated with x tends to rise and converges to the highest possible value associated with basket x.

2. Decentralised Decision Making

Welfare economics has a side in "high theory" with the First and Second Fundamental Theorem of Welfare Economics. But it also has a very practical side with cost-benefit analysis. This practical side is very much linked to the concept of what I like to call "incremental efficiency" – or Kaldor- Hicks- Scitovsky efficiency. The basic usefulness of this cost-benefit approach relies on partial equilibrium analysis – as opposed to general equilibrium analysis.

Cost-benefit analysis is used all the time in policy making, but also in private decisions by individuals or firms or associations. It is a method, which intellectually isolates certain parts of the world from the rest of the world and then concentrates on these parts, which appear to be relevant for the issue at hand. Parliament has to decide whether to change a certain law. A firm has to decide whether to make a certain investment in order to enlarge its production capacity. A Schumpeterian entrepreneur has to decide whether to introduce an innovation in the market. An individual has to decide whether to accept a certain job offer or not. The "rest of the world" generally is represented by the money involved in the particular decision. It is "money" and market prices which make sure that the wider context of the particular decision is taken account of (Hayek 1945). To the extent that this kind of representation of the interdependence of everything with everything is appropriate, the "money form" of this representation makes decision taking vastly simpler than it would otherwise be. This vast simplification is the prerequisite for a world in which a very large number of decisions can take place simultaneously. Without such simplification the number of feasible simultaneous decisions would have to be very much lower. Society could not have obtained its present degree of complexity and could not draw on its present high degree of the division of labour[1]. Without the money form of representation of the wider world the status quo bias in the form of "non-decision" would be absolutely dominant.

[1] "The greatest improvement in the productive powers of labour, and the greater part of the skill, dexterity, and judgement with which it is anywhere directed, or applied, seem to have been the effects of the division of labour." (Smith 1979 [1776]: Book 1 Chapter 1)

Economists have investigated the conditions under which it is appropriate to do this partial equilibrium exercise which is involved in any cost-benefit analysis. The general presumption here is the all-round existence of reasonably competitive markets. Without going into the details of these analyses it is so far clear that they all rely on the assumption that members of the economy are people who maximise an ordinal utility function which is exogenously given.

In the following I show that there is hope that we can carry over such analyses to a world of adaptive preferences.

3. Smoothly Adaptive Preferences

As stated, the basic concept of my general approach is the concept of adaptive preferences. For purposes of deriving theorems with my rather modest mathematical skills, I sometimes use a somewhat stronger assumption which I call smoothly adaptive preferences. Thus, also here for purposes of cost-benefit analysis, I stick to this stronger assumption. Later work may allow us to generalise the theory to weaker versions of the assumption of adaptive preferences. In this particular paper I use a version of smoothly adaptive preferences which is overly strong: with more cumbersome mathematics I could have used a weaker version of smoothly adaptive preferences.

Definition I first introduce the relation *"more similar than... to..."*. We write $q(x)\overline{q}$ for "q is more similar to x than is $\overline{q}$ and this relation between q and $\overline{q}$ is fulfilled if we have the following inequalities

$$|x_i - q_i| \le |x_i - \overline{q}_i| \text{ for } i = 1,2,\ldots.n \qquad (2)$$

and

$$(x_i - q_i)(x_i - \overline{q}_i) \ge 0 \text{ for } i = 1,2,\ldots.n \qquad (3)$$

In words: q is more similar to x than is $\overline{q}$, if the distance between q and x is smaller in each vector component than the distance between $\overline{q}$ and x and if in addition q and $\overline{q}$ are on the same side of x in each vector component. To put it differently: q is said to be more similar to x than $\overline{q}$ if any reasonable distance measure would yield the result that the distance between x and q is smaller than the distance between x and $\overline{q}$. Note that this definition of "similarity" to a third vector does not make each pair of vectors comparable in terms of similarity to a third vector.

Now I make the *Assumption of smooth adaptive preferences: If preferences q are more similar to corresponding preferences x than are preferences $\overline{q}$ then $u(x;q) \ge u(x;\overline{q})$* .

Since adaptive preferences already mean $u(x;x) \ge u(x;q)$ the addition of smoothness mainly means that utility for the basket x is higher if preferences are closer to the utility peak at preferences which correspond to the basket x. Given the differential equation

$$\frac{dq}{dt} = \alpha(x(t) - q(t))$$

it is clear that as long as x remains the same q becomes more similar to x through time.

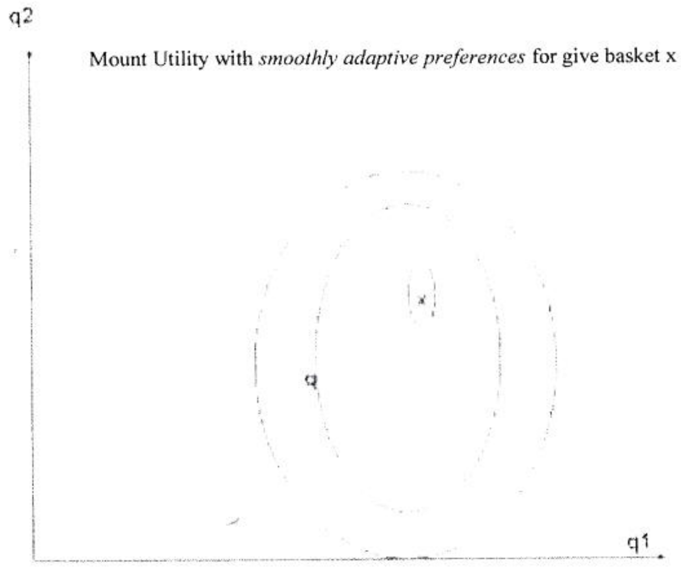

Figure 1: Mount Utility with smoothly adaptive preferences for given basket x

4. A Theorem

Cost-benefit analysis is about policy choices between different alternatives. In the simplest case we answer a single "yes or no" question. Should a certain bridge be built? Should a certain legislative proposal be adopted or not? Does a certain innovation enhance welfare or not? I look at this simplest case. Thus, we may have to decide between two paths of consumption vectors *x(t)* and *z(t)*. With them preferences change by means of the differential equations discussed before. Let *q(t)* be the preferences corresponding to path *x(t)* and let *r(t)* be the preferences corresponding to path *z(t)*. Thus we have the differential equations

$$\dot{q} = \alpha(x - q) \quad \text{and} \quad \dot{r} = \alpha(z - r) \tag{4}$$

We can assume that the two alternative paths have identical starting points so that *z(0) = x(0)* and *r(0) = q(0)*.

In the following I treat the paths *x(t)* and *z(t)* asymmetrically. Here *x(t)* is the "default option", i.e. the state of the world, in the case of "non-decision": the law is not changed, the bridge is not built, or the innovation is not introduced. It does not mean that *x(t)* is a stationary path. It could be a growing or shrinking economy. Any kind and number of decisions may be taken in the economy at large which have an expected influence on *x(t)*. Following the partial equilibrium philosophy of cost-benefit analysis we take these other developments as given and only look at the particular decision at hand: whether to change the world by implementing *z(t)* or not, the latter implying that the world is *x(t)*.

Now, the decision between *x(t)* and *z(t)* is taken so to speak with "preferences corresponding to *x(t)*". I will not make this precise here. It is precise in the case that *x(t)* is a stationary path and that preferences already correspond to this stationary path. If, as realistically is the case, *x(t)* is not stationary, and also not expected to be stationary by the decision makers, we may have a large array of possibilities concerning the preferences expected to be prevailing along the path. But, I adhere to the assumption that the movement of the preferences through time corresponds to the specified differential equations. Yet, we have some freedom in the choice of initial preferences *q(0) = r(0)*. They need not correspond to the initial value *x(0)* of *x(t)*.

Let us now observe that changes due to certain measures like building a bridge or changing the law or product innovations evolve through time. The impact of these measures rises through time. Thus, it is of interest to consider divergences between *z(t)* and *x(t)* which become larger through time. Such a pair of paths I call: a pair of paths with "monotonic divergence". The precise definition is the following:

Definition There is *monotonic divergence* between *x(t)* and *z(t)* on the time interval *i [0,T]* with *z(0) = x(0)* if the following holds:

1. for each component $i, i = 1,2,....n$ either $z_i(t) - x_i(t) > 0$ for all $t \in (0;T]$ or $z_i(t) - x_i(t) < 0$ for all $t \in (0;T]$ or $z_i(t) = x_i(t)$ for $t \in [0;T]$.
2. If $z_i(t) - x_i(t) > 0$ then $z_i(t) - x_i(t) \geq z_i(\tau) - x_i(\tau)$ for $t > \tau$; if $z_i(t) - x_i(t) < 0$ then $z_i(t) - x_i(t) \leq z_i(\tau) - x_i(\tau)$ for $t > \tau$.

A further distinction is important: the project implementing *z(t)* rather than "the default" *x(t)* either can be in the general trend of goings-on or it can be the opposite, i.e. against the trend. The theorem I prove below only applies to *trend-projects*. This concept refers to the relation of actual consumption to actual preferences. If there is a prevailing general trend, which deviations from the default take, we expect preferences to lag behind the actual developments, due to adaptive preferences. As an example take food. We have observed a trend of substitution from food which requires a lot of work of the cook in the household towards ready made food products which require much less work in the household. The tastes of people lagged behind this development and thus also retarded it, because people who were used to self-cooked food first had aversions against the "new" labour saving mode of nourishment.

Definition A project which implements *z(t)* rather than the "default" *x(t)* with monotonic divergence is called a *trend project*, if on the time interval *[0,T]* for each *i = 1,2...n* the following inequality holds $((z_i(t) - x_i(t))(x_i(t) - q_i(t)) \geq 0$.

Thus, for a monotonically diverging trend project we have: if $z_i(t) - x_i(t) > 0$ then $x_i(t) - q_i(t) \geq 0$. If $z_i(t) - x_i(t) < 0$ then $x_i(t) - q_i(t) \leq 0$. For such a project the "direction" of the change, as indicated by the "i´s" with inequalities $z_i(t) - x_i(t) > 0$ and the "i´s" with inequalities $z_i(t) - x_i(t) < 0$ is in line with the recent direction of the economy at large as traced by the lag of preferences relative to actual consumption, i.e. as traced by the inequalities $x_i(t) - q_i(t) \geq 0$ and $x_i(t) - q_i(t) \leq 0$.

Figure 2: Trend Project

For trend projects we then can prove the following:

Theorem Assume smoothly adaptive preferences. Assume that the pair of paths *x(t)* and *z(t)* is characterised by monotonic divergence on a time interval *[0,T]* and that *z(0) = x(0)*. Assume further that the project involved is a trend project. Then, for any $t \in [0,T]$ we have

$$u(z(t);r(t)) \geq u(z(t);q(t)) \tag{5}$$

Proof Solving the differential equations for *q(t)* and *r(t)* yields the n equations

$$r_i(t) - q_i(t) = \alpha e^{-\alpha t}\int_0^t e^{\alpha\tau}(z_i(\tau) - x_i(\tau))d\tau \text{ for } i = 1,2...n \tag{6}$$

If $z_i(t) - x_i(t) \geq 0$ then by monotonic divergence we have

$$z_i(t) - x_i(t) \geq z_i(\tau) - x_i(\tau) \text{ for } t \geq \tau \tag{7}$$

And thus

$$r_i(t) - q_i(t) \geq 0 \tag{8}$$

But

$$r_i(t) - q_i(t) \leq \alpha e^{-\alpha t}\int_0^t e^{\alpha\tau}(z_i(t) - x_i(t))d\tau \leq z_i(t) - x_i(t) \tag{9}$$

Then, by the characteristic of a trend project we have

$$r_i(t) - z_i(t) \leq q_i(t) - x_i(t) \leq 0 \tag{10}$$

which, together with $r_i(t) - q_i(t) \geq 0$, implies

$$q_i(t) \leq r_i(t) \leq z_i(t) \tag{11}$$

Similarly we show for $z_i(t) - x_i t) \leq 0$ that

$$r_i(t) - q_i(t) \leq 0, \tag{12}$$

but

$$r_i(t) - q_i(t) \geq \alpha e^{-\alpha t}\int_0^t e^{\alpha\tau}(z_i(t) - x_i(t))d\tau \geq z_i(t) - x_i(t) \tag{13}$$

and therefore

$$q_i(t) \geq r_i(t) \geq z_i(t) \tag{14}$$

Thus we have shown that $r(t)(z(t)q(t)$(in words: *r(t)* is more similar to *z(t)* than is *q(t)*, which by the assumption of smooth adaptive preferences implies

$$u(z(t);r(t)) \geq u(z(t);q(t)). \tag{15}$$

Q.E.D.

5. Economic Meaning of the Theorem

What is the economic meaning of this theorem? Assume a society is confronted with the decision to either go path *x(t)* or to go path *z(t)*. As discussed before *x(t)* is the "default option" and thus preferences which influence the decision are those which evolve along the path *x(t)*. If, with these anticipated preferences *q(t)* society decides to choose path *z(t)* then – the theorem says – having chosen path *z(t)* and thus now being associated with the unanticipated preferences *r(t)*, society will not regret to have preferred *z(t)* over *x(t)*, provided the project was a trend project with monotonic divergence.

Take a few examples. Government decides to build the bridge. Then the ensuing impact of the bridge on preferences a fortiori justifies ex post that it was right to have built the bridge. Or, Parliament decides to change a law, which encourages the movement of consumption in the already established trend. Then the ensuing impact of the new law on preferences a fortiori justifies the change in the law. Or, we are in a market economy and an innovative firm introduces a new product in the market. It calculates this to be profitable given the pre-existing preferences of consumers. Then a fortiori the innovation will be profitable with the preference change induced by the new product. Innovations tend to be trend projects in the sense defined above.

We should note that project characteristics of monotonic divergence and being in trend are *sufficient* conditions for the ex-post justification of a project undertaken with ex-ante preferences. I have little doubt that further research will provide other classes of projects which also have this property. But there will of course be exceptions.

The general message then is: it remains possible to do cost-benefit analysis even with endogenously changing preferences as long as the "law of motion" of the preferences conforms to smoothly adaptive preferences. Thus the advantages of decentralisation (say, by markets) of social decisions which economists implicitly or explicitly rely on by explicitly or implicitly assuming fixed preferences can remain valid also if preferences are not fixed, but smoothly adaptive.

But we also should note the following: *the converse is not true.* If with preferences $r(t)$ the choice of $z(t)$ over $x(t)$ is justified and thus this choice would not be regretted afterwards, there is no guarantee that $z(t)$ will be chosen, given that the decision is taken with (expected) preferences $q(t)$. In other words: for the class of changes investigated a decision for change taken with present preferences is a sufficient condition for the decision to be right in view of the feedback of the change on preferences; but it is not a necessary condition. Thus, with adaptive preferences there is less change in terms of legislation, investment in infrastructure and innovations than could be justified. In this sense adaptive preferences generate a conservative bias.

I believe that there are good evolutionary reasons for the hypothesis that human preferences are adaptive. But, beyond that speculation about the evolution of human nature, adaptive preferences (with the special case of fixed preferences included) also seem to be an anthropological requisite of the astounding success of world society to generate wealth so much above the level of subsistence and with so high a world population. As said in this paper before, the high complexity (high degree of the division of labour) of a modern wealth generating society as we observe it in the OECD countries requires decision making in the partial equilibrium mode, i.e. in the cost-benefit mode described above.

Assume now the opposite of adaptive preferences. Thus, with the choice of $z(t)$ rather than the default option $x(t)$, the attractiveness of $z(t)$ declines in comparison with the preferences of $x(t)$, under which the decision to choose $z(t)$ had been made. In that case, from the welfare economic point of view it would be much more difficult to justify the partial-equilibrium, i.e., the decentralised decision mode. Also psychologically, disappointment about decisions would abound and thus people would become much more prone to avoid decisions altogether. In a loose sense we then can consider the success of the Western "wealth machine" itself to be a proof of the hypothesis of adaptive preferences.

6. Conclusion

Economic evolution led to a highly complex and highly successful economic system in the western world. According to the very concept of evolution in the Darwinian tradition this development came about by highly decentralised decision making. In so many cases small parts of society did not take the default option of the status quo. The institutional set-up happened to be one in which decisions for change on average tended to be decisions for the better rather than for the worse. There was an "efficiency filter" for change built in the institutions which provided that the changes were efficient in most cases. But all these concepts of efficiency relied on a measuring rod of fixed preferences. My theory is that we can extend this traditional theory to a more evolutionary measuring rod, i.e. adaptive preferences: changes which are efficient given ex ante preferences remain efficient for ex-post preferences and thus are not regretted afterwards.

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