Socially Responsible Investment in General Equilibrium

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Summary

Socially responsible investment in analyzed in a general equilibrium context. This is important in order to understand the ultimate consequences of SRI on the decisions of economic agents. Building on models by Brock (1982) and Merton (1987), SRI is modelled as the choice to voluntarily give up investment in stocks and bonds issues by a firm producing an externality. The model is used to analyze the utility costs of SRI to the responsible investor and the impact on the price of the stock issued by the firm which is responsible for the externality. The results shed light on the factors which may magnify or reduce the impact of SRI, among which are crucial the wealth commended in relative terms by the responsible agents and the diversification possibilities offered by the firms which are excluded from the investment opportunity set. A set of firms targeted by SRI may be seriously affected by SRI only if the responsible investors command a large portion of overall wealth; moreover the same firms are more likely to be hit by SRI behavior if they do not represent important diversification instruments. Firms with unique characteristics from the point of view of overall diversification are less likely to be the target of SRI.

Keywords: General equilibrium, Redistributive effects, Public goods

JEL: D50, H23, H41

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1. Introduction

SRI (socially responsible investment) can be described as an asset allocation style according to which securities are selected not only on the basis of their probability distribution and of the risk aversion of the investor but also taking into account characteristics of the companies issuing the securities. The typical case is that of a mutual or pension fund manager excluding tobacco stocks or polluting stocks *a priori* from his asset allocation. A good example dates from February 22, 2002, with the pension fund Calpers deciding to stop investing in Thailand, Indonesia, Malaysia and the Philippines because of violations of human and worker rights. Also typical is an index-producer such as Dow Jones excluding firms from a socially responsible index. From this point of view, SRI may be regarded as a way of using the power of financial markets to take into account externalities that are normally ignored in a market equilibrium.

The issue is topical for several reasons, including increased consciousness of the social consequences of firms' activities, the increase in the amount of wealth managed by institutions, and the increasing fraction of this devoted to SRI funds, which in the US now manage 12% of the total of institutionally-managed funds. Recently the UK passed legislation requiring that pension funds invest a certain fraction of their assets according to socially responsible criteria. Most major fund management groups now have funds in the SRI field.

The practical implementations of SRI are widespread. There are many socially responsible mutual funds and socially responsible indices managed according to a wide range of criteria. It is interesting to notice that most of these are specific to particular countries, at least in Europe. For example many Northern European countries regard alcohol production as bad, while Mediterranean countries are more inclined to regard smoking as particularly negative. There seems to be some correlation between the "typical sins" of each country and the concerns of those proposing socially responsible investing. This may reflect a sensation that many externalities are local in nature, or at least that the local financial community should try first to cure local problems.

Some funds exclude classical negative externality-producers like tobacco and weapons companies. Others look at companies doing business with certain dictatorial governments not respecting human rights, as was the case of South Africa under apartheid. Others are more sophisticated and try to distinguish firms according to their compliance with the general rules of sustainable development.

From this latter point of view, there seem to be obvious connections with company-level applications of green and sustainable accounting.

It is puzzling that very little research has been devoted to understanding the causes and effects of SRI, both at the theoretical and at the applied level, particularly given its rapid rise to prominence. The reasons for SRI are not entirely clear. It is presumably an attempt to use the power of capital markets to further social goals not normally attainable by market action, even though this may be a costly attempt. Various papers, for example Lakonishok et al. (1992), have discussed at length the agency problems associated with delegated financial management, and have concluded that pension fund investing is affected by many agency problems. SRI is mainly carried out by institutional investors like pension funds. Why would a rational pension fund decide to complete even further a very complex financial management problem by excluding potentially useful assets? Of course there is no agreement that investing in financial markets in a way that supports social goals is costly for the decision-maker. According to some practitioners, compliance with social duties is useful to identify best companies in terms of current and future profits. Responsible companies could be the ones which can afford a socially positive behavior because of their high overall efficiency. They could also be the ones which minimize future potential liabilities associated with operations which do not comply with best practices from a social point of view. In short, responsible companies might well be the most profitable companies.

In this paper we focus on the first possibility, i.e. that SRI is costly. In other words, we assume that there is no connection between company responsibility and company profitability. This makes the economic problem interesting. If social responsibility were one of the many dimensions of profitability then there would be no cost to SRI. Our purpose in instead to understand whether SRI is a costly method which is effective in changing the equilibrium of the economy. Do countries and firms that are discriminated against encounter any specific problems as a consequence? Before undertaking an SRI choice, decision makers who want to bear the cost also should make sure that the cost produces a result. Surprisingly, there is even less research on this question. While SRI funds advertise their financial performance, few document the attainment of their social goals.

By building mutual funds or stock indices that only include socially responsible firms, proponents probably hope to change the behaviour of the excluded companies. But how exactly can these investment and index choices affect the firms and countries? Consider a case where the supply function of shares of a firm is vertical and the demand function is negatively sloped. Then exclusion of the firm from an index is likely to shift the demand function down and decrease the equilibrium price. The price must be lower to convince non-socially responsible groups to increase their holding

of the asset. However one could argue that the price of a stock is the present discounted value of its fundamentals. In this case the decreased demand on the part of one group of investors would be rapidly offset by an increased demand on the part of another group who would perceive the opportunity to buy stocks at a market price lower than value. SRI would have no effect on the price of the stocks, but only on the portfolio of the investors carrying out SRI.

Even when there is an effect on the price of the stock it is far from clear what may be the final consequences. First it is not clear whether the effect would be a one-time decrease in market price or a sequence of falling prices. The latter would be more effective but would probably require an ever-increasing part of society obeying the rules of SRI to create a continuous shift of the demand function. Second it is not clear what the damage is for the firm, especially in the case of short run price pressure.

This paper develops a simple two-period model which achieves two goals. First is to clarify under what conditions SRI may affect stock prices and expected returns. Second is to connect stock prices to firm investment and to final consumption in order to evaluate the effect of SRI on the general equilibrium of the economy. We have already clarified why we believe these are important issues which are missing from the theory. To remark on this, we believe that SRI may develop and attract a larger portion of investors only if it can be shown that there are specific and concrete effects. SRI is likely to remain a fashion which may easily pass by if it does not force firms and consumers to modify their behaviour.

Assume that socially responsible investors bear an opportunity cost for their portfolio choice. Why should they take such a cost in the long run if SRI does not modify the equilibrium of the economy? On the contrary, assume that SRI does modify the general equilibrium of the economy through its effects on stock prices and returns. Then it may be plausible that ethical investors who did not choose in a socially responsible way, for example because they did not believe that this was a worthwhile effort, switch to the ethical side of the investment. An increase in the proportion of ethical investors would reinforce the original effect and further affect the general equilibrium.

The plan of the paper is as follows. After this Introduction, in the second section we describe the general equilibrium model. In the third section we comment on the results obtained from numerical solution of the model. The fourth section concludes.

2. A general equilibrium model of SRI

2.1 The model

Our model is a two-agent two-period model. It is similar in the description of the investment opportunity set to the model proposed by Brock (1982), which is an early production version of the simple Lucas (1978) tree economy (for more recent attempts to introduce endogenous production in the Lucas model see for example Naik (1994), Abel (2000), Dai (2000)). In the Brock (1982) model a representative consumer with an infinite horizon decides how many resources to lend to firms and how many stocks to buy in order to maximize intertemporal utility. Firms use resources lent by consumers and carry out production which is subject to exogenous production shocks. After the loans are repaid, the profit of the firms are distributed to stockholders.

This model is of interest because of its considering production processes and the possibility to include externalities going from production activities to utility. Given that we are going to model socially responsible investment as a discrimination choice on the part of a subset of the population, it is crucial to allow for heterogeneity of agents, since not all of them will behave in a socially responsible way. This heterogeneity however implies technical problems in the solution of the model. Lucas (1982) in a pure exchange economy can simply analyze the perfectly pooled equilibrium where the portfolio of the two agents are equal. The perfectly pooled equilibrium is not useful for our case because we want to study the consequences of heterogeneous behavior with respect to portfolio choice. Therefore we use a simple finite-horizon version of the model due to the technical difficulties associated with analysing heterogeneous-agent, infinite-horizon models involving heterogeneous portfolios of financial assets, production and externalities. Our choice is also justified by referring to Merton (1987), which considers a two-period economy for studying a financial market populated by heterogeneous agents.

In our two-period model, consumers are denoted with i and j. Firms are denoted with A and B. The problem of consumer k, k=i,j, can be described as:

$$\max u(c_{k,0}) + \delta E_t u(c_{k,1})$$
$$c_{k,1} = \pi_{A,1} z_{k,A,0} + \pi_{B,1} z_{k,B,0} + r_{A,1} x_{k,A,0} + r_{B,1} x_{k,B,0}$$
$$c_{k,0} = W_{k,0} - x_{k,A,0} - x_{k,B,0} - p_{A,0} z_{k,A,0} - p_{B,0} z_{k,B,0}$$

Consumer k maximizes a two period expected utility function. Initial wealth $W_{k,0}$ is exogenous. Initially the agent selects consumption and resources invested in financial assets. Final consumption is given by the share of profits distributed by the two firms and by the interest paid on the loans.

$\pi_{A,1}$ is the time 1 profit of firm A, $p_{A,0}$ is the time 0 market price of the stock issued by firm A, $z_{k,A,0}$ is the quantity of stocks of firm k held by investor A at time 0. A similar notation is used for firm B. $r_{A,1}$ is equal to 1 plus the rate of interest paid by firm A on the loan $x_{k,A,t0}$ made by investor k at time 0. Determination of the interest rate and the price of the stocks obtains endogenously according to a mechanism that will be explained soon.

The first order conditions for loan supply and stock demand of the investor are:

$$
\begin{aligned}
&-u'(c_{k,0}) + E_0 u'(c_{k,1}) r_{A,1} = 0 \\
&-u'(c_{k,0}) + E_0 u'(c_{k,1}) r_{B,1} = 0 \\
&-p_{A,0} \times u'(c_{k,0}) + E_0 u'(c_{k,1}) \pi_{A,1} = 0 \\
&-p_{B,0} \times u'(c_{k,0}) + E_0 u'(c_{k,1}) \pi_{B,1} = 0
\end{aligned}
$$

These first order conditions have the standard form, i.e. they equate the marginal disutility of saving to the expected marginal utility of the financial investment.

Production and profit at time 1 for a generic firm k, k=A,B are described by:

$$
\begin{aligned}
y_{k,1} &= \Gamma_k \times f(x_{k,01}) \\
x_{k,0} &= x_{i,k,0} + x_{j,k,0} \\
\pi_{k,1} &= y_{k,1} - r_{k,1} x_{k,0}
\end{aligned}
$$

where it is assumed that the production shows decreasing returns to scale. Production therefore is obtained by direct use of the loans made by the investors, but is subject to an exogenous shock which is firm-specific, Γ_k. Following Brock (1982), it is assumed that the shock is known to the firm when making decisions about the input of resources. Profit is what remains to the firm after paying the loan and the interest to the consumers. Profit is completely redistributed to shareholders in period 1.

What is the difference between loans and stocks from the point of view of the investors? Following Brock we assume that the exogenous shock is unknown to the investors when these decide the size of the loans but it is known to the firm when the interest rate is set. Therefore both loan and stocks are risky for the investors which in the aggregate get hold of the whole production. The timing of decisions in the model is therefore the following: first agents determine their demand functions for consumption and financial investments in loans and stocks, then firms see the productivity shock and after that determine the demand for loans. Time 1 consumption is finally determined on the basis of the asset holdings and the productivity shocks which affect production and profit.

The first order condition of the firm is simply:

$$\Gamma_k \times f'(x_{k,0}) - r_{k,1} = 0$$

where f' is the marginal product. Remember that we assume that the firm knows the value of the productivity shock before deciding the level of production. The firm therefore takes up the amount of loans which is optimal for the realized productivity shock.

2.2 The mechanics of the model

We assume that there are two productivity shocks for each firm so that there are 4 states of nature at time t. $q_{A,s}$ is the probability of the s-th state for firm A, s=1,2, $q_{B,s}$ is the probability of the s-th state for firm B, s=1,2, q_s is the probability of the s-th aggregate state, s=1,2,3,4. The aggregate states are described by the following combinations of shocks:

aggregate state 1 (state 1 for A and state 1 for B) $\Gamma_A = \Gamma_B = 1 + \varepsilon, q_1 = q_{A,1} \times q_{B,1}$
aggregate state 2 (state 1 for A and state 2 for B) : $\Gamma_A = 1 + \varepsilon, \Gamma_B = 1 - v, q_2 = q_{A,1} \times q_{B,2}$
aggregate state 3 (state 2 for A and state 1 for B) : $\Gamma_A = 1 - v, \Gamma_B = 1 + \varepsilon, q_3 = q_{A,2} \times q_{B,1}$
aggregate state 4 (state 2 for A and state 2 for B) : $\Gamma_A = \Gamma_B = 1 - v, q_4 = q_{A,2} \times q_{B,2}$

where ε and v are constant terms. Shocks are therefore independently and identically distributed. This production structure implies that the payoffs of the two stocks are uncorrelated when $q_{A,1} = q_{B,1} = 0.5$. This assumption is clearly important for evaluating the consequences of exclusion of one of the two assets from the portfolio of any investor. The zero correlation assumption can be justified on the basis of the results of Campbell et al. (2000), showing that the average correlation between two stocks in the US market has decreased over time and is currently very close to 0. In order to also analyze the case of high correlation, which could hold true for the case where the stocks of the two firms in the model represent two international stock markets, one can assume the following structure of joint probabilities:

$$q_1 = 0.4, q_1 = 0.1, q_1 = 0.1, q_1 = 0.4$$

where the first and the fourth state have a higher probability than the other two states. Negative correlation could be described by:

$$q_1 = 0.1, q_1 = 0.4, q_1 = 0.4, q_1 = 0.1$$

At the initial time the investor, given available wealth, has to make a consumption and portfolio decisions. The portfolio is potentially composed of four risky assets, two issued by each firms. The rates of return obtained from the assets are positively correlated for each firm across the two states:

given the size of the capital leant for productive processes, the higher the productivity shock the larger the returns on both assets. After the consumption and portfolio decisions are taken the productivity shocks are realized and observed by the firms, which finally demand loans on the market.

Equilibrium is characterised by the following equations:

$$
\begin{aligned}
& c_{i,0} + c_{j,0} + x_{i,A,0} + x_{i,B,0} + x_{j,A,0} + x_{j,B,0} = W_{A,0} + W_{B,0} \\
& \bar{z}_A = z_{i,A,0} + z_{j,A,0} \\
& \bar{z}_B = z_{i,B,0} + z_{j,B,0} \\
& x^s_{A,0} = x_{i,A,0} + x_{j,A,0}, s = 1,2,3,4 \\
& x^s_{B,0} = x_{i,B,0} + x_{j,B,0}, s = 1,2,3,4
\end{aligned}
$$

where $x^s_{A,0}$ and $x^s_{B,0}$ are the amounts of loan taken up by the two firms in state s at time 0.

We have therefore a system of 18 equations to be solved for 18 endogenous variables. The 18 equations are: the supply function of loans on the part of the two agents (2 equations), the demand function for two stocks on the part of the two agents (4 equations), 8 equilibrium equations between loan demand and supply, the 4 demand functions for loans (4 equations). The 18 variables are the 2 stock prices, the 2 interest rates, the 2 demand for loans, the 8 loan supplies, the 4 stock demand.

Notice that this system does not impose any non-negativity constraint on the variables, in particular on the supply of loans and on the demand for stocks on the part of the investors. A negative value for the supply of loan, for example $x_{i,A,0}$, is compatible with the equilibrium as long as $x_{j,A,0}$ is positive and large enough to make the total supply of loan to firm *A* positive in equilibrium. A small negative loan on the part of consumer *i* to firm *A* and a large positive loan on the part of *j* to the same company in the aggregate is equivalent to a positive loan of the consumers to the firm together with an internal system of loans whereby consumer *i* borrows resources from consumer *i*. The interpretation of this case may refer to a sort of internal financial system, where agents can lend resources to each other. The firm of this stylized model therefore both implements production activities and carries out the role of financial intermediary for personal loans.

A similar interpretation occurs in the case of a negative holding of stock. In equilibrium the supply is fixed so the two consumers together have to hold the stocks. However there can be internal contracts between the two consumers according to which one lends resources to the other with a remuneration contingent on the future valuation of the stock.

2.3 SRI and externalities

We now interpret SRI as a reaction to externalities. Many of the examples of SRI we have mentioned in the introduction can in our opinion be interpreted in this way. Discrimination against tobacco reflects concerns about the social effects of smoking, which are strictly associated with the externalities arising when it is not possible to separate smokers and non-smokers in the population. Even when separation is possible, there are indirect externalities associated with the demand for resources produced by smokers who contract some illness due to smoking. In a system where it is not possible to internalise all medical costs, non-smokers have an interest in reducing the number of smokers. Discrimination against environmentally unfriendly companies may be interpreted the same way. In various cases it is technically impossible to isolate environmental damages as these are global in nature.

Of course it is possible to find other examples. Discrimination against firms producing weapons might also be explained on the basis of the possibility that the weapons will directly affect the utility of the agent. However it might also be explained as a reaction to the possibility that weapons will affect other agents. This would be a truly altruistic behavior where the agent internalizes the negative consequences for other agents. However to capture this effect we would need a much more sophisticated economic structure, which is left to future research.

The externality we consider is a negative effect of demand for loans of firm A on the utility of the *i*-th agent, whose utility function becomes

$$u(c_{i,0}) + \delta E_0 u(c_{i,1}, x_A)$$

with $u'_x(c_{i,1}, x_A) < 0$. Remember that the specification implies that productive capital equals the value of loans, so this is a way to describe a negative external effect of the capital used in production of one firm on welfare. The reason why the negative externality regards consumption at time 1 is that in such a way the consumer may hope that the socially responsible investment may affect the choices of the polluting firm through the indirect effects of market prices.

It would also be possible to consider the case where the agent is not sure about the future negative externality. For example firms might be discriminated against for their contribution to future pollution and non sustainable behavior on the basis of an estimate of the damage inflicted to society. This damage might turn out to be non existent or very weak if some future technological innovation is used to eliminate the negative consequences of production. For example, the airline industry is the largest source of CO_2 emissions but is exempt from any extra charges for the

emission of greenhouse gas. However there is no scientific agreement on the climate change issue, so that private agents may decide to proceed with discrimination of the industry on the basis of an estimate of possible future damages associated with CO_2 emissions. In the model, we could assume that the agent might therefore attach a probability *n* to the case of a future damage, so at to maximize:

$$u(c_{i,0}) + \delta E_0\left[n \times u(c_{i,1}, x_A^s) + (1-n) \times u(c_{i,1})\right]$$

This case however does not change the qualitative characteristics of the model, it simply affects the quantitative results making less strong the socially responsible investment process with respect to the case where n=1.

It is worth noticing that the externality affects the first order condition of agent *i* if the utility function is non-separable in future consumption and the externality:

$$\begin{aligned}
&-u'(c_{i,0}) + E_0 u'(c_{i,1}, x_A) r_{A,1} = 0 \\
&-u'(c_{i,0}) + E_0 u'(c_{i,1}, x_A) r_{B,1} = 0 \\
&-p_{A,0} \times u'(c_{i,0}) + E_0 u'(c_{i,1}, x_A) \pi_{A,1} = 0 \\
&-p_{B,0} \times u'(c_{i,0}) + E_0 u'(c_{i,1}, x_A) \pi_{B,1} = 0
\end{aligned}$$

To model SRI we refer to the financial side of Merton (1987) which assumes that investors are heterogeneous in their information sets about securities. They decide to trade only stocks for which they have information. The model shows how heterogeneous information sets impact stock prices and returns. More precisely it is shown that stocks of firms with smaller investor bases have relatively larger expected returns, and lower prices, than in the comparable complete-information model. Here we assume that one of the two agents decides a priori to finance only one of the two firms in the economy, voluntarily giving up the possibility of diversification offered by investment in the polluting firm. Extending the behavioral assumption of Merton (1987) to the case where exclusion is justified by SRI may imply that the stocks of externality-producing firms will be damaged in equilibrium by means of the negative effect on the price level.

We interpret this model in terms of the impact of ethical considerations on the demand for assets issues by firms. We define agent i as the social responsible investor. In the minimal case he decides not to invest in the stock of firm A, the firm which is responsible for the externalities in the model. Therefore $z_{i,A,0} = 0$. In the maximal case he also decides not to lend resources to firm A, $x_{i,A,0} = 0$. In the latter case discrimination is extended simultaneously to both assets[1]. Notice that there is a

[1] This is not unrealistic. In June 2003 nine major banks from seven countries have decided to adopt guudelines (known as "Equator principles") for project finance in emerging markets, requiring the banks to adhere to the IFC (International

difference between discriminating with stock and discriminating with loans. In the model the former does not affect production activity but the latter does. This difference reflects the working of the economic system in the short run, lacking rights issues from firms. We will return to this in the conclusions, when commenting possible extensions of the framework.

Investor *i* therefore exposes herself to a dramatic decrease in the investment opportunity set. By not diversifying, she forces herself to hold a suboptimal portfolio which is concentrated on firm B. It is also possible to extend the model to allow for negative externality of the firm towards the second consumer as well:

$$u(c_{j,0}) + \delta E_0 u(c_{j,1}, x_A)$$

Production on the part of A in this case affects both consumers. In such a way one creates an indirect effect of SRI on the part of consumer *i* on consumer *j*. Such indirect effect is one element that may stop investors from actively implementing SRI.[2]

We can use the model to study a few interesting elements. What are the effects of the discrimination carried out by agent i? What are the effects of discriminating against stocks in terms of overall equilibrium? Is it helpful to discriminate against loans? What is the utility loss of the discrimination? What is the utility transfer between agents i and j following unilateral discrimination? What is the damage inflicted to the firm which produces the externality?

In order to answer these questions we will numerically solve the model. The presence of heterogeneous agents requires this technique, as in equilibrium the two investors will end up with different portfolios and consumption choices.

3. Results

We have solved numerically the model due to the presence of various asymmetries, a standard procedure in the literature on the equity premium see for example Heaton and Lucas (1992). Initially we only explor the model which includes externality on consumer *i* (columns 3-5 of the table). The utility functions are constant relative risk aversion of the type:

$$(1-\alpha)^{-1} c_{i,0}^{1-\alpha} + \delta(1-\alpha)^{-1}(c_{i,0} e^{-\gamma x_{A,0}})^{1-\alpha}$$

Finance Corporation) social and environmental rules for sustainable development. This implies that the banks will not provide loansa directly to projects where the borrower cannot comply with certain requirements.

[2] For example Tom Jones, in an interview with the Financial Times, published in Financial Times Fund Management June 16, 2003, said that "There is a free-rider problem. If we spend money to do shareholder activism, Citigroup asset management shareholders bear the expense but don't get a benefit that is distinct from other shareholders".

$$(1-\alpha)^{-1} c_{j,0}^{1-\alpha} + \delta(1-\alpha)^{-1} c_{j,0}^{1-\alpha}$$

The parameter δ is fixed at 0.9 in all the computations. The parameters α is set equal to 0.5 and alternatively to 4 in order to analyze the impact of risk aversion on the solution. Calibration of the parameter γ is more difficult. We will calibrate the parameter in such a way to control for the total decrease in utility for consumer i associated with the externality with respect to the baseline case of no externality. For example, we will see that when externalities are ignored and $\alpha = 0.5$, the total value of loans to firm A is about 0.2. With this value, a choice of $\gamma = 1$ is coherent with a 20% reduction of consumption of consumer *i* associated with the external effect, while a choice of $\gamma = 0.5$ is associated with a 10% reduction of consumption. Therefore 1 and 0.5 will be the two values considered in the exercizes. A similar computation will be performed for the other sets of parameters, yielding $\gamma = 0.3$ and 0.6 when risk aversion is high. The production functions assume decreasing returns to scale with a parameter $\beta = 0.4$.

To start, we have solved the model assuming no externalities and no SRI (second column of Table 1), externality but no SRI and finally SRI without externalities. The rows represent the symbols used in the text to describe the model, that is respectively demand for stock issued by firm *A* on the part of *i* and *j*, stock demand for firm *B* on the part of the two consumers, price of stock *A* and price of stock *B*, loans to firm *A* by *i* and *j*, loans to firm *B* by *i* and *j*, rate of interest paid by firm *A* in the two states of nature, rate of interest paid by *B*, production of firm *A* in the two states, production of *B*, profits of *A* in the two states, profits of *B*, utility of *i*, utility of *j*.

Table 1: baseline cases, low risk aversion, $\alpha = 0.5$

	No externalities, no SRI	Externality on consumer i, no SRI	Externality on consumer i, no SRI
	$\gamma = 0$	$\gamma = 0.5$	$\gamma = 1$
$z_{i,A,0}$	0.5000	0.5062	0.5130
$z_{j,A,0}$	0.5000	0.4938	0.4870
$z_{i,B,0}$	0.5000	0.5062	0.5130
$z_{j,B,0}$	0.5000	0.4938	0.4870
$c_{i,0}$	0.7644	0.7363	0.7055
$c_{j,0}$	0.7644	0.7773	0.7913
p_A	0.3533	0.3648	0.3774
p_B	0.3533	0.3648	0.3774
$x_{i,A,0}$	0.1178	0.1296	0.1424
$x_{j,A,0}$	0.1178	0.1136	0.1091
$x_{i,B,0}$	0.1178	0.1296	0.1424
$x_{j,B,0}$	0.1178	0.1136	0.1091
$y_{A,1}$	0.6169	0.6249	0.6334
$y_{A,2}$	0.5048	0.5112	0.5182
$y_{B,1}$	0.6169	0.6249	0.6334
$y_{B,2}$	0.5048	0.5112	0.5182
$\pi_{A,1}$	0.3702	0.3749	0.3801
$\pi_{A,2}$	0.3028	0.3067	0.3109
$\pi_{B,1}$	0.3702	0.3749	0.3801
$\pi_{B,2}$	0.3028	0.3067	0.3109
u_i	3.2062	3.0133	2.9239
u_j	3.2062	3.0960	3.0968

In the absence of externality and SRI the equilibrium is symmetric. Each consumer holds ½ of the available stock, and the market prices of the stock are equal. Loans are equal. Production, profit and the interest rates are constant across firms even though they vary across states of nature. Consumers have the same utility level.

Introduction of a small externality (with no SRI) affects the equilibrium because the optimal choices of consumer *i* are affected due to non-separability between the externality and consumption. Consumer *i* decreases the demand for the stock of the polluting firm and gives less loans to the same firm, however he also varies the demand for assets associated with the non-polluting firm. This can be explained on the basis of the first order conditions of consumer *i*. The presence of

externalities reduces the future marginal utility of consumption; this provides an incentive to increase immediate consumption, to provide less loans and to invest less in the stock market. In equilibrium however the supply of stocks has to be held, and consumer *j* increases the demand. In order to give an incentive, the price of stocks goes down.

Consumer *j* also reacts to the change in prices by decreasing initial consumption, partly undoing the decreased saving of consumer *i*. Utility of consumer *i* decreases while utility of consumer *j* increases. Production and profit of both firms decrease due to the incentive to consume a larger portion of the initially available resources.

An increase in the importance of the externalities from 1.1 to 3.5 magnifies these effects.

Table 2 analyzes the case of high risk aversion.

Table 2: baseline cases, high risk aversion, $\alpha = 4$

	No externalities, no SRI	Externality on consumer i, no SRI	Externality on consumer i, no SRI
	$\gamma = 0$	$\gamma = 0.3$	$\gamma = 0.6$
$z_{i,A,0}$	0.5000	0.3563	1.6359
$z_{j,A,0}$	0.5000	0.6437	-0.6359
$z_{i,B,0}$	0.5000	0.5072	1.4792
$z_{j,B,0}$	0.5000	0.4098	-0.4792
$c_{i,0}$	0.6821	0.6473	0.6096
$c_{j,0}$	0.6821	0.6845	0.6881
p_A	0.4767	0.4998	0.5265
p_B	0.4767	0.4998	0.5265
$x_{i,A,0}$	0.1590	0.2483	-0.4027
$x_{j,A,0}$	0.1590	0.0857	0.7539
$x_{i,B,0}$	0.1590	0.1723	-0.3204
$x_{j,B,0}$	0.1590	0.1615	0.6715
$y_{A,1}$	0.6956	0.7092	0.7238
$y_{A,2}$	0.5690	0.5800	0.5919
$y_{B,1}$	0.6956	0.7092	0.7238
$y_{B,2}$	0.5690	0.5800	0.5919
$\pi_{A,1}$	0.4173	0.4521	0.4344
$\pi_{A,2}$	0.3413	0.3474	0.3549
$\pi_{B,1}$	0.4173	0.4252	0.4344
$\pi_{B,2}$	0.3413	0.3473	0.3549
u_i	-2.2744	-2.6932	-3.2647
u_j	-2.2744	-2.2769	-2.2693

The results are qualitatively similar except that there are lower transfers of resources between one period and the other. This is not surprising as this model, contrary to the more general class of models introduced by Epstein and Zin (1989), is unable to distinguish between risk aversion and elasticity of intertemporal substitution. In the model used in this paper a higher risk aversion therefore also means lower willingness to substitute consumption over time. Indeed Table 2 shows a smaller increase of the initial consumption of the two agents with respect to the case described in Table 1. In the case of high impact of the externality agent *i* shorts both stocks and bonds in order to anticipate consumption.

The main interest of the paper is in the general equilibrium effects of SRI. We therefore now analyze the case of responsible behavior of agent *i* in the presence of various degrees of externalities.

Table 3: SRI and externalities, various degrees of risk aversion

	$\alpha = 0.5, \gamma = 0.5$	$\alpha = 0.5, \gamma = 1.1$	$\alpha = 4, \gamma = 0.3$	$\alpha = 4, \gamma = 0.6$
$z_{i,A,0}$	0.0	0.0	0.0	0.0
$z_{j,A,0}$	1.0	1.0	1.0	1.0
$z_{i,B,0}$	0.7458	0.7716	1.0994	2.1981
$z_{j,B,0}$	0.2542	0.2284	-0.0994	-1.1981
$c_{i,0}$	0.7375	0.7005	0.6926	0.6048
$c_{j,0}$	0.7765	0.7993	0.6829	0.6917
p_A	0.3629	0.3778	0.4860	0.5107
p_B	0.3661	0.3815	0.5192	0.5457
$x_{i,A,0}$	0.0	0.0	0.0	0.0
$x_{j,A,0}$	0.2419	0.2519	0.3252	0.3404
$x_{i,B,0}$	0.3539	0.3848	0.2914	-0.2759
$x_{j,B,0}$	-0.1099	-0.1305	0.0552	0.6393
$y_{A,1}$	0.6235	0.6337	0.7016	0.7147
$y_{A,2}$	0.5102	0.5185	0.5734	0.5849
$y_{B,1}$	0.6258	0.6361	0.7197	0.7335
$y_{B,2}$	0.5120	0.5205	0.5888	0.6010
$\pi_{A,1}$	0.3741	0.3802	0.4210	0.4288
$\pi_{A,2}$	0.3061	0.3111	0.3431	0.3511
$\pi_{B,1}$	0.3755	0.3817	0.4316	0.4396
$\pi_{B,2}$	0.3072	0.3123	0.3528	0.3614
u_i	3.0114	2.9041	-2.8171	-3.3848
u_j	3.0970	3.0980	-2.2412	-2.2263

The Table shows that SRI has little impact on the general equilibrium, even though there are important effects on personal portfolios. SRI on the part of consumer *i* deeply affects the distribution of stockholdings and the distribution of loans. Consumer *j* ends up being the owner of the polluting firm, with a strong reduction in the stockholding of firm *B* and a much more concentrated stock portfolio. Overall concentration of financial holdings of consumer *B* is counterbalanced by changes in the loans given to the two firms. In equilibrium the price of stock *A* is now lower than the price of stock *B*, as predicted by the model by Merton in the case of asymmetric demand. Total utility marginally decreases for consumer *i* and marginally increases for consumer *j*. The most relevant result is that there are weak price effects on the market prices of both stocks. Consumers substitute each other in stockholdings. There are weak effects on production and profits.

Table 4 investigates the effects of a reduced form of SRI, consisting of excluding only stocks:

Table 4: SRI directed at stocks only

	$\alpha = 0.5, \gamma = 0.5$	$\alpha = 0.5, \gamma = 1.1$
$z_{i,A,0}$	0.0	0.0
$z_{j,A,0}$	1.0	1.0
$z_{i,B,0}$	0.5909	0.607
$z_{j,B,0}$	0.4091	0.393
$c_{i,0}$	0.7362	0.6998
$c_{j,0}$	0.7773	0.7943
p_A	0.3645	0.3798
p_B	0.3649	0.3802
$x_{i,A,0}$	0.2072	0.227
$x_{j,A,0}$	0.0361	0.0265
$x_{i,B,0}$	0.2057	0.2234
$x_{j,B,0}$	0.0375	0.0299
$y_{A,1}$	0.6248	0.6351
$y_{A,2}$	0.5114	0.5200
$y_{B,1}$	0.6248	0.6351
$y_{B,2}$	0.5114	0.5200
$\pi_{A,1}$	0.3748	0.3809
$\pi_{A,2}$	0.3069	0.3121
$\pi_{B,1}$	0.3748	0.3809
$\pi_{B,2}$	0.3069	0.3121
u_i	3.013	2.9048
u_j	3.0961	3.0971

In Table 5 we experiment with the relative wealth of the two consumers. In the first column the initial wealth of agent *i* is 1.1 while that of *j* is 0.9, while in the second column the opposite happens.

Table 5: SRI and relative wealth

	$\alpha = 0.5, \gamma = 0.5,$ $W_{A,0} = 1.1, W_{B,0} = 0.9$	$\alpha = 0.5, \gamma = 0.5,$ $W_{A,0} = 0.9, W_{B,0} = 1.1$
$z_{i,A,0}$	0.0	0.0
$z_{j,A,0}$	1.0	1.0
$z_{i,B,0}$	0.7701	0.7214
$z_{j,B,0}$	0.2299	0.2786
$c_{i,0}$	0.7926	0.6825
$c_{j,0}$	0.7203	0.8326
p_A	0.3634	0.3623
p_B	0.3672	0.3651
$x_{i,A,0}$	0.0	0.0
$x_{j,A,0}$	0.2423	0.2415
$x_{i,B,0}$	0.3900	0.3177
$x_{j,B,0}$	-0.1452	-0.0744
$y_{A,1}$	0.6239	0.6231
$y_{A,2}$	0.5105	0.5098
$y_{B,1}$	0.6265	0.6250
$y_{B,2}$	0.5126	0.5114
$\pi_{A,1}$	0.3744	0.3739
$\pi_{A,2}$	0.3063	0.3059
$\pi_{B,1}$	0.3759	0.3750
$\pi_{B,2}$	0.3075	0.3069
u_i	3.1194	2.8991
u_j	2.9817	3.2082

A change in the distribution of initial wealth has the expected consequences on the solution. Relative utilities move in the same direction as relative wealth, and the price of stock of firm *A* is more severely affected by discrimination the larger the share of initial wealth going to the socially responsible investor.

In Table 6 we analyze the effects of the varying degrees of correlation among the four states of nature by experimenting with the joint probability distribution. We consider one case where the states with shocks which are simultaneously positive or negative have lower probabilities than the other two states (we call this case “negative correlation”) and one case where the states with shocks

which are simultaneously positive or negative have higher probabilities than the others ("positive correlation").

Table 6: SRI and correlation

	$\alpha = 0.5, \gamma = 0.5$ $q_1 = 0.1, q_2 = 0.4,$ $q_3 = 0.4, q_4 = 0.1$	$\alpha = 0.5, \gamma = 0.5$ $q_1 = 0.4, q_2 = 0.1,$ $q_3 = 0.1, q_4 = 0.4$
$z_{i,A,0}$	0.0	0.0
$z_{j,A,0}$	1.0	1.0
$z_{i,B,0}$	0.7448	0.7471
$z_{j,B,0}$	0.2552	0.2529
$c_{i,0}$	0.7381	0.7369
$c_{j,0}$	0.7759	0.7771
p_A	0.3619	0.3639
p_B	0.3670	0.3652
$x_{i,A,0}$	0.0	0.0
$x_{j,A,0}$	0.2413	0.2426
$x_{i,B,0}$	0.353	0.3548
$x_{j,B,0}$	-0.1083	-0.1113
$y_{A,1}$	0.6299	0.6242
$y_{A,2}$	0.5096	0.5107
$y_{B,1}$	0.6264	0.6251
$y_{B,2}$	0.5125	0.5115
$\pi_{A,1}$	0.3737	0.3745
$\pi_{A,2}$	0.3058	0.3064
$\pi_{B,1}$	0.3758	0.3751
$\pi_{B,2}$	0.3075	0.3069
u_i	3.0106	3.0121
u_j	3.098	3.0959

The first column of Table 6 considers the case where there are higher probabilities to the state where a positive shock to productivity of one firm is counterbalanced by a negative shock to the productivity of the other firm (negative correlation), while the second considers the reverse case of positive correlation. The results confirm that SRI is more painful to the agent when the correlation is negative. One can expect that from the hedging portfolio of the investor, trying to smooth consumption across states of nature. Also the price differential of the two stocks increases in the

negative correlation case with respect to the positive correlation case. This is due to the fact that a negative correlation is equivalent to considering the case where stocks are "more different" among themselves than the case of positive correlation. Therefore giving up the possibility of investing in one asset with a negative correlation is more costly in utility terms, because this exclusion increases volatility of consumption across states of nature.

Finally, Table 7 considers the case where the externality affects both consumer *i* and consumer *j*. In this case SRI on the part of consumer *i* benefits both consumers.

Table 7: externality on both consumers

	$\alpha = 0.5, \gamma = 0.5$	$\alpha = 0.5, \gamma = 1.1$
$z_{i,A,0}$	0.5	0.0
$z_{j,A,0}$	0.5	1.0
$z_{i,B,0}$	0.5	0.7384
$z_{j,B,0}$	0.5	0.2616
$c_{i,0}$	0.7485	0.7496
$c_{j,0}$	0.7485	0.7479
p_A	0.3773	0.3753
p_B	0.3773	0.3784
$x_{i,A,0}$	0.1258	0.0
$x_{j,A,0}$	0.1258	0.2502
$x_{i,B,0}$	0.1258	0.3478
$x_{j,B,0}$	0.1258	-0.0955
$y_{A,1}$	0.6334	0.632
$y_{A,2}$	0.5181	0.5171
$y_{B,1}$	0.6334	0.6341
$y_{B,2}$	0.5181	0.5188
$\pi_{A,1}$	0.3800	0.3792
$\pi_{A,2}$	0.3108	0.3103
$\pi_{B,1}$	0.3800	0.3805
$\pi_{B,2}$	0.3108	0.3113
u_i	3.0121	3.0102
u_j	3.0121	3.0132

The first column shows that when both consumers are affected, the equilibrium is symmetric also when an externality is present. The second column shows what happens when consumer *i* implements SRI. SRI affects market prices of stocks, as shown by the differential between the price

of the two stocks. It therefore indirectly affects the choices of consumer *j*, who decreases initial consumption, buys all of the stock of firm *A* and decreases the holding of stock *B*. Production and profit by firm *A* decrease but increase in firm *B*. Utility of *i* goes down as a consequence of activism and utility of *j* increases indirectly benefiting from SRI.

4. Conclusions

We started to explore the consequences of socially responsible investment in a simple two-period general equilibrium model. We assume that the firms which are discriminated against generate a negative externality towards a part of the consumers. We also assume that discrimination may be about all the financial assets issued by the firm or alternatively only the stock. The simulation model is simple but powerful enough to show some strong implications. Perhaps one of the main messages emerging from the results is that SRI is not likely to be a major force in shaping the market equilibrium in cases where it is restricted to a small subset of the agents, there is high substitutability across firms and does not consider loans to the firms. As such, it is not likely to change the productive choices of the firms and the negative implications for the consumers.

In a large economy with heterogeneous agents and firms there are many substitution possibilities. Firms which are discriminated against from a financial point of view can always find other investors who are willing to provide the financial resources necessary for the normal productive operations. Responsible agents are unlikely to deeply affect the overall equilibrium. On the other hand, their utility loss is likely to be minimal in such a case. SRI produces little but costs little. In a large economy there are many firms that issue financial assets which are useful for investors to smooth consumption over time. Giving up a priori investments in a given subset of firms does not amount to change the consumption program, which can be implemented by means of other financial assets.

Our results are plausible in the context of empirical observations: firms which are the subject of investors discrimination do not seem to be deeply affected in terms of performance. Moreover, socially responsible mutual funds do not seem to significantly underperform or overperform the other mutual funds, as shown by Hamilton, Jo and Statman (1993), and that is what one could expect in an environment characterized by large substitution possibilities across financial assets. Legal causes against single companies, take for example tobacco companies or pharmaceutical companies under the threat of having sold cures which revealed themselves to be dangerous, certainly affect the value of the firm. However this is one step beyond SRI per se.

Under what conditions can socially responsible behaviour be effective? Our results show that this may happen with the increase of the share of responsible investors and with the importance of the stock, where the latter concept is defined in terms of hedging against overall uncertainty. These are also the conditions in which SRI is particularly painful in utility terms, it may produce a lot but it also costs much.

Of course our results are obtained in the context of a stylized model. SRI is more likely to be relevant whenever companies are heavily dependent on the stock market as a financing instrument. For example companies are crucially dependent on the stock market in the phase of the initial public offering. Also the initial phase of venture capital depends heavily on the possibility to liquidate the investment by means of a public offering. A coalition of socially responsible investors which were able to boycott the IPO of a firm might perhaps be useful to block its expansion, even though it is hard to believe that other non-responsible investors were not willing to finance a profitable business.

Of course the current negative results on the relevance of SRI may be due to the specific functional choices made in this paper. The current version of the model is rather ad hoc and might be improved with an extended theoretical base (for example an infinite horizon or an overlapping generations structure) and with a richer set of experiments on the relevant parameters. The model may be used to understand which combinations of parameters generate an important effect of socially responsible investments. Our guess is that socially responsible investments is likely to be little effective in all cases of large substitutability across firms and financial assets. If this is true, investors will either find that SRI indicators are useful predictors of company profitability and stock price performance which merit attention on the grounds of purely financial analysis or drop SRI altogether, unless the proportion of investors who are concerned with SRI becomes so large as to really affect the amount of financial resources available to non SRI firms.

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