ISSN 1651-0852

FIEF Working Paper Series 2002

No. 178

Economic Growth, Inequality, Democratization, and the Environment*

by

Clas Eriksson[†] and Joakim Persson[‡]

Abstract

We augment the Stokey (1998) model by allowing agents to differ with respect to environmental quality and income in order to analyze the impact of income and environmental inequality, and of democratization on aggregate pollution. We find that the impact of a more equal income distribution depends on the degree of democracy. In a complete democracy a more equal income distribution generates, *ceteris paribus*, less pollution, which is consistent with indirect empirical evidence, whereas the opposite is the case if democratic rights are highly restricted. Furthermore, a democratization is argued to typically lower both the income and the environmental quality of the median voter. In this case, if, in utility terms, the fall in environmental quality is worse than the fall in consumption the median voter decides to tighten environmental legislation so that aggregate pollution decreases.

Keywords: Economic growth and the environment; inequality; politics
JEL classification: O41, Q20, Q30

August 16, 2002

---

* We are grateful for comments from seminar participants at the Swedish University of Agricultural Sciences, Dalarna University and Umeå University. In addition, we thank Fredrik Carlsson, Rob Hart, Susanna Lundström, Michael Rauscher and three anonymous referees of this journal for useful suggestions.

† Corresponding author. Swedish University of Agricultural Sciences, Department of Economics, P.O. Box 7013, SE-750 07 Uppsala, Sweden. Telephone: 46-18-671000. E-mail: clas.eriksson@ekon.slu.se .

‡ Trade Union Institute for Economic Research, Wallingatan 38, SE-111 24 Stockholm, Sweden. Telephone: 46-8-240450. E-mail: j.persson@fief.se .

1. Introduction

A number of empirical studies on the relationship between pollution and economic growth have been conducted in the past ten years (e.g. Grossman and Krueger, 1993, 1995; Hettige et al., 1992; Holtz-Eakin and Selden, 1995; and Selden and Song, 1994). These studies report an inverse U-shaped relation between pollution and the level of economic development for some pollutants. The more local (in space and time) the effects of different pollutants are, the more likely it appears that this inverse U-shaped pollution-income pattern applies[1]. Because of its similarity to the pattern of income inequality documented by Kuznets (1955), an inverse U-shaped pollution-income pattern is often called an Environmental Kuznets Curve (EKC). However, it should be emphasized that these empirical findings are debated (e.g. Ekins, 1997; Harbaugh et al., 2000), and that there are warnings against exaggerated optimism based on them (Arrow et al., 1995).

As the empirical evidence typically relies on reduced-form regressions of environmental quality on income per capita and other explanatory variables, they do not shed light on the causes of the inverse U-shaped pollution-income pattern. As a result, a number of explanations have been put forward. One explanation is that the pattern arises because different sectors have different pollution intensities. During the course of development there is a movement from clean agrarian economy to dirty manufacturing economy to clean service economy (Arrow et al., 1995). Other explanations rely on corner solutions. For example, Stokey (1998) develops a model where the social planner chooses the pollution intensity of the production technology. At incomes below a critical level there are no pollution controls and the most polluting technology is therefore used. As a result, total pollution increases with production. Above the critical level, emission standards become tougher and total pollution declines (given that the marginal benefit of higher consumption decreases rapidly). Also John and Pecchenino (1994) rely on a corner solution (in the context of an overlapping generation model) to produce an inverse U-shaped pollution-income pattern. The critical assumption of Andreoni and Levinson (2001), on the other hand, is that the pollution abatement technology exhibits

[1] Two possible reasons for this is that it is difficult to reach international agreements on emissions reductions and that it is impossible to reach agreements with future generations. For recent analyzes of these issues, see Kaitala et al. (1995), von Amsberg (1995), and Perman et al. (1999, Ch. 13).

increasing returns to scale. Other papers in the strand of literature that provides possible explanations for the inverted U-shaped pollution-income pattern include Ansuategi and Perrings (2000), Jones and Manuelli (2001), and Lopez (1994). (A survey is given by Vogel, 1999.)

This paper adds a new element to the theoretical literature on the EKC. We introduce agent heterogeneity in both environmental quality and income[2]. By allowing for heterogeneous agents, it is possible to study the impact of income and environmental inequality as well as the degree of democracy on aggregate environmental quality[3]. Empirical evidence suggests that these factors are relevant. For example, Harbaugh et al. (2000) find that countries that are more democratic tend to pollute less (in terms of SO2) than countries that are less democratic, when holding the level of income per capita (and other controls) constant. In an earlier study, Grossman and Krueger (1993, tables 2-4) find that communist countries tend to pollute more than non-communist countries, when holding income per capita and other explana-tory variables constant. In addition, the World Development Report (1992, pp.1-2) strongly supports the hypothesis that inequality in environmental quality across individuals within countries is present and moreover that environmental quality tends to be correlated with income. It states that "it is often the poorest who suffer most from the consequences of pollution and environmental degradation" and that "sound environmental policies are thus likely to be powerfully redistributive".

In this paper we analyze the impact on aggregate pollution of changes in income and environmental inequality and in the degree of democracy when the average level of productivity per voter is held constant. Thus, the focus is here on exogenous changes in inequality and in the degree of democracy; that is, on changes that are not linked to the level of development. The aim is not to explain why an EKC might arise but rather to provide insights on why some countries pollute more than others, when holding the level of economic development constant.

---

[2] Also Marsiliani and Renström (2000) allow agents to differ with respect to income. In contrast to our model, they do, however, not allow environmental quality to differ across individuals.

[3] In contrast, by using the representative agent framework the issue of aggregating divergent views is avoided. Stokey (1998, p. 22), e.g., states that "the optimal regulation problems analyzed here can be interpreted, roughly, as positive models of democratic societies in which income is not too unequally distributed". As many of the countries in the samples for which environmental Kuznets curves have been estimated are neither democratic nor can at best be characterized by an equal income distribution, a motivation for our study is provided.

Our analysis is based on the static representative agent model of Stokey (1998, section 2), which we augment by allowing for heterogeneity in income and environmental quality across individuals. We assume that pollution controls are determined by the median voter. The model economy is closed and it is the flow of pollution that affects utility. Some types of pollution dissipate very rapidly (e.g., sulfur dioxide, particulates in the air, and some types of water pollution), so high levels of pollution can be reduced quickly once actions have been taken to do so. In these cases it is reasonable to assume that the disutility of pollution is related to the flow of new pollutants and it is thus adequate to use a static model.

What are then the predictions of our model? To be consistent with income distributions of the real world, we assume that the productivity of the median citizen is lower than the average productivity. Under this assumption a mean-preserving change of the productivity distribution that implies a more equal distribution, increases the income of the median voter in a complete democracy and lowers the income of the median voter if democracy is highly restricted. As both consumption and environmental quality are assumed to be normal goods, a higher (lower) income of the median voter is used to improve (worsen) aggregate environmental quality by tightening (loosening) the environmental legislation. The theoretical result that there is a positive partial relation between the level of income inequality and aggregate pollution in a complete democracy may (at least in part) explain the puzzling observation of e.g. Grossman and Krueger (1995) that there is (for some pollutants) a third phase of the pollution-income pattern in which pollution is increasing in income per capita. This is because this third phase appears to be solely due to the presence of the US in the sample, which also, among the rich countries, is very unequal with respect to the distribution of income. Recall that Grossman and Krueger (1995) do not control for the level of income inequality in their regressions.

Whether less inequality in environmental quality across individuals implies less or more aggregate pollution depends again on how the median voter is affected, which in turn depends both on the degree of democracy and on the shape of the distribution for environmental quality, which we, in contrast to the income distribution, know little about. If the distribution is symmetric, less environmental inequality has no effect on aggregate pollution in a complete democracy, whereas it decreases if democracy is less than complete.

The prediction of the model regarding the impact on aggregate pollution of increased democracy is ambiguous. We typically assume that an expanded franchise lower both the income and the environmental quality of the median voter. If, in utility terms, the fall in environmental quality is worse than the fall in consumption he votes for stricter environmental legislation to the extent that aggregate pollution decreases, which then is consistent with the empirical results of Harbaugh et al. (2000). However, this empirical study is not a test of our model as other variables such as measures of income inequality are not accounted for, which empirically tend to be correlated with democracy indices.

The paper proceeds as follows. In section 2 the components of the model are described: preferences, technology, and the assumptions regarding income and environmental inequality. Section 3 analyzes the median voter's optimal choice of environmental legislation. Section 4 and 5 analyze the impact on aggregate pollution of exogenous changes in inequality and in the degree of democracy, respectively. Section 6 concludes the paper.

2. The model

We assume that the economy consists of many individuals. Each individual is assumed to be endowed with one unit of inelastically supplied labor and his production is assumed to equal his consumption. The individuals enjoy different levels of consumption, because of different levels of productivity. The consumption level of individual *i* depends on the technology used, *z*, and his potential output, y_i:

$$c_i = y_i z \tag{1}$$

$z \in [0,1]$ is an index of the technology used and it is the same for each individual. A higher *z* means a larger output, but also more pollution. When *z* = 1, the most polluting technology is used and potential output is obtained. Thus, z is an index of the emission rate of the production process. The decision-making problem of this model is to choose the optimal level of *z*, which we assume is determined by the median voter.

The potential production of individual *i* is

$$y_i = af(i) \qquad f'(i) > 0 \ , \qquad f''(i) > 0 \tag{2}$$

The individuals are uniformly distributed on the unit interval (i.e. $i \in [0,1]$) and an individual with a higher *i* has a higher productivity. The productivity function *f* is illustrated in Figure 1. *f* is assumed to be a convex function which means that the productivity of the median citizen is lower than the average productivity. This assumption is thus consistent with the empirical fact that the median income in a society typically is lower than the mean income. a is a technology parameter measuring the average level of productivity. We assume that *a* grows exogenously over time.

This paper analyzes, inter alia, what the possible effects of increased democratization are on the policy choice, i.e. the choice of *z*. We model this by assuming that any government (both so-called democracies and non-democracies) responds to the wishes of the median voter who thereby determines the policy outcome. However, in non-democracies only a particular subset of the population has the right to vote. This subset, which is assumed to be exogeneously given, may typically be a privileged group, both in terms of environmental quality and income, since this group may have the means to live further away from the emission sources[4].

In Figure 1 the franchise is found between i_L and 1. The median voter is found in the middle: at $m = (i_L + 1)/2$. An extended franchise means that i_L falls, which then means that the identity of the median voter changes; i.e., *m* falls. Thus, in our model an extended franchise means that poorer groups get the right to vote. This assumption is consistent with the historical experience of many countries. (See e.g. Acemoglu and Robinson, 2000, who also provide a theory of why political reforms of this kind come about: they are strategic decisions by the political elite to prevent social unrest and revolution.) If i_L = 0 the economy is a complete democracy and the median citizen (*i* = ½) is also the median voter.

Pollution from individual *i* is assumed to be an increasing function of production and the technology index: $y_i z \cdot z^{\beta-1}$, where $\beta > 1$. To get aggregate pollution, we sum over all individuals:

$$x = \int_0^1 y_i z^\beta di = az^\beta \int_0^1 f(i) di \equiv az^\beta F \equiv az^\beta \tag{3}$$

[4] We assume that the geographical distribution of the population is exogenously given. See Vogel (1999, p. 103ff) for a discussion on how middle income households may be more in favor of a strict environmental legislation than the very rich as the latter can afford to move to a good local environment.

The integral F is thus normalized to unity. Equation (3) shows that at a given level of pollution controls, pollution increases with average productivity. It also shows that if cleaner technologies are adopted (z falls) a decline in aggregate pollution may coexist with growth in productivity.

Our assumption that there is heterogeneity with respect to perceived environmental quality among the population is captured by a function that describes the pollution level perceived by individual i:

$$x_i = xg(i) \qquad g'(i) < 0, \qquad g''(i) = 0 \tag{4}$$

Thus, the citizens are uniformly ordered (on the unit interval) so that a consumer/producer with a higher i is less affected by aggregate pollution than a consumer with a lower i. This is shown in Figure 2. In contrast to the income distribution, we lack empirical data to guide us on the curvature of g; in Figure 2 we depict a middle ground, the linear case. In the subsequent analysis we assume that the order of individuals with respect to income is identical to the order of individuals with respect to environmental quality, or, at least, we assume that individuals excluded from voting are disadvantaged in terms of income or in terms of environmental quality. The assumption that the order of individuals with respect to income is identical to the order of individuals with respect to environmental quality then means that a consumer with a higher i (relative to a consumer with a lower i) both has a higher environmental quality and a higher productivity, and that the median voter in Figures 1 and 2 is the same person. The assumption that the orderings of individuals are identical in both dimensions is unlikely to be true, but income and perceived environmental quality may be positively correlated across individuals in many economies. This is argued by e.g. the World Development Report (1992, pp.1-2). Finally, note that the model is identical to the Stokey (1998) model, if $f(i) = g(i) = 1, \forall i$.

We assume that the individuals have identical preferences that, for individual i, are represented by the utility function

$$U(c_i, x_i) = \frac{c_i^{1-\sigma} - 1}{1-\sigma} - \frac{x_i^{\gamma}}{\gamma}, \quad \sigma > 0, \gamma > 1 \tag{5}$$

Based on empirical evidence (e.g. Hall, 1988; Hahm, 1998) we typically, in the subsequent analysis, impose the more restrictive assumption that $\sigma > 1$, which adds more structure to the model.

To help the understanding of the optimal choice (described in the next section), note that, close to the origin, the marginal utility of consumption

$\left(c_i^{-\sigma}\right)$ is very large, while the marginal disutility of pollution $\left(-x_i^{\gamma-1}\right)$ is small (in absolute terms). In such a situation, more consumption is valued more than a cleaner environment. As growth in *a* makes consumption and pollution increase, the absolute levels of marginal utilities converge. As a result, one expects the value of *z* to decrease below one during later phases of development.

3. The equilibrium

Since we assume that the economy consists of many individuals, each of them neglects his own contribution to aggregate pollution. The emission externalities are, in part, internalized by voting on *z*. Thus, voters affect their own environmental quality by voting on the value of *z*, and thereby the aggregate level of pollution is determined. The choice of the median voter is decisive for the magnitude of *z*. We assume that voting on *z* takes place at every point in time.

Since we apply the median voter theorem, we abstract from features of the political process that might be important for policy outcomes. Such features would include the electoral and legislative process, bureaucratic behavior as well as special interest group activity. Despite this simplify-cation, the median voter theorem is widely applied (in this ”Downsian” manner) to so-called general interest issues (as opposed to special interest issues; see Persson, 1998).

A political equilibrium exists, because we deal with a single issue and single-peaked preferences. The median voter decides on the level of pollution controls, throughout the economy, by maximizing

$$U(z)=\frac{(af(m)z)^{1-\sigma}-1}{1-\sigma}-\frac{\left(az^{\beta}g(m)\right)^{\gamma}}{\gamma} \tag{6}$$

with respect to *z*. The first order condition for a maximum is

$$U'(z^*)=(af(m))^{1-\sigma}(z^*)^{-\sigma}-\beta\left(a(z^*)^{\beta}g(m)\right)^{\gamma}(z^*)^{-1}\geq 0 \qquad \text{w.e.w. } z^*<1 \tag{7}$$

The optimal value of *z*, defined by (7), may change over time due to growth in the level of productivity, *a*. By the assumptions about the functions of the model, a corner solution, *z** = 1, is optimal at low levels of development. When the level of productivity reaches a critical level, it is optimal to start tightening environmental standards; that is, $z^* < 1$. To see this, we note that $U''(z^*) < 0$ and compute the derivative

$$\frac{\partial U'(z^*)}{\partial a} = \frac{1-\sigma}{a}\left(af(m)\right)^{1-\sigma}(z^*)^{-\sigma} - \frac{\gamma}{a}\beta\left(a(z^*)^{\beta} g(m)\right)^{\gamma}(z^*)^{-1} \tag{8}$$

Assuming $\sigma > 1$, this expression is negative. The economy starts with a phase one when a is low, $z^* = 1$ and $U'(1) > 0$. As productivity increases $U'(1)$ decreases and eventually reaches a point where $U'(1) = 0$. When productivity increases further, a second phase starts during which $z^* < 1$ and decreasing. The economic interpretation of this pattern is as follows: at low levels of development, when the level of production is low, additional consumption is valued highly. At the same time, the low level of production does not harm the environment much. When a has increased sufficiently, production satisfies more than basic consumption needs. At this stage it is optimal to vote for a tighter environmental legislation, which implies less than potential production and a better aggregate environmental quality.

To obtain more details about this pattern, we first compute the critical productivity level, a_S, where we have the switch between phases. We set $z^* = 1$ in equation (7) with equality and solve:

$$a_S = \left[\beta\left(g(m)\right)^{\gamma}\left(f(m)\right)^{\sigma-1}\right]^{\frac{1}{1-\sigma-\gamma}} \tag{9}$$

During phase one $z^* = 1$, $c_i^* = af(i)$ and $x^* = a$. Thus, consumption and aggregate pollution grow at a common rate during this first stage of development.

During phase two, $a > a_S$ so equation (7) holds with equality and we have an interior solution for the optimal level of technology:

$$z^* = \left[\beta\left(g(m)\right)^{\gamma} a^{\gamma+\sigma-1}\left(f(m)\right)^{\sigma-1}\right]^{\frac{1}{1-\sigma-\beta\gamma}} < 1 \tag{10}$$

By the assumptions about the parameters, z^* clearly decreases as a grows. To see what happens to consumption and pollution, we substitute (10) into (1) and (3):

$$c_i* = f(i)\left[\beta(g(m))^{\gamma} a^{\gamma(1-\beta)}(f(m))^{\sigma-1}\right]^{\frac{1}{1-\sigma-\beta\gamma}} \tag{11}$$

$$x* = \left[\beta^{\beta}(g(m))^{\beta\gamma} a^{(1-\beta)(1-\sigma)}(f(m))^{\beta(\sigma-1)}\right]^{\frac{1}{1-\sigma-\beta\gamma}} \tag{12}$$

Since $\beta > 1$, consumption is increasing in a. A necessary and sufficient condition for pollution to decrease during phase 2 is that $\sigma > 1$. To interpret this, recall that the higher value of σ, the more "concave" is the utility function with respect to consumption. In particular, when $\sigma > 1$, utility of consumption approaches the maximum level $1/(\sigma - 1)$ asymptotically as consumption grows. In other words, there is a tendency to satiation in consumption. In this case, $z*$ is lowered to the extent that the level of aggregate pollution in fact decreases. Since income is equal to consumption in this model, the development described here thus produces an EKC; an inverse U-shaped (or more correctly an inverse V-shaped) pollution-income pattern. Thus, at given levels of $f(m)$ and $g(m)$ our model exhibits the same qualitative behavior as the Stokey (1998) model.

4. The effect of inequality on pollution

In this section we analyze the impact on aggregate pollution of changes in inequality when average level of productivity is held constant. Thus, the focus is here on exogenous changes in inequality; that is, on changes in inequality that are not linked to the level of development. What we study is the effect of changes in the functions $f(m)$ and $g(m)$ when the median voter, *m*, is unaltered.

We first note, from equations (9) and (12), that a higher value of $f(m)$ implies lower values of a_S and $x*$ (given that $\sigma > 1$). Thus, if the median voter in terms of potential output becomes richer he wants to increase both consumption and environmental quality as both these goods are normal goods. Consequently, his voting implies that phase two starts earlier, and that aggregate pollution is lower (at given values of *a*) during the second phase.

To address the question whether a more equal income distribution leads to less aggregate pollution, consider one relatively unequal distribution,

$f^1(i)$, and one relatively equal distribution, $f^2(i)$, in Figure 3. We assume that both distributions satisfy the assumption that $F = 1$, i.e. a change in the distribution does not change the average level of productivity[5]. In a complete democracy a mean-preserving change toward a more equal income distribution, $f^2(i)$, implies that the productivity of the median citizen increases; that is, $f^2(1/2) > f^1(1/2)$. As both consumption and environmental quality are normal goods, the median voter then favors stricter pollution controls to also improve aggregate environmental quality. In other words, holding the average level of productivity or income per voting worker constant, the partial relation between the level of income inequality and aggregate pollution is positive in a complete democracy. This theoretical result may explain why Grossman and Krueger (1995, Figure 1), puzzling enough, find a third phase of the empirical pollution-income pattern (e.g., for sulphur dioxide in cities) in which pollution is increasing in income[6]. This third phase appears to be solely due to the presence of the US in the sample[7], which also, among the rich countries, is very unequal with respect to the distribution of income (see e.g. Dollar and Kray, 2001; Deininger and Squire, 1996). Thus, our theoretical result that a rise in income inequality, ceteris paribus, increases aggregate pollution indicates that Grossman and Krueger's (1995) third phase may (at least in part) be due to an omitted variable, the degree of income inequality, which they do not account for.

If, on the other hand, democracy is highly restricted, say between i_L and 1 in Figure 3, a more equal productivity distribution means that the productivity of the median voter falls: $f^2(m) < f^1(m)$[8]. To regain some consumption, he votes for looser environmental regulation and aggregate pollution therefore increases. In other words, holding the average level of productivity or income per voting worker constant, the partial relation

---

5 As both distributions are convex, they both imply that the productivity of the median citizen, $f^j(1/2)$ (j = 1,2), is lower than the average level of productivity.

6 Grossman and Krueger (1995) find that the empirical pollution-income pattern for some pollutants is best described by a third-degree polynomial; that is, at first pollution increases with income, then it decreases, and, finally, pollution increases again.

7 This is because the third phase occurs at a level of income per capita (in 1985 prices) of around 17000 US Dollars, and the US is the only country in the sample with a level of income per capita this high.

8 Note that if the degree of democracy is only somewhat restricted we get the same qualitative effect on aggregate pollution of a more equal productivity distribution that we get in the case of a complete democracy.

between income inequality and aggregate pollution is negative in a society in which voting rights are highly restricted.

The effect on aggregate pollution of a change in the distribution for environmental quality across individuals depends on the curvature of *g(m)* as well as on the degree of democracy. If the function *g* is linear (which we have assumed), there is no difference between the median and mean environmental quality in a complete democracy. As a mean-preserving change of a symmetric distribution does not change the environmental quality of the median voter, the aggregate level of pollution is unaffected by changes in the distribution for environmental quality in a complete democracy. If, on the other hand, democracy is restricted, there is a difference between the average environmental quality and that of the median voter. An equalization of environmental quality then means that the median voter is more affected by a givel level of aggregate pollution. In Figure 4 we move from g^1 to g^2 and $g^2(m) > g^1(m)$. As a consequence the aggregate level of pollution decreases (see equation (12))[9].

5. The effect of democratization on pollution

In this section we investigate under what assumptions more democracy means less aggregate pollution, holding everything else (including the average level of productivity) constant. We study the impact of changes in $f(m)$ and $g(m)$ that are due to changes in *m*. Democratization means that *m* declines (see Figures 1-4). The impact of democratization is studied by computing the logarithmic partial derivatives of equations (9) – (12) with respect to *m*. (We denote a proportional change by a circumflex.):

$$\hat{a}_S = \frac{1}{1-\sigma-\gamma}\left[(\sigma-1)\hat{f} + \gamma\hat{g}\right] \tag{13}$$

[9] We get the same effect if g is a convex function regardless of whether democracy is restricted or not. In the case g is a concave function, we may get the same qualitative effect when democracy is restricted, but we get the opposite qualitative effect if the economy is a complete democracy.

$$\hat{z}^* = \hat{c}_i{}^* = \hat{x}^* = \frac{1}{1-\sigma-\beta\gamma}\left[(\sigma-1)\,\hat{f} + \gamma\hat{g}\right] \qquad (14)\text{-}(16)$$

Note that the expressions outside the brackets on the right hand side of the equations are negative. In this section we consider one case in which there is no income inequality (i.e., $f'(m)=0$) and one case in which there is no inequality in environmental quality (i.e., $g'(m)=0$). Thus, in this section $\hat{f} \equiv f'(m)/f(m) \geq 0$ and $\hat{g} \equiv g'(m)/g(m) \leq 0$. Furthermore, we here maintain the assumption that $\sigma > 1$.

We consider four different cases when analyzing the impact on aggregate pollution of increased democratization. In the first two cases we assume that only one heterogeneity - income inequality or inequality in environmental quality - exists at a time. In these two cases we do not rely on the assumption that the order of the individuals with respect productivity is identical to the order of individuals with respect to perceived environmental quality. However, we do assume that more democracy means that disadvantaged groups in terms of income or in terms of environmental quality get the right to vote. **Case I**: We assume that the citizens of the economy are equal with respect to how they perceive a certain aggregate level of pollution but differ in productivity: that is, $\hat{f} > 0$ and $\hat{g} = 0$. A democratization reform means that the level of consumption of the new median voter is lower relative to the level of consumption of the median voter prior to the reform, whereas the level of environmental quality is unchanged. To compensate for the fall in consumption, the new median voter therefore favors a less tight environmental legislation, i.e. he votes for a higher *z**, and aggregate pollution increases. Thus, in an economy where $\hat{f} > 0$ and $\hat{g} = 0$ we find that the partial relation between the degree of democracy and aggregate pollution is positive. (We also conclude that more democracy in this economy means a higher a_S.)

Case II: If $\hat{f} = 0$ and $\hat{g} < 0$, more democracy means less aggregate pollution. In this case, the median voter after a democratic reform is more affected by a given level of aggregate pollution relative to the median voter prior to the reform whereas the level of consumption is unchanged. The new median voter therefore favors a lower *z** at the cost of a lower level of consumption. (We also conclude that a democratic reform in this economy lowers a_S, and, as a result, this economy enters phase 2 earlier.)

In the last two cases we rely on the assumption that the order of consumers with respect to productivity is identical to the order of consumers with respect to perceived environmental quality. The results from these two cases can be summarized as follows: More democracy is assumed to lower both the income and the environmental quality of the median voter. If, in utility terms, the fall in environmental quality is worse than the fall in consumption, he votes for stricter environmental legislation and aggregate pollution decreases. **Case III**: We assume that the rates of change with respect to *m* of the distribution functions are equal but with opposite signs; that is, $\hat{g} = -\hat{f}$. Under this assumption more democracy means less pollution if $\gamma > \sigma - 1$. To see this, we rewrite the first order condition of equation (7) with equality:

$$U'(z^*) = (af(m))^{1-\sigma}(z^*)^{-\sigma} - \beta\left(a(z^*)^{\beta} g(m)\right)^{\gamma}(z^*)^{-1} = 0 \tag{7'}$$

If a change in *m* causes *f* and *g* to change in about equal proportions, but in opposite directions, the change of the expression for $U'(z)$ depends primarily on the exponents above *f* and *g*. Given that $\gamma > \sigma - 1$, the loss of utility from a fall in consumption is lower than the increased disutility from pollution (U' decreases). Consequently, the new median voter counteracts this by lowering *z**.

Case IV: We assume that $\gamma = \sigma - 1$. In this case, aggregate pollution decreases as a result of an expanded franchise if and only if $-\hat{g} > \hat{f}$, which occurs if environmental quality is more unequally distributed than productivity is around *m*. More democracy then means that the environmental quality of the median voter decreases to a larger extent than his level of consumption does. Since both consumption and environmental quality are valued equally much at the margin (i.e., $\gamma = \sigma - 1$), the new median voter compensates the larger fall in environmental quality by lowering *z** which decreases aggregate pollution.

Do the predictions of the model correspond the results of the previous empirical literature? E.g. Harbaugh et al. (2000) find that the degree of democracy, holding everything else including the level of income per capita constant, is negatively correlated with pollution of SO2. In cases II-IV of our model more democracy generates indeed less pollution. However, in case I more democracy means more pollution. In short, the predictions of our model on democracy and pollution are not unambiguous. Can we say that Harbaugh et al.'s (2000) empirical study points out what cases (of cases I-IV) we should believe in? No, we cannot. Partly because Harbaugh et al. do not include other variables, which our model says are relevant for the level of pollution. In particular, measures of income inequality are not included and such measures tend to be correlated with democracy indices. Thus, from the perspective of our theoretical model we expect an omitted variable bias on the estimated coefficient of the democracy index in Harbaugh et al's study. To test the model both measures of income inequality and of the level of democracy should be included as explanatory variables in EKC-regressions.

6. Discussion and conclusions

This paper contributes to the theoretical literature on the relation between pollution and the level of income per capita. More specifically, we study the impact of exogenous changes in income and environmental inequality as well as in the degree of democracy when the level of income per capita is held constant. A motivation for the paper is provided by the stylized fact that countries (in the samples for which EKC have been estimated) to a considerable degree vary with respect to income inequality and with respect to the degree of democracy. E.g., Harbaugh et al. (2000) find that countries that are more democratic, ceteris paribus, tend to pollute less (in terms of SO2) than countries that are less democratic.

The theoretical framework for the analysis is the static representative agent model of Stokey (1998) which we extend by allowing for heterogeneity in income and environmental quality across individuals. We find that the impact on aggregate pollution of a more equal income distribution depends on the degree of democracy. In a complete democracy a more equal income distribution generates, ceteris paribus, less pollution, whereas the opposite is the case if democracy is highly restricted. The impact of less inequality in environmental quality across individuals depends both on the degree of democracy and on the shape of the distribution for environmental quality, which we, in contrast to the income distribution, know little about. In the case of a symmetric distribution, we find that less environmental inequality has no effect on aggregate pollution in a complete democracy, whereas it lowers aggregate pollution if voting rights are restricted.

An expanded franchise typically means that lower income groups get the right to vote. Moreover, lower income groups may also be the ones most subject to a given level of aggregate pollution. This is e.g. argued by the World Development Report (1992). As a result, we typically assume that an expansion of the franchise lower both the income and the environmental quality of the median voter. The prediction of the model regarding the impact of an expanded franchise under this assumption is ambiguous. If, in utility terms, the fall in environmental quality is worse than the fall in consumption the median voter votes to tighten emission rates so that that aggregate pollution decreases.

One prediction of the model is consistent with indirect empirical evidence. The theoretical result that there is a positive partial relation between the level of income inequality and aggregate pollution in a complete democracy may (at least in part) explain the puzzling observation of e.g. Grossman and Krueger (1995) that there is (for some pollutants) a third phase of the pollution-income pattern in which pollution is increasing in income per capita. This is because this third phase appears to be solely due to the presence of the US in the sample, which also, among the rich countries, is very unequal with respect to the distribution of income. Recall that Grossman and Krueger (1995) do not control for income inequality in their regressions. It would be desirable that future research more directly test both the link between income inequality and aggregate pollution well as the other predictions of the model. In order to do so both measures of income inequality and of democracy should be included as explanatory variables in EKC-regressions. Moreover, as the effect of a change in inequality typically depends on the degree of democracy, the empirical analysis should also include interaction terms between these two variables. (Note, however, that empirical work is restricted by the lack of measures of environmental inequality across individuals within countries.)

References

Acemoglu, D. and Robinson, J. A. (2000) "Why Did the West Extend the Franchise? Democracy, Inequality and Growth in Historical Perspective", *Quarterly Journal of Economics*, 115, 1167-1199.

Andreoni, J. and Levinson, A. (2001). "The Simple Analytics of the Environmental Kuznets Curve", *Journal of Public Economics*, 80, 269-286.

Ansuategi, A. and Perrings, C. (2000) "Transboundary Externalities in the Environmental Transition Hypothesis", *Environmental and Resource Economics*, 17, 353-373.

Arrow, K. J. et al. (1995). "Economic Growth; Carrying Capacity, and the Environment", S*cience*, 268, 520-521

Carlsson, F. and Lundström, S. (2002) "Political and Economic Freedom and the Environment: the Case of CO2 Emissions", mimeo, Department of Economics, Göteborg University.

Deininger, K. and Squire, L. (1996). "A New Data Set Measuring Income Inequality", *World Bank Economic Review* 10 (3): 565-591.

Dollar, D. and Kraay, A. (2001). "Growth Is Good for the Poor", working paper, the World Bank.

Ekins, P. (1997). "The Kuznets curve for the environment and economic growth: examining the evidence", in *Environment and Planning A*, 29, 805-830.

Grossman, G. M. and Krueger, A. B. (1993). "Environmental Impacts of a North American Free Trade Agreement", in P. Garber (ed.) *The US-Mexico Free Trade Agreement*, MIT Press, Cambridge, MA, 165-177.

Grossman, G. M. and Krueger, A. B. (1995). "Economic Growth and the Environment", *Quarterly Journal of Economics*, 110, 353-377.

Hahm, J. H. (1998) "Consumption Adjustment to Real Interest Rates: Intertemporal Substitution Revisited", *Journal of Economic Dynamics and Control*, 22, 293-320.

Hall, R. E. (1988) "Intertemporal Substitution in Consumption", *Journal of Political Economy*, 96, 339-357.

Hettige, H., Lucas, R. E. B. and Wheeler, D. (1992). "The Toxic Intensity of Industrial Production: Global Patterns, Trends and Trade Policy", *American Economic Review*, 82(2), 478-481.

Harbaugh, W., Levinson, A. and Wilson, D. (2000) “Reexamining the Empirical Evidence of the Environmental Kuznets Curve”, *NBER Working Paper*, #7711, May.

Holtz-Eakin, D. and Selden, T. M. (1995). “Stoking the Fires? CO_2 Emissions and Economic Growth”, *Journal of Public Economics*, 57, 85-101.

John, A. and Pecchenino, R. (1994). “An Overlapping Generations Model of Growth and the Environment”, *The Economic Journal*, 104 (November), 1393-1410.

Jones, L. E. and Manuelli, R. E. (2001). “Endogenous Policy Choice: The Case of Pollution and Growth”, *Review of Economic Dynamics*, 4, 369-405.

Kaitala, V., Mäler, K.-G. and Tulkens, H. (1995). “The Acid Rain Game as a Resource Allocation Process with an Application to the International Cooperation among Finland, Russia and Estonia”, *Scandinavian Journal of Economics*, 97(2), 325-343.

Kuznets, S. (1955). “Economic Growth and Income Inequality”, *American Economic Review*, 45(1), 1-28.

López, R. (1994). “The Environment as a Factor of Production: The Effects of Economic Growth and Trade Liberalization”, *Journal of Environmental Economics and Management*, 27, 163-184.

Marsiliani, L. and Renström, T. I. (2000) ”Inequality, Environmental Protection and Growth”, mimeo, CentER, Tilburg University.

Perman, R., Ma, Y., McGilvray, J. and Common, M. (1999). *Natural Resource and Environmental Economics*, Addison Wesley Longman, Essex. Second Edition.

Persson, T. (1998). “Economic Policy and Special Interest Politics”, *The Economic Journal*, 108 (March), 1-18.

Selden, T. M. and Song, D. (1994). “Environmental Quality and Development: Is there a Kuznets Curve for Air Pollution Emissions?” *Journal of Environmental Economics and Management*, 27, 147-162.

Stokey, N. L. (1998). “Are There Limits to Growth?”, *International Economic Review*, 39, 1-31.

Vogel, M. P. (1999), *Environmental Kuznets Curves. A Study on the Economic Theory and Political Economy of Environmental Quality Improvements in the Course of Economic Growth*, Springer, Berlin.

von Amsberg, J. (1995). “Excessive Environmental Risks: an Intergenerational Market Failure”, *European Economic Review*, 39, 1447-1464

World Bank (1992), *World Development Report 1992: Development and The Environment*, Oxford University Press, Oxford.

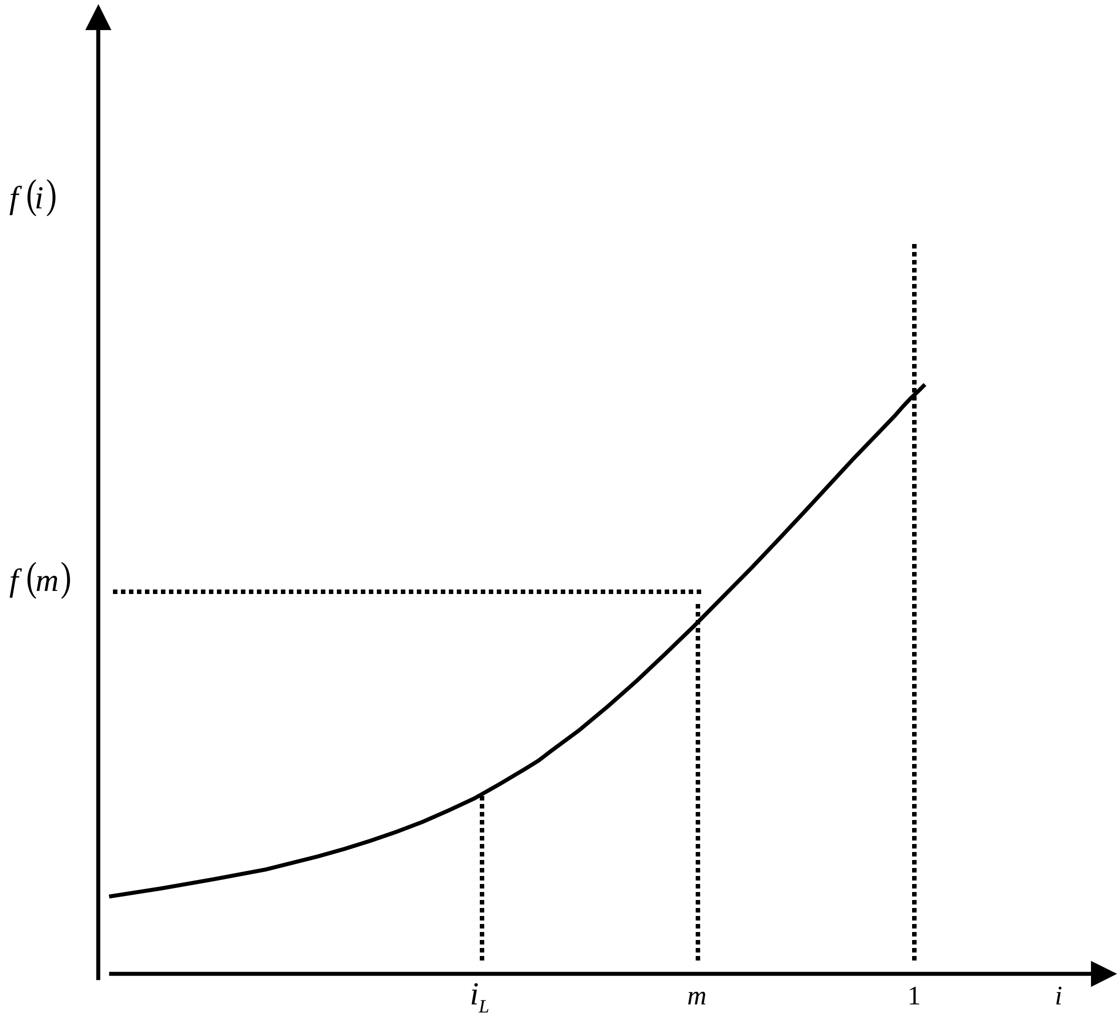

Figure 1. The productivity distribution

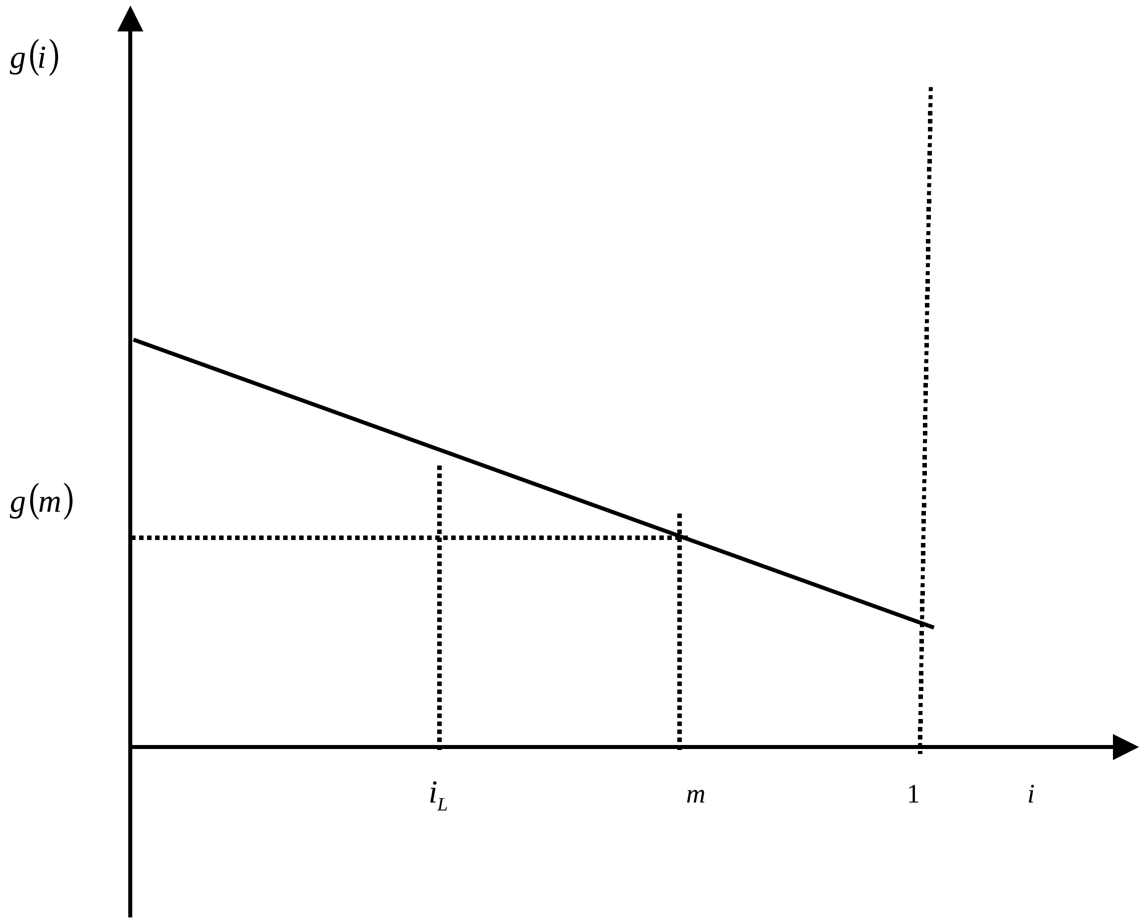

Figure 2. The distribution for environmental quality

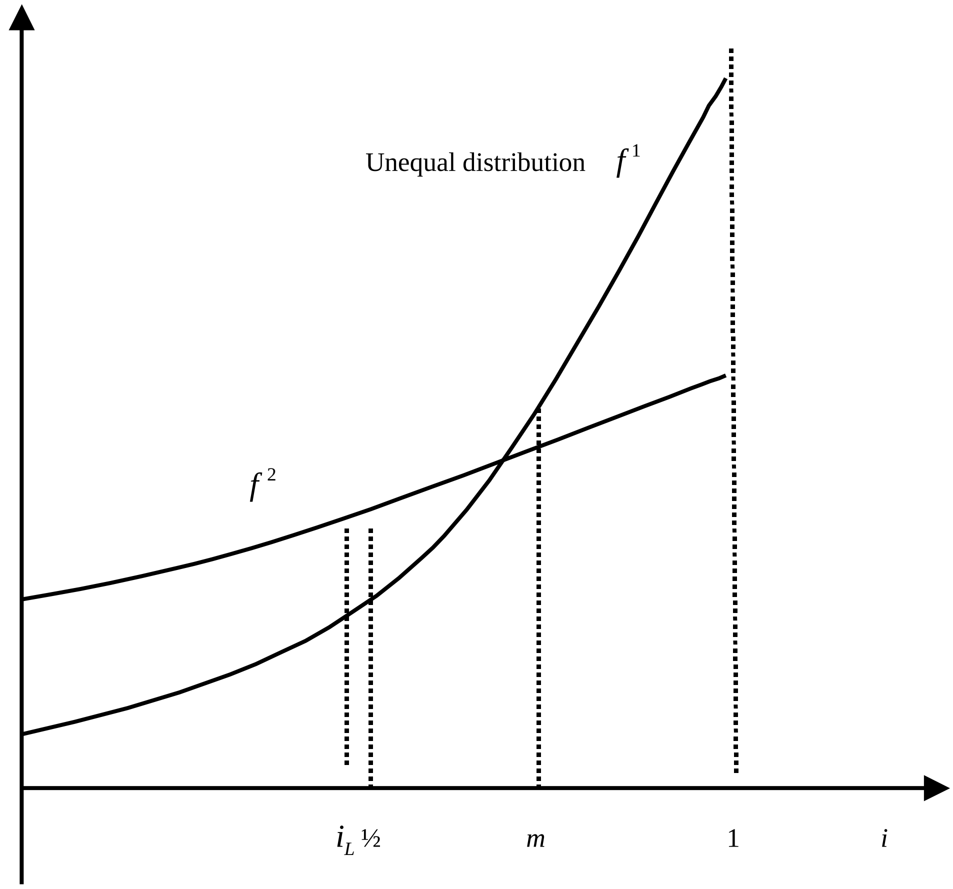

Figure 3. A mean-preserving change of the productivity distribution

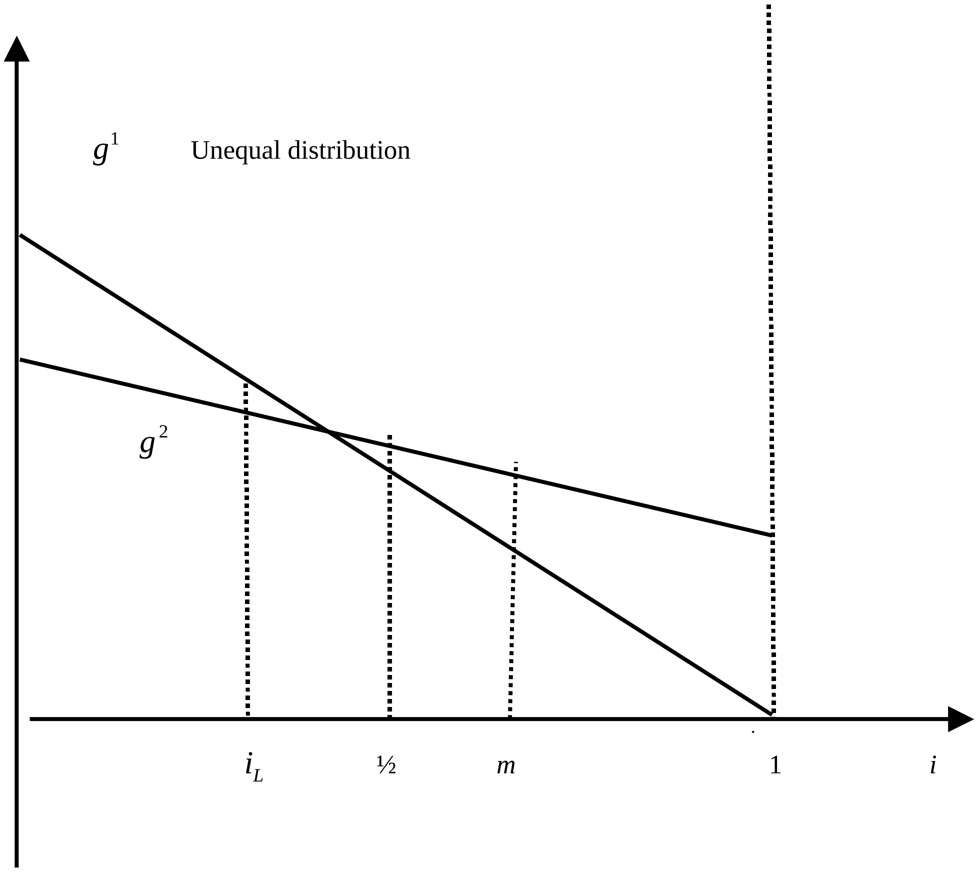

Figure 4. A mean-preserving change of the distribution for environmental quality

Working Paper Series/Arbetsrapport

FIEF Working Paper Series was initiated in 1985. A complete list is available from FIEF upon request. Information about the series is also available at our website on URL http://www.fief.se/Publications/WP.html.

2000

158. **Antelius, Jesper**, “Sheepskin Effects in the Returns to Education: Evidence on Swedish Data”, 17 pp.

159**. Erixon, Lennart**, “The ‘Third Way’ Revisited. A Revaluation of the Swedish Model in the Light of Modern Economics”, 97 pp.

160**. Lundborg, Per**, “Taxes, Risk Aversion and Unemployment Insurance as Causes for Wage Rigidity”, 16 pp.

161. **Antelius, Jesper** and **Lundberg, Lars**, “Competition, Market Structure and Job Turnover”, 27 pp.

162. **Johansson, Sten** och **Sélen, Jan**, ”Arbetslöshetsförsäkringen och arbetslös-heten – En reanalys av IFAUs studie”, 46 s.

163. **Edin, Per-Anders, Fredriksson, Peter and Lundborg, Per,** ”Trade, Earnings, and Mobility – Swedish Evidence”, 28 pp.

164. **Strauss, Tove**, “Economic Reforms and the Poor”, 25 pp.

165. **Strauss, Tove**, “Structural Reforms, Uncertainty, and Private Investment”, 31 pp.

2001

166. **Hansson, Pär**, “Skill Upgrading and Production Transfer within Swedish Multinationals in the 1990s”, 27 pp.

167. **Arai, Mahmood** and **Skogman Thoursie, Peter**, “Incentives and Selection in Cyclical Absenteeism”, 15 pp.

168. **Hansen, Sten and Persson, Joakim,** “Direkta undanträngningseffekter av arbetsmarknadspolitiska åtgärder”, 27 pp.

169. **Arai, Mahmood** and **Vilhelmsson, Roger**, ”Immigrants’ and Natives’ Unemployment-risk: Productivity Differentials or Discrimination?”, 27 pp.

170. **Johansson, Sten** och **Selén, Jan**, ”Arbetslöshetsförsäkringen och arbetslösheten (2). Reformeffekt vid 1993 års sänkning av ersättningsgraden i arbetslöshetsförsäkringen?”, 39 pp.

171. **Johansson, Sten**, ”Conceptualizing and Measuring Quality of Life for National Policy”, 18 pp.

172. **Arai, Mahmood** and **Heyman, Fredrik**, “Wages, Profits and Individual Unemployment Risk: Evidence from Matched Worker-Firm Data”, 27 pp.

173. **Lundborg, Per** and **Sacklén, Hans**, “Is There a Long Run Unemployment-Inflation Trade-off in Sweden?”, 29 pp.

174. **Alexius, Annika** and **Carlsson, Mikael**, “Measures of Technology and the Business Cycle: Evidence from Sweden and the U.S.”, 47 pp.

175. **Alexius, Annika**, “How to Beat the Random Walk”, 21 pp.

2002

176. **Gustavsson, Patrik**, “The Dynamics of European Industrial Structure”, 41 pp.

177. **Selén, Jan**, “Taxable Income Responses to Tax Changes – A Panel Analysis of the 1990/91 Swedish Reform”, 30 pp.

178. **Eriksson, Clas** and **Persson, Joakim**, “Economic Growth, Inequality, Democratization, and the Environment”, 21 pp.