

The real effects of socially responsible investing:
Disagreement on the doing well while doing good hypothesis and
the cost of capital

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November 16, 2013

Abstract

The paper develops a micro-structure trading model shedding new light on the relationship between socially responsible investment screening practices and a firm's equity cost of capital. Previous research argued that SRI screening will lead firms shunned by socially responsible investors to trade at a discount, or have a higher cost of capital, relative to comparable non-boycotted firms. The argument brought on is that SRI screening limits the amount of risk diversification in the market for shunned firms causing traditional investors to demand an additional risk premium. Although this channel is present in the current paper, adding asymmetric information combined with heterogeneity in beliefs regarding the relationship between corporate social and financial performance is shown to dampen and even reverse the cost of capital gap between shunned and non-shunned firms. As such the model in the paper delivers a richer set of predictions which might help explain the mixed support in the empirical literature regarding the link between SRI screening and equity cost of capital.

1 Introduction

Socially responsible investment (SRI) has become an increasingly popular investment practice in recent years. The US Social Investment Forum (USSIF), a national not-for-profit organization that promotes the concept, practice and growth of socially responsible investing, reports that in 2010 12.2 % of the \$25.2 trillion in total assets under management tracked by Thomson Reuters Nelson is involved in some strategy of socially responsible investing.

One of the primary goals of SRI is to allow consumers to align their investment savings decisions with their personal values and its most popular application at the moment is the use of socially re-

sponsible investment screens. These investment screens are applied within otherwise standard financial investment analysis and effectively reduce the universe of stocks to a subset of shares who are deemed morally or ethically acceptable to socially responsible investors.

Broadly speaking, a socially responsible investment screen is a set of environmental, social or ethical criteria which determine which shares are eligible for trade to an investor who wishes to invest only in firms whose practices and policies are in line with his personal values. As such the portfolio allocation decisions of socially responsible investors are a function of not only financial but also non-financial factors reflecting the personal attitude of these investors towards certain corporate practices and policies.

Advocates of SRI however claim that SRI screens are more than a mere tool allowing investors to meet their moral obligations towards investing. In particular they argue that by selectively investing in firms exhibiting a high corporate social performance (CSP) socially responsible investors lower these firms cost of capital thus stimulating firms in general to improve their CSP.

Research in finance examining this claim about the real effects of SRI however is scarce and therefore relatively little is known about its validity. This is unfortunate since research in finance is increasingly examining how financial markets feed back into the investment decision by firms (Chen, Goldstein, and Jiang (2007), Bond, Edmans, and Goldstein (2012)) By analyzing SRI, a new channel through which financial markets determine firm investment decisions can therefore be explored.

The goal of this paper is to partly fill this gap in the literature by revisiting the question on equilibrium equity cost of capital formation when the financial market is populated by socially responsible investors. Socially investors differ from traditional investors in two ways.

First, socially responsible investors apply SRI screens and invest only in firms which exhibit a high CSP.

Secondly, socially responsible investors believe that firms with a higher CSP also have a higher corporate financial performance (CFP). This so called “doing well while doing good” hypothesis is currently hotly debated in both professional and academic circles.

Nevertheless many SRI practitioners claim that the screening of firms on their CSP not only allows them to selectively invest in virtuous firms but also that it unearths valuable insights into firms’ competitiveness and profitability. As such socially responsible investors can be expected to condition their trades above and beyond the screening outcome on this additional piece of information about a firm’s fundamental.

Previous research which looked into the effects of socially responsible investors on a firm’s equilibrium cost of capital, primarily focussed on the impact of SRI screening, Angel and Rivoli (1997) and Heinkel, Kraus, and Zechner (2001). This paper adds to the existing literature by not only assuming the application of SRI screens by socially responsible investors, but also the active trading of socially

responsible investors on information related to the firm's corporate social performance.

Moreover, traditional investors are assumed to not to trade on this CSP information because they regard it as irrelevant. As such socially responsible and traditional investors are assumed to openly disagree on the cash flow importance of a firm's corporate social performance.

The main point this paper will then seek to make is that although SRI screens have the potential to lower the cost of capital of firms with a high CSP, this need not be the case if socially responsible investors trade on and disagree with traditional investors about the importance of CSP information.

The reason for this is that although trading on so called environmental, social and governance (ESG) information, which captures corporate social performance, has gained momentum among investors, it is primarily socially responsible investors who are leading this trend. Most traditional investors still dismiss the relevance of ESG risks and opportunities and hence largely ignore it as a source of information on the firm's future cash flow performance.

This apparently open disagreement between traditional and socially responsible investors on the importance of CSP information is what might lead the investment strategies of socially responsible investors to harm the cost of capital of high CSP firms or to at least make the cost of capital gap between high and low CSP firms to be smaller than what standard theory in finance might predict.

In particular, socially responsible investment screens imply that high CSP firms will have a larger investor base than low CSP firms, all else equal, because the former are more likely to be included into the portfolios of socially responsible investors. Standard theory in finance then predicts that in a simple economy with risk averse investors, high CSP firms will enjoy a relatively lower cost of capital because their risk is spread out over more investors.

In a Grossman and Stiglitz (1980) economy with open disagreement on the value of CSP information this argument still holds, but needs to be complemented by the fact that traditional investors will perceive the trading by socially responsible investors on CSP information as an additional source of noise trading. If traditional investors are not fully informed on this CSP noise such that they can not fully anticipate the effects on the equilibrium share price, they will charge a risk premium for trading the shares of high CSP firms which might offset the discount these firms enjoys because of their larger investor base.

This negative externality on the risk premium charged however is not the only effect the open disagreement has on a firm's cost of capital. In particular, in addition to the above risk compensation channel, open disagreement affects a firm's equilibrium cost of capital through a mean return channel. The effect will moreover be positive or negative depending on what the true underlying relationship is between CSP and CFP, that is whether the beliefs of socially responsible or of traditional investors are correct.

For instance, if in reality CSP has no effect on the firm's CFP yet socially responsible investors

believe there is, then their trading generates an additional demand for the shares of high CSP firms which is reflected in the equilibrium price but not in the expectation of the firm's fundamental. This will lead a high CSP firm's cost of capital to be too low relative to what it should be.

On the other hand, if socially responsible investors are correct in their beliefs, then a high CSP firm's cost of capital will be too high relative to what it should be. This is because although the firm's fundamental will now fully reflect the CSP - CFP relationship, the equilibrium price will only partly do so since only socially responsible investors incorporate the true relationship into the equilibrium price.

The arguments put forward in this paper might therefore shed some light on why it has been hard to find empirical evidence on the impact of socially responsible investment strategies on firms' cost of capital, despite the growing popularity of socially responsible investing. Future empirical research might then be guided by the propositions in this paper in order to see whether corporate social performance effect on firms' cost of capital can be identified.

In addition, the paper has implications for policy makers who want to stimulate socially responsible investing as a mechanism to make firms internalize environmental or social externalities. In particular, if traditional and socially responsible investors continue to disagree on the relevance of CSP information, then the screening efforts by socially responsible investors can be rendered less effective or even ineffective as a tool to make make firms internalize their externalities via the cost of capital channel. For socially responsible investment screens to be more effective, policy makers need to control as much as possible the noise premium charged by traditional investors.

The noise premium however is a result of traditional investors being less informed than socially responsible investors about the firm's CSP. If traditional investors were equally well informed, they would be able to filter out the impact of socially responsible investor's trading activities on the equilibrium price. CSP information would then no longer appear as a source of noise for traditional investors in the price signal and they would no longer charge an additional noise premium.

In the next section an overview will be given of the current state of the socially responsible investment sector. Following that, there will be a brief discussion of past research on socially responsible investing in the finance literature.

2 Socially responsible investment sector

Socially responsible investing in the United States has experienced strong growth in the last 15 years. Growing substantially faster than the broader universe of conventional investment assets under professional management, table 1 reports that assets following SRI strategies grew from \$639 billion in 1995 to \$ 3.07 trillion in 2010. This represents a growth of 380 % in just over 15 years. Furthermore, during the recent financial crises, from 2007 to 2010, the overall universe of professionally managed assets has

(In Billions)	1995	1997	1999	2001	2003	2005	2007	2010
ESG Incorporation	\$162	\$529	\$1,497	\$2,010	\$2,143	\$1,685	\$2,098	\$2,512
Shareholder Advocacy	\$473	\$736	\$922	\$897	\$448	\$703	\$739	\$1,497
Community Investing	\$4	\$4	\$5	\$8	\$14	\$20	\$25	\$41.7
Overlapping strategies	N/A	(\$84)	(\$265)	(\$592)	(\$441)	(\$117)	(\$151)	(\$981.18)
Total	\$639	\$1,185	\$2,159	\$2,323	\$2,164	\$2,290	\$2,711	\$3,069

Table 1: SRI in the United States 1995-2010.

remained roughly flat while SRI assets have enjoyed a healthy growth.

Table 1 furthermore indicates that there are roughly three broad categories of socially responsible investment strategies: first, the incorporation of ESG criteria in standard investment analysis, secondly, shareholder advocacy strategies and finally, investing in community development projects. This paper is concerned with the first, and largest, category which represents the use of socially responsible investment screens based on environmental, social and governance criteria.

Of the \$2.51 trillion of assets under management that apply ESG screening strategies, \$691.9 billion are identified within specific investment vehicles managed by money managers, while at least \$2.03 trillion are identified as owned or administered by institutional investors. These figures indicate that not only is the market share of SRI screening strategies sizeable, the ESG screens are applied by professional, informed investors who carry out research and trade on private information in order to make speculative profits.

When a socially responsible investment fund applies an SRI screen it focusses on one or several dimensions of corporate environmental, social or governance performance. In addition, socially responsible investors can implement the screens in a positive, negative restrictive or negative exclusionary manner.

Positive screening implies seeking out firms who excel their industry peers along a certain dimension of ESG performance. Negative restrictive and exclusionary screening on the other hand implies avoiding firms who perform badly on ESG criteria. Restrictive screens differ from exclusionary screens in that the former are usually interpreted in a more flexible manner. In particular, restrictive screens sometimes allow investment in relatively poor ESG performers if it is deemed necessary to ensure the viability of the investment portfolio for instance to ensure the portfolio is sufficiently diversified. For exclusionary screens, no such exceptions are allowed and the fund applying them commit to divest from any firms or industries whose ESG performance falls below a certain benchmark. An example of a popular positive screen is clean technology. Funds applying such a screen actively seek out investment in firms who outperform in the procurement of electricity from alternative energy sources such as wind or water. As such, they tilt their portfolios towards these clean tech firms potentially over and above what might be deemed optimal from a purely financial perspective.

Positive screens also differ from negative screens in that the former usually do not imply divestment

from entire industries. In particular, firms from the heavy manufacturing industry for instance might by the very nature of their energy needs find it difficult to purchase all their electricity from alternative sources. A negative clean tech screen would then divest from all heavy manufacturing firms. A positive clean tech screen however would seek out those firms that outperform their industry peers in the procurement of clean energy, although on an absolute basis these firms perform much worse than say software developers.

Finally, popular negative screens are those that screen out firms involved in the tobacco, alcohol or gambling industries. Historically these are probably the first examples of socially responsible investment screens. In particular, dating as far back as the 19th century methodists and quakers in the United States are known to apply these screens to align their investments with their religious beliefs.

3 Related literature

The question about the real effects of socially responsible investment screening is not new. It has previously been addressed theoretically in at least two papers.

First, Angel and Rivoli (1997) used the model of Merton (1987) to argue that stocks of firms who are shunned from the portfolios of socially responsible investors will have a higher cost of capital relative to non shunned firms all else equal. The central intuition is that socially responsible investing creates market segmentation effects akin to those generated by incomplete information in Merton (1987).

Secondly, Heinkel, Kraus, and Zechner (2001) analyze in a simple model of capital market equilibrium whether firms may have an incentive to take a costly action to change their technology from a dirty to an environmentally friendly one in the presence of socially responsible investors. Central to the paper is the idea that socially responsible investors shun the stocks of firms with a dirty technology out of ideological motivations. This will cause the risk of dirty technology firms to be carried by a smaller number of investors limiting the potential for risk diversification and causing traditional investors to charge a risk premium in order to invest in dirty technology firms. Firms could then be expected to be willing to change their technology if the cost of doing so is less than the discount in their market valuation if they stick to the old technology.

Both papers suggest a reason for why the shares of stocks shunned by socially responsible investors should have a higher cost of capital than otherwise comparable shares which face no boycott. The current paper differs importantly from both papers in that its central conclusion is that stocks actively traded may trade at a discount or a premium depending on the model parameter and is therefore richer in the predictions it makes.

The framework of the current paper has most in common with Heinkel, Kraus, and Zechner (2001) in that it does not rely on an asset pricing model such as Angel and Rivoli (1997), but differs impor-

tantly in that the model assumes asymmetry of information between investors and heterogeneity of beliefs regarding the relationship between corporate social and financial performance. In particular, the main factor driving the different conclusions of the current paper are generated by the asymmetry of information and the trading behavior of socially responsible investors who are assumed to trade actively on corporate social performance information.

The only paper which thus far has been able to provide evidence that SRI screening may result in a cost of capital gap between virtuous and non-virtuous firms is Hong and Kacperczyk (2009). The paper documents that sin stocks, defined as shares of firms involved in the production of alcohol, tobacco and gambling, have a higher expected return than comparable non-sin stocks. The paper argues that this is a result of SRI screening rather than unobserved risk factors to which sin stocks are exposed. The main argument they provide to back this claim is that sin stocks are held to a much lesser extent by institutional investors who are more exposed to pressure not to invest in shares of firms involved in the so called sin-stock industries.

Besides the above theoretical arguments cited above, the paper is also related to a large swath of empirical research pertaining to the relationship between corporate social and financial performance. Indeed, one of the paper's main assumptions is that traditional and socially responsible investors differ in their beliefs regarding the cash flow importance of responsible corporate behavior. Apart from the anecdotal evidence on observed investment strategies by institutional investors, the disagreement in beliefs can be justified in light of the mixed evidence in academic journals on the relationship between corporate social and financial performance.

Responsible corporate behavior can be defined along several dimensions such as environment, community relationships, human resources, customer and supplier relationships, human rights and corporate governance. Although socially responsible investors screen and trade on all of the above dimensions, the academic literature is far from clear on which if any of the above dimensions of responsible corporate behavior may boost a firm's financial performance.

A different variety of approaches has been used in the past in order to shed empirical light on the doing well while doing good hypothesis.

First, a series of event studies have focussed on corporate environmental performance and have sought to link it to stock prices. In particular, papers such as Shane and Spicer (1983) , Hamilton (1995) , Klassen and McLaughlin (1996) and Karpoff, Lott, and Wehrly (2005) all document significant stock price reactions in response to news related to firms' environmental pollution record. Moreover, Klassen and McLaughlin (1996) documents that downward price movements after negative news about pollution records are stronger than upward movements after positive news. Furthermore, Karpoff, Lott, and Wehrly (2005) finds that downward movements in share prices are closely related to expected penalties and fines firms may be exposed to after bad environmental performance. As such these papers

suggest that investors pay more attention to potential short term negative implications in terms of fines and penalties of firms with a bad environmental record rather than potential long term future benefits in terms of productivity gains.

Next a strand of literature seeks to shed light on the relationship between financial and social or environmental performance by analyzing the returns of socially screened stock portfolios and comparing them to the returns of traditional stock portfolios. The key distinguishing feature among the papers taking this approach is usually how the SRI screens are defined and hence which firms are included in the socially screened portfolios. Furthermore, whether or not socially responsible portfolios outperform appears to depend on the specific screens used.

Cohen, Fenn, and Konar (1997) examines the relationship between financial and environmental performance by constructing two industry balanced portfolios of S&P 500 companies and comparing the stock returns of the “higher polluter” and “lower polluter” portfolio. Overall, the paper finds no penalty nor extra return for the green portfolio.

Derwall, Guenster, Bauer, and Koedijk (2005) on the other hand finds that a portfolio of eco-efficient companies significantly outperforms less environmentally efficient companies even after controlling for commonly used asset pricing factors.

Kempf and Osthoff (2007) documents that a long short portfolio strategy which entails buying stocks with a high social performance ratings while selling stocks with low social performance ratings delivers high abnormal returns which are robust to reasonable transaction costs. In order to obtain the high abnormal returns, the social performance ratings are based on a combination of several criteria and several dimensions of responsible behavior do not yield abnormal returns when looked at in isolation.

In particular, in contrast to Derwall, Guenster, Bauer, and Koedijk (2005), long short strategies which invest in high versus low environmental performance firms does not yield abnormal returns. The biggest contributors to abnormal returns on the other hand appear to be firm performance on employee relations and community relations.

It should be noted however that Derwall, Guenster, Bauer, and Koedijk (2005) and Kempf and Osthoff (2007) differ crucially in how firm performance on the different dimensions is defined. In particular, Derwall, Guenster, Bauer, and Koedijk (2005) uses a proprietary database of Innovest a fundmanager advisory firm while Kempf and Osthoff (2007) uses the publicly available social ratings from Kinder, Lindenberg and Domini (KLD).

The results in Edmans (2011) are in line with the findings in Kempf and Osthoff (2007) regarding the importance of employee relations by finding that a portfolio consisting of the 100 best companies to work for significantly outperforms a comparable base portfolio.

Nelling and Webb (2009) find a weak correlation between measures of corporate social responsibility and financial performance. Moreover, their analysis suggests that high corporate social performance is

driven by rather than drives high financial performance. That is, firms engage in CSR because they have the necessary financial resources rather than because it will boost their financial performance.

In addition to studies on stock prices and portfolio returns, researchers have also looked at valuation measures such as tobin's Q in order to determine whether good social performance leads to higher than average valuation.

Jiao (2010) looks at the effect of corporate social performance on firm valuation as defined by tobin's Q. The social performance ratings are constructed using the KLD rating data and overall the paper finds that a high score on a broad stakeholder welfare measure leads to positive valuation effects. The results depend strongly however on how the stakeholder measure is constructed. In particular, although employee welfare and environmental performance generate positive valuation effects, diversity, community relations and product quality do not seem to matter. Therefore, although certain stakeholder groups appear to be generally important for valuation others do not.

Finally, Ghoul, Guedhami, Kwok, and Mishra (2011) use the approach from PÅastor, Sinha, and Swaminathan (2008) to estimate the ex-ante expected cost of capital. This approach combines both market data and analyst forecasts to obtain a cleaner measure of a firm's equity cost of capital. The main finding from the paper is that corporate social responsibility is associated with lower equity cost of capital in particular when responsible behavior is defined along employee relations, environmental performance and product strategies.

4 Model.

4.1 Outline.

I analyze the impact of socially responsible investment (SRI) strategies on a firm’s equilibrium cost of capital in a two stage Grossman and Stiglitz (1980) type model with two classes of investors.

In particular, the model is populated by a continuum of investors with mass n . A proportion λ^T of these investors belongs to the first investor class and are called “traditional” investors, while a proportion λ^S belongs to the second investor class and are called “socially responsible” investors.

There is a single firm in the economy with a measure Ω of shares outstanding, traded in the financial market at a price \tilde{P} . In addition to the firm’s shares, investors in the model are able to invest in a risk free asset which is in unlimited supply and with payoff and price normalized to one.

In contrast to the standard Grossman and Stiglitz (1980) model, the trading stage in this model is preceded by a pre-trading stage during which socially responsible investors decide whether they will trade the shares of the firm or not. During the socially responsible screening stage, only socially responsible investors are assumed to play a role. Moreover, the exposition of the screening stage is moreover kept as simple as possible since the focus of the current paper is to examine the cost of capital and price formation implications of socially responsible investment strategies under heterogenous beliefs. Though analyzing the precise structure of the screening stage might nevertheless prove insightful, this needs to be relegated to future research.

The next two sections describe respectively the socially responsible screening stage and the trading stage.

4.2 Socially responsible screening stage.

During the screening stage, socially responsible investors determine whether they will trade the firm’s shares during the subsequent trading stage. In essence, during the screening stage socially responsible investors determine whether the firm scores sufficiently high on its corporate social performance in order for its shares to be eligible for trade. To this end, socially responsible investors collect information on the firm’s corporate social performance and apply a performance threshold.

Through the screening procedure, socially responsible investors seek to align their investment savings decisions with their personal values.

The firm’s corporate social performance is modelled as the sum of two components: the firm’s average corporate social performance, $\tilde{\mu}_\Xi$ and a zero mean shock component, $\tilde{\delta}$.

$$\tilde{\Xi} = \tilde{\mu}_\Xi + \tilde{\delta}.$$

The firm's average corporate social performance is modelled as a binary random variable,

$$\tilde{\mu}_{\Xi} = \begin{cases} \mu_H & \text{with prob. } p \\ \mu_L < \mu_H & \text{with prob. } 1 - p \end{cases}. \quad (1)$$

The shock component is a zero mean normally distributed random variable,

$$\tilde{\delta} \sim \mathcal{N}(0, \sigma_{\delta}^2). \quad (2)$$

When socially responsible investors collect information on the firm's corporate social performance, it will be assumed that they perfectly learn its two components, $\tilde{\mu}_{\Xi}$ and $\tilde{\delta}$. Although the assumption of perfect learning is strong, it is mainly made to maintain tractability throughout the model.

In particular, as will become clearer from the discussion on the trading stage, this assumption avoids a situation in which the price would be informative about two fundamentals. In such a case, solving for the equilibrium price becomes much more cumbersome and would not add anything to the point this paper seeks to make regarding the negative externality socially responsible investors have on traditional investors under heterogeneity of beliefs.

In addition it should be noted that the information collection process is not modelled explicitly in this paper. This is in part done in order to simplify the exposition but also because it is upfront not clear how the information process should be modelled.

In particular, since socially responsible screening is at least in part driven by the non-pecuniary motive to align investment savings decisions with personal values, modelling information collection would require a stance on how to model the utility derived from this utility and more importantly a stance on how it relates to utility derived from financial gains. Though research in social psychology has attempted to shed light on modelling this non-profit motive, a consensus is far from reached. As such this paper will avoid going into this complication and will assume that socially responsible investors become perfectly informed about the firm's corporate social performance during the screening stage.

Next, the paper will assume that the screening decision by socially responsible investors is assumed to be based solely on the firm's average corporate social performance, $\tilde{\mu}_{\Xi}$ and not $\tilde{\delta}$. In particular, the straightforward screening rule socially responsible investors apply is that they will trade the firm's shares if $\tilde{\mu}_{\Xi} = \mu_H$ and not otherwise.

The assumption that screening is based on $\tilde{\mu}_{\Xi}$ is made primarily for tractability. Together with another assumption made below, it will ensure that the remaining uncertainty faced by traders during the trading stage is normally distributed. Without this assumption, uncertainty of a binary nature would be introduced in the model causing loss in tractability since a closed form solution of the equilibrium

would no longer be available in the CARA utility Grossman and Stiglitz (1980) set-up.

Nevertheless, the assumption is less strong than may seem in the first place since evidence suggests that socially responsible investors base their screening decisions primarily on firms' long run corporate social performance and to a lesser extent on short run shocks.

The set-up as described above now seems to introduce a new type of uncertainty for traditional investors. In particular, in so far as traditional investors are not perfectly informed about the firm's corporate social performance, they technically do not know whether socially responsible investors are present in the market and hence whether they trade the firm's shares. This makes it harder for traditional investors to condition their demand on the equilibrium stock price, and hence makes trading for them riskier.

However, there is ample reason to believe that although this source of uncertainty is likely present, it is of only secondary importance. The main reason for this is that there exist a number of public information sources which indicate whether or not a firm is likely to be screened in or out of the portfolios of socially responsible investors.

The first such source are socially responsible investment indices, such as for instance the KLD 400 social index, the Dow Jones sustainability index or the FTSE4good index. These are indices comprising firms who according to the companies managing the indices have positive environmental, social and governance (ESG) characteristics. The composition of these indices is publicly available and can be thought of as reflecting the average consensus among socially responsible investors regarding which firms are eligible for adoption into a socially responsible investment portfolio.

Secondly, socially responsible financial intermediaries such as ethical or social banks aim to lend only to firms with positive ESG characteristics and apply a policy of transparent reporting on the firms adopted in their portfolios. To the extent that social and ethical banks use SRI screens similar to the ones used by the broader SRI community, their lending decisions are a second good public source of which firms are included or excluded from the portfolios of socially responsible investors.

In order to reflect this, the paper will continue under the assumption that the screening rule used by socially responsible investors is common knowledge and that the outcome of the screening process is publicly observed. As such traditional investors will perfectly learn the value of $\tilde{\mu}_{\Xi}$ at the end of the screening stage and will be able to condition their trades on it during the subsequent trading stage.

The above discussion is summarized in assumption 1

Assumption 1. *Information during the screening stage:*

- *Socially responsible investors perfectly learn $\tilde{\mu}$ and $\tilde{\delta}$ during the screening stage.*
- *Traditional investors perfectly learn $\tilde{\mu}$ during the screening stage.*

The screening stage will then determine whether only traditional investors or both traditional and socially responsible investors will trade the firm's shares in the financial market.

4.3 Trading stage.

During the trading stage, all investors seek to earn speculative trading profits on the information they have about the firm's fundamental. Both traditional and socially responsible investors are endowed with CARA utility preferences defined over end of period wealth and have a risk aversion of $\frac{1}{\gamma}$. All investors also have the same initial wealth \bar{W} .

Though both types of investors are motivated by the same speculative trading profit motive, socially responsible and traditional investors are assumed to disagree on how the firm's fundamental should be defined. In particular, socially responsible investors believe the firm's corporate social performance is a key additional factor driving its financial performance while traditional investors consider it irrelevant.

Furthermore, as was indicated above, socially responsible investors have an informational advantage, $\tilde{\delta}$, over traditional investors which they inherited from the socially responsible screening stage. Since socially responsible investors believe corporate social performance drives cash flow performance, they will trade on the additional information they have and incorporate it into the equilibrium price.

In so far as traditional investors do not believe $\tilde{\delta}$ is relevant however, they will view the equilibrium price as having been contaminated by an additional factor of noise similar to the noise introduced by noise traders. If they are informed about $\tilde{\delta}$, then they can remove its effect from the equilibrium price. If they remain uninformed however, traditional investors will charge an additional risk premium for trading the firm's shares since the equilibrium price is less informative about what they view is the firm's fundamental. The trading behavior and the informational advantage of socially responsible investors then has a negative externality on traditional investors putting upward pressure on the firm's cost of capital.

To model the trading process, the following elements are introduced.

First, apart from its corporate social performance, $\tilde{\Xi}$, the firm is characterized by a random variable $\tilde{\Theta}$ which represents "traditional" sources of financial performance. Both traditional and socially responsible investors agree on the importance of $\tilde{\Theta}$ as a driver of financial performance.

Conditional on the firm passing the screening process, $\tilde{\Xi}$ is normally distributed since the uncertainty about the mean component is resolved by the time the trading process begins. In particular, the joint distribution between $\tilde{\Theta}$ and $\tilde{\Xi} = \mu_H + \tilde{\delta}$ is given by

$$\begin{pmatrix} \tilde{\Theta} \\ \tilde{\Xi} \end{pmatrix} \sim \mathcal{N} \begin{pmatrix} 0 & , & \sigma_{\Theta}^2 & 0 \\ \mu_H & , & 0 & \sigma_{\delta}^2 \end{pmatrix},$$

$$\tau_{\Theta} = \frac{1}{\sigma_{\Theta}^2}, \quad \tau_{\delta} = \frac{1}{\sigma_{\delta}^2}.$$

Secondly, let ϕ^t , $t \in \{S, T\}$ represent the contribution of corporate social performance to financial performance according to investor class t . Then socially responsible investors believe $\phi^S \geq 0$, while $\phi^T = 0$. This is summarized in assumption 2.

Assumption 2. *Let ϕ^t , $t \in \{S, T\}$ denote the contribution of corporate social performance to financial performance according to investor class t then,*

- *Traditional investors believe $\phi^T = 0$,*
- *Socially responsible investors believe $\phi^S \geq 0$.*

The cash flow fundamental for traditional investors, \tilde{V}^T , is then given by

$$\tilde{V}^T = \tilde{\Theta}.$$

The cash flow fundamental for socially responsible investors, \tilde{V}^S , is then given by

$$\tilde{V}^S = \tilde{\Theta} + \phi^S \tilde{\Xi}.$$

As was indicated above, all investors are motivated the possibility to earn speculative trading profits on the information they have about the firm's fundamental. In what follows, the information set of the different investor types will be discussed.

First, both traditional and socially responsible investors are assumed to be endowed with a private signal about $\tilde{\Theta}$,

$$\tilde{s}_i = \tilde{\Theta} + \tilde{\epsilon}_i$$

and

$$\tilde{\epsilon}_i \sim \mathcal{N}(0, \sigma_{\epsilon}^2), \quad \tau_{\epsilon} = \frac{1}{\sigma_{\epsilon}^2}, \quad \tilde{\epsilon} \perp \tilde{\Theta}.$$

By trading on their private signal \tilde{s}_i , all investors make the price informative about the cash flow fundamental $\tilde{\Theta}$, causing investors to seek to learn from the equilibrium price.

Secondly, socially responsible investors are perfectly informed about $\tilde{\Xi}$. In particular, during the screening stage socially responsible investors learn both $\tilde{\mu}$ and $\tilde{\delta}$.

Traditional investors however only learn $\tilde{\mu}$ and not necessarily $\tilde{\delta}$. Because one of goals of the model is to analyze the implications of the informational disadvantage between traditional and socially responsible investors, traditional investors will be assumed to belong to one of the following two subgroups.

First, a proportion λ^{TI} of traditional investors is assumed to observe both $\tilde{\mu}$ and $\tilde{\delta}$. This set of

traditional investors is implicitly assumed to have collected additional information about the firm's corporate social performance in order to learn $\tilde{\delta}$.

For simplicity this information collection process is not modelled explicitly since it would not yield additional insights into the point the paper wants to make. The proportion of informed traditional investors will therefore be assumed to be given exogenously. Nevertheless, it should be intuitively clear why traditional investors might be interested in collecting information about $\tilde{\delta}$. Indeed, even though traditional investors do not believe in the cash flow relevance of corporate social performance, knowing $\tilde{\delta}$ allows them to make the equilibrium price more informative about $\tilde{\Theta}$ because it allows them to remove what they interpret as corporate social performance noise incorporated by socially responsible investors.

Secondly, the remaining proportion of traditional investors, $\lambda^{TU} = \lambda^T - \lambda^{TI}$ is assumed to have access only to the public signal $\tilde{\mu}$ which is revealed by observing the outcome of the screening process.

Finally, in addition to the informed investors, there is a measure ρn of noise traders who trade for liquidity reasons. Each noise trader is assumed to demand $-\tilde{z}$ where

$$\tilde{z} \sim \mathcal{N}(0, \sigma_z^2).$$

In addition it will be assumed that the measure of noise traders in the market is independent of whether the firm passes or fails the SRI screen. This seems reasonable if one assumes that noise trading is carried out for liquidity reasons and is unlikely to depend on the corporate social performance of the firm.

Finally, all investors can condition their trades on the equilibrium stock price. However, because not all investors have the same information set, the equilibrium stock price will not be equally informative to all investors.

Figure 1 gives a quick summary of the two stages of the model

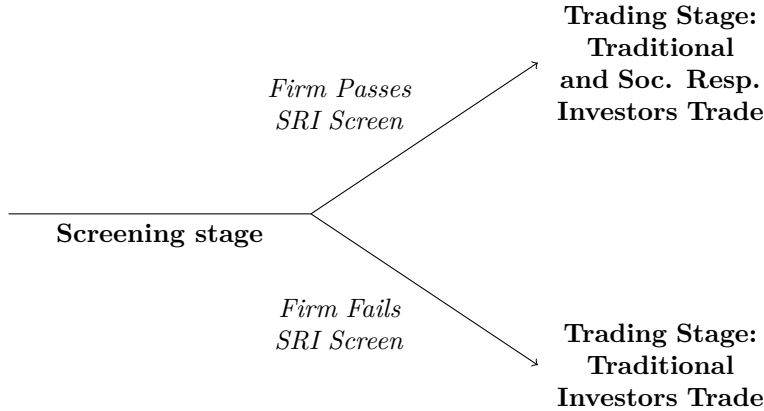


Figure 1: Timeline.

5 Model solution

The structure of the firm's equilibrium share price is a function of whether the firm fails or passes the SRI screen. Furthermore, because of assumption 1, all investors during the trading stage know the outcome of the screening stage and hence know whether socially responsible investors are present or not. In the next two sections the equilibrium share price and cost of capital are derived for respectively the case where the firm passes the SRI screen and when it fails it.

5.1 Equilibrium cost of capital when the firm fails the SRI screen

As a benchmark, the equilibrium price and cost of capital will be derived when the firm fails the SRI screen. In this case only traditional investors are present who share the same beliefs and who have the same informational disadvantage. The benchmark case is the basic solution to the Grossman and Stiglitz (1980) model.

In order to solve for the equilibrium, a conjecture is made about the equilibrium price which is then later verified. The equilibrium price when the firm fails the SRI screen is conjectured to take the following linear form.

$$\tilde{P} = q_0 + q_1\tilde{\Theta} + q_2\tilde{z}$$

5.1.1 Traditional investors: inference and demand

When the firm fails the SRI screen, only traditional investors trade the firm's shares. This implies that the total number of investors trading the firm's shares is not n but $\lambda^T n$ where $\lambda^T = (\lambda^{TI} + \lambda^{TU})$. All else equal, the lower informed investor base will render the equilibrium price less informative since a smaller number of investors trade on their private signal \tilde{s}_i .

Furthermore, since there are no socially responsible investors to incorporate the corporate social performance information into the equilibrium price, there is no difference between the inference and demand of informed versus uninformed traditional investors.

Under CARA preferences and normally distributed fundamentals, the equilibrium demand of traditional investors takes the following form

$$x_i^T = \gamma \frac{\mathbb{E}[\tilde{\Theta}|\tilde{s}_i, \tilde{P}] - \tilde{P}}{\text{Var}(\tilde{\Theta}|\tilde{s}_i, \tilde{P})}.$$

The equilibrium price then constitutes a signal \hat{P} of the cash flow fundamental $\tilde{\Theta}$, given by

$$\hat{P} = \frac{\tilde{P} - q_0}{q_1} = \tilde{\Theta} + \frac{q_2}{q_1}\tilde{z},$$

with precision τ_P

$$\tau_P = \left\{ \left(\frac{q_2}{q_1} \right)^2 \sigma_z^2 \right\}^{-1}.$$

Since all random variables are normally distributed, we obtain the expressions for the inference on $\tilde{\Theta}$ by applying Bayes' rule.

$$\begin{aligned} \mathbb{E} \left[\tilde{\Theta} | \tilde{s}_i, \tilde{P} \right] &= \frac{\tau_\epsilon \tilde{s}_i + \tau_P \hat{P}}{\tau_\Theta + \tau_\epsilon + \tau_P} \\ \text{Var} \left(\tilde{\Theta} | \tilde{s}_i, \tilde{P} \right) &= \frac{1}{\tau_\Theta + \tau_\epsilon + \tau_P} \end{aligned}$$

After plugging these expressions in we obtain the equilibrium share demand of traditional investors.

$$x_i^T = \gamma \left(\tau_\epsilon \tilde{s}_i + \tau_P \hat{P} - (\tau_\Theta + \tau_\epsilon + \tau_P) \tilde{P} \right).$$

5.1.2 Equilibrium

The equilibrium condition when the firm fails the SRI screen equates total demand of the firm's shares to total supply,

$$\lambda^T \int x_i^T d_i - \rho \tilde{z} = \frac{\Omega}{n}.$$

Using the equilibrium condition we can then solve for the equilibrium price coefficients. 1 summarizes the result and the proof is relegated to appendix A.1.

Proposition 1. *There exists a unique linear rational expectations equilibrium*

$$\tilde{P} = q_0 + q_1 \tilde{\Theta} + q_2 \tilde{z}.$$

The coefficients $q_0 < 0, q_1 > 0, q_2 < 0$ are a function of the exogenous parameters and are given in appendix A.1.

Using the expressions for the equilibrium price coefficients, we can now derive an expression for the firm's ex-ante cost of capital conditional on the firm having failed the socially responsible investment screen. In the model however, different investors share different beliefs regarding the relationship between the firm's social and its financial performance.

Rather than taking a specific stance on whether traditional or socially responsible investors are correct, the ex ante cost of capital will be defined with respect to the true underlying relationship between a firm's financial and social performance to be denoted by $\bar{\phi}$ and which will be assumed to lie between traditional investors' and socially responsible investors' beliefs $\bar{\phi} \in [0, \phi^S]$. In doing so the

paper follows Easley, O’hara, and Yang (2012) who in a model of ambiguity aversion about a model parameter define the ex-ante cost of capital with respect to the true underlying value. By varying $\bar{\phi}$ over the beliefs interval, the extent to which one investor group can be viewed as over or underestimating the relationship between corporate social and corporate financial is changed.

The ex-ante cost of capital conditional on the firm failing the investment screen is then defined as

$$\mathbb{E}^F [\tilde{V} - \tilde{P}] = \mathbb{E}^F [\tilde{\Theta} + \bar{\phi}\tilde{\Xi} - \tilde{P}].$$

2 then gives the expression for the equilibrium cost of capital conditional on failing the socially responsible investment screen.

Proposition 2. *The firm’s ex-ante cost of capital conditional on failing the socially responsible investment screen is given by*

$$\mathbb{E}^F [\tilde{V} - P] = \bar{\phi}\mu_L + \frac{\Omega}{\gamma n [\tau_{\Theta} + \tau_{\epsilon} + \tau_P]},$$

where,

$$\tau_P = \left\{ \left(\frac{\rho}{\gamma \lambda^T \tau_{\epsilon}} \right)^2 \sigma_z^2 \right\}^{-1}.$$

5.2 Equilibrium cost of capital when the firm passes the SRI screen

When the firm passes the investment screen, both traditional and socially responsible investors will trade the firm’s shares. This has implications for the firm’s equilibrium price which will now be a function not only of $\tilde{\Theta}$ but also of $\tilde{\Xi}$. Although the higher number of investors will have a positive effect on the firm’s cost of capital, the heterogeneity in beliefs will be shown to potentially offset this.

In order to solve for the equilibrium, a conjecture is made about the equilibrium price which is then later verified. The equilibrium share price when the firm passes the SRI screen is conjectured to take the following linear form

$$\tilde{P} = p_0 + p_1\tilde{\Theta} + p_2\tilde{\Xi} + p_3\tilde{z}.$$

5.2.1 Corporate social performance informed traditional investors

Under CARA preferences and normally distributed fundamentals, the equilibrium demand of $\tilde{\Xi} = \mu_H + \tilde{\delta}$ informed traditional investors takes the following form

$$x_i^{TI} = \gamma \frac{\mathbb{E} \left[\tilde{\Theta} | \tilde{s}_i, \tilde{\Xi}, \tilde{P} \right] - \tilde{P}}{\text{Var} \left(\tilde{\Theta} | \tilde{s}_i, \tilde{\Xi}, \tilde{P} \right)}.$$

Conditional on the information of informed traditional investors, the equilibrium price constitutes a signal \bar{P} of the cash flow fundamental $\tilde{\Theta}$, given by

$$\bar{P} = \frac{\tilde{P} - p_0 - p_2 \tilde{\Xi}}{p_1} = \tilde{\Theta} + \frac{p_3}{p_1} \tilde{z},$$

with precision τ_P^I

$$\tau_P^I = \left\{ \left(\frac{p_3}{p_1} \right)^2 \sigma_z^2 \right\}^{-1}.$$

The intuition behind this is straightforward. First, traditional investors attempt to infer from the equilibrium price the private information about $\tilde{\Theta}$ incorporated by other investors. Secondly however, traditional investors do not believe that corporate social performance information is relevant for the value of the firm. Because the trading behavior of socially responsible investors however incorporates corporate social performance information into the equilibrium price, corporate social performance informed traditional investors will use their information on $\tilde{\Xi}$ to remove its effect on the equilibrium share price. In this way informed traditional investors obtain a price signal that is more precise about $\tilde{\Theta}$.

The inference on $\tilde{\Theta}$ made by traditional informed investors is then given by

$$\begin{aligned} \mathbb{E} \left[\tilde{\Theta} | \tilde{s}_i, \tilde{\Xi}, \tilde{P} \right] &= \frac{\tau_\epsilon \tilde{s}_i + \tau_P^I \bar{P}}{\tau_\Theta + \tau_\epsilon + \tau_P^I} \\ \text{Var} \left(\tilde{\Theta} | \tilde{s}_i, \tilde{\Xi}, \tilde{P} \right) &= \frac{1}{\tau_\Theta + \tau_\epsilon + \tau_P^I} \end{aligned}$$

The equilibrium demand by informed traditional investors is then given by

$$x_i^{TI} = \gamma \left(\tau_\epsilon \tilde{s}_i + \tau_P^I \bar{P} - (\tau_\Theta + \tau_\epsilon + \tau_P^I) \tilde{P} \right).$$

5.2.2 Corporate social performance uninformed traditional investors

Under CARA preferences and normally distributed fundamentals, the equilibrium demand of $\tilde{\Xi}$ uninformed traditional investors takes the following form

$$x_i^{TU} = \gamma \frac{\mathbb{E} \left[\tilde{\Theta} | \tilde{s}_i, \tilde{P} \right] - \tilde{P}}{\text{Var} \left(\tilde{\Theta} | \tilde{s}_i, \tilde{P} \right)}.$$

Because $\tilde{\Xi}$ is not contained in the information set of uninformed traditional investors, the equilibrium

price constitutes a different signal, \bar{P} , about the fundamental $\tilde{\Theta}$. \bar{P} is given by

$$\bar{P} = \frac{\tilde{P} - p_0 - p_2\mu_H}{p_1} = \tilde{\Theta} + \frac{p_2}{p_1}\tilde{\delta} + \frac{p_3}{p_1}\tilde{z}.$$

with precision τ_P^U

$$\tau_P^U = \left\{ \left(\frac{p_2}{p_1} \right)^2 \sigma_\delta^2 + \left(\frac{p_3}{p_1} \right)^2 \sigma_z^2 \right\}^{-1}.$$

One immediately notices that uninformed traditional investors indeed face a less informative price signal than their informed counterparts due to the factor $\left(\frac{p_2}{p_1} \right)^2 \sigma_\delta^2$.

$$\tau_P^U = \left\{ \overbrace{\left(\frac{p_2}{p_1} \right)^2 \sigma_\delta^2}^{\text{CSP noise effect}} + \left(\frac{p_3}{p_1} \right)^2 \sigma_z^2 \right\}^{-1} < \left\{ \left(\frac{p_3}{p_1} \right)^2 \sigma_z^2 \right\}^{-1} = \tau_P^I.$$

Moreover, the precision decreases in $\tilde{\delta}$ which reflects the uncertainty regarding the firm's corporate social performance and $\frac{p_3}{p_1}$ which captures the relative importance of $\tilde{\Xi}$ as a component of the equilibrium price.

The inference on $\tilde{\Theta}$ made by traditional uninformed investors is then given by

$$\begin{aligned} \mathbb{E} \left[\tilde{\Theta} | \tilde{s}_i, \tilde{P} \right] &= \frac{\tau_\epsilon \tilde{s}_i + \tau_P^U \bar{P}}{\tau_\Theta + \tau_\epsilon + \tau_P^U} \\ \text{Var} \left(\tilde{\Theta} | \tilde{s}_i, \tilde{P} \right) &= \frac{1}{\tau_\Theta + \tau_\epsilon + \tau_P^U} \end{aligned}$$

The equilibrium demand by uninformed traditional investors is then given by

$$x_i^{TU} = \gamma \left(\tau_\epsilon \tilde{s}_i + \tau_P^U \bar{P} - (\tau_\Theta + \tau_\epsilon + \tau_P^U) \tilde{P} \right).$$

5.2.3 Socially responsible investors

Under CARA preferences and normally distributed fundamentals, the equilibrium demand of socially responsible investors takes the following form

$$x_i^S = \gamma \frac{\mathbb{E} \left[\tilde{\Theta} + \phi^S \tilde{\Xi} | \tilde{s}_i, \tilde{\Xi}, \tilde{P} \right] - \tilde{P}}{\text{Var} \left(\tilde{\Theta} + \phi^S \tilde{\Xi} | \tilde{s}_i, \tilde{\Xi}, \tilde{P} \right)}.$$

Given the information of socially responsible investors, the equilibrium price constitutes the following signal of the firm's fundamental

$$\bar{P} = \frac{\tilde{P} - p_0 - p_2 \tilde{\Xi}}{p_1} = \tilde{\Theta} + \frac{p_3}{p_1} \tilde{z},$$

with precision τ_P^I

$$\tau_P^I = \left\{ \left(\frac{p_3}{p_1} \right)^2 \sigma_z^2 \right\}^{-1}.$$

The precision of the price signal for socially responsible investors is as precise as it is for $\tilde{\Xi}$ informed traditional investors since socially responsible investors are assumed to have perfect information on the firm's corporate social performance and hence understand the different sources of variation of the equilibrium price.

Socially responsible investors differ from traditional investors however in that their trades are conditional on the firm's corporate social performance since they believe $\tilde{\Xi}$ is a cash flow relevant fundamental. The extent to which the trades are a function of $\tilde{\Xi}$ is a function of ϕ^S . It is because the trades of socially responsible investors are conditioned on $\tilde{\Xi}$ that the equilibrium price is a function of both $\tilde{\Xi}$ and $\tilde{\Xi} + \tilde{\delta}$. The dependence on $\tilde{\Xi} + \tilde{\delta}$ comes from the fact that uninformed traditional investors use the public signal on the firm's corporate social performance to filter out some of the corporate social performance information incorporated into the equilibrium price.

The equilibrium demand for socially responsible investors as a function of ϕ^S is given by

$$x_i^S = \gamma \left(\tau_\epsilon \tilde{s}_i + \tau_P^I \bar{P} + (\tau_\Theta + \tau_\epsilon + \tau_P^I) \phi^S \tilde{\Xi} - (\tau_\Theta + \tau_\epsilon + \tau_P^I) \tilde{P} \right).$$

5.2.4 Equilibrium

The equilibrium condition when the firm passes the SRI screen equates total demand of the firm's shares to total supply,

$$\lambda^{TI} \int x_i^{TI} di + \lambda^{TU} \int x_i^{TU} di + \lambda^S \int x_i^S di - \rho \tilde{z} = \frac{\Omega}{n}.$$

Using the equilibrium condition we can then solve for the equilibrium price coefficients. ?? summarizes the result and the proof is relegated to appendix A.2.

Proposition 3. *There exists a unique linear rational expectations price equilibrium*

$$\tilde{P} = p_0 + p_1 \tilde{\Theta} + p_2 \tilde{\Xi} + p_3 \tilde{z}.$$

The coefficients $p_0 < 0, p_1 > 0, p_2 > 0, p_3 < 0$ are a function of the exogenous parameters and are given in appendix A.2.

In line with the previous section, the firm's ex ante cost of capital conditional on passing the SRI

screen will be defined with respect to the true underlying relationship between corporate financial and social performance $\bar{\phi}$.

The firm's ex ante cost of capital conditional on passing the socially responsible investment screen can then be defined as

$$\mathbb{E}^P [\tilde{V} - \tilde{P}] = \mathbb{E}^P [\tilde{\Theta} + \bar{\phi}\tilde{\Xi} - \tilde{P}]$$

Proposition 4. *The firm's ex-ante cost of capital conditional on passing the socially responsible investment screen is given by*

$$\mathbb{E}^P [\tilde{V} - \tilde{P}] = \bar{\phi}\mu_H - \frac{\phi^S \mu_H \lambda^S (\tau_\Theta + \tau_\epsilon + \tau_P^I)}{\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U} + \frac{\Omega}{\gamma n [\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U]},$$

where,

$$\tau_P^I = \left\{ \left(\frac{\rho}{\gamma \tau_\epsilon} \right)^2 \sigma_z^2 \right\}^{-1},$$

and

$$\tau_P^U = \left\{ \left(\frac{\phi^S \lambda^S (\tau_\Theta + \tau_\epsilon + \tau_P^I)}{\tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I} \right)^2 \sigma_\delta^2 + \left(\frac{\rho}{\gamma \tau_\epsilon} \right)^2 \sigma_z^2 \right\}^{-1}.$$

6 Analysis

After having characterized the equilibrium cost of capital, we can now turn to an analysis of how SRI screening affects a firm's cost of capital when socially responsible differ from traditional investors in their view on the cash flow importance of corporate social performance.

There are two main channels which can be identified with respect to the impact of SRI screening: a mean-return channel and a risk compensation channel. In the next two sections both channels will be discussed.

6.1 Risk compensation channel

First lets consider the risk compensation channel. The risk compensation channel is represented by

$$\frac{\Omega}{\gamma n [\tau_{\Theta} + \tau_{\epsilon} + \tau_P]}$$

when the firm fails the SRI screen and by

$$\frac{\Omega}{\gamma n [\tau_{\Theta} + \tau_{\epsilon} + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U]}$$

when the firm passes the SRI screen.

We immediately see that the difference between the two risk compensation components lies in the precision of the price as signal of the cash flow fundamental, $\tilde{\Theta}$, as viewed from the perspective of the different investor groups, τ_P , τ_P^I and τ_P^U .

In particular, when the firm fails the SRI screen, the traditional investors trading the stock all face the same precision of the price signal,

$$\tau_P = \left\{ \left(\frac{\rho}{\gamma \lambda^T \tau_{\epsilon}} \right)^2 \sigma_z^2 \right\}^{-1}.$$

On the other hand when the firm passes the SRI screen, socially responsible and informed traditional investors face a precision of,

$$\tau_P^I = \left\{ \left(\frac{\rho}{\gamma \tau_{\epsilon}} \right)^2 \sigma_z^2 \right\}^{-1},$$

while uninformed traditional investors face a price precision of

$$\tau_P^U = \left\{ \underbrace{\left(\frac{\phi^S \lambda^S (\tau_{\Theta} + \tau_{\epsilon} + \tau_P^I)}{\tau_{\epsilon} + (\lambda^{TI} + \lambda^S) \tau_P^I} \right)^2}_{\text{CSP noise effect}} \sigma_{\delta}^2 + \left(\frac{\rho}{\gamma \tau_{\epsilon}} \right)^2 \sigma_z^2 \right\}^{-1}.$$

Let's first look at what happens to the precision of the price signal for informed traditional investors when the firm transitions to being adopted into the SRI screen. From the expressions of τ_P and τ_P^I , it is easy to see that $\tau_P^I > \tau_P$, or in words the price becomes more informative about the $\tilde{\Theta}$ fundamental when the firm passes the SRI screen. This is due to the fact that when the firm passes the SRI screen, a larger number of investors trade on their private signal about the cash flow fundamental $\tilde{\Theta}$, making the price more informative.

Only informed traditional investors however benefit unambiguously in this way from the entry of socially responsible investors. In particular, though uninformed investors also benefit from a higher amount of trading on signals of $\tilde{\Theta}$, they are negatively affected by the trading on the corporate social performance information which socially responsible investors incorporate into the equilibrium price and which uninformed traditional investors are unable to remove. This corporate social performance (CSP) noise effect is captured by the first term in the expression of τ_P^U .

The CSP noise component is driven by several model parameters but importantly by ϕ^S which governs the beliefs socially responsible investors have regarding the relationship between corporate social and corporate financial performance. In particular, when $\phi^S = 0$, then the CSP noise effect goes away and uninformed traditional investors are unambiguously positively affected by the entry of socially responsible investors. For ϕ^S high enough however, the CSP noise effect will start to dominate the beneficial effect of a higher number of informed traders and uninformed traditional investors will face a lower precision of the price signal, that is $\tau_P^U < \tau_P$.

These findings are summarized in proposition 5

Proposition 5. *There exists a belief threshold ϕ^{S*} such that for $\phi^S > \phi^{S*}$, $\tau_P^U < \tau_P$.*

ϕ^{S*} is given by

$$\phi^{S*} = \left(\frac{\tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I}{\phi^S \lambda^S (\tau_\Theta + \tau_\epsilon + \tau_P^I)} \right) \frac{\rho}{\gamma \tau_\epsilon} \frac{\sigma_z}{\sigma_\delta} \left(\frac{1}{\lambda^{T^2}} - 1 \right)^{\frac{1}{2}}.$$

Using the expression for ϕ^{S*} we can arrive at some comparative statics results.

First, consider $\frac{\sigma_z}{\sigma_\delta}$. This ratio captures the importance of noise caused by liquidity traders relative to CSP noise as perceived by uninformed traditional investors. As can be seen from 5, ϕ^{S*} is increasing in $\frac{\sigma_z}{\sigma_\delta}$. Intuitively, the more important liquidity trading noise becomes relative to CSP noise, the stronger the beliefs need to be in order for the CSP noise effect to dominate the beneficial effect of a higher number of informed investors.

Secondly, an increase in λ^{TI} , keeping λ^T constant, increases ϕ^{S*} . The higher the proportion of informed traditional investors, the more aggressive the amount of trading on the $\tilde{\Theta}$ signals. In particular, informed traditional investors trade more aggressively on their information because they face a lower overall uncertainty due to their knowledge of the CSP information. This causes dampens the negative

effect of socially responsible investors on price informativeness.

Thirdly, the effect of λ^S on ϕ^{S*} is ambiguous. Although socially responsible investors on the one hand also trade more aggressively on their private information, they also introduce the CSP noise effect which harms the price informativeness for uninformed traditional investors.

6.2 Mean return channel

The second channel through which SRI screening affects the cost of capital is the mean return channel. The mean return channel in the model appears foremost because the different investor groups are allowed to disagree amongst each other about the contribution of corporate social to corporate financial performance and because the firm's corporate social performance does not necessarily has a zero mean.

The mean return channel is represented by

$$\bar{\phi}\mu_L$$

when the firm fails the SRI screen and by

$$\bar{\phi}\mu_H - \frac{\phi^S \mu_H \lambda^S (\tau_\Theta + \tau_\epsilon + \tau_P^I)}{\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U}$$

when the firm passes the SRI screen.

First let's consider the case when the firm fails the SRI screen.

The mean component appears because the traditional investors trading the firm's shares do not consider that the cash flow fundamental is driven by the firm's corporate social performance. In particular, under the true relationship between social and financial performance, $\bar{\phi}$, the expected value of the firm will have a non-zero mean component if $\tilde{\Xi}$ has a non-zero mean. If investors trading the firm's shares were to agree with the true relationship, then the equilibrium price would correctly reflect the non-zero mean of the fundamental and the ex-ante cost of capital would only show a risk compensation component.

Depending on whether $\mu_L < 0$ or $\mu_L > 0$, this will increase the cost of capital for the firm relative to what it would be if $\bar{\phi}$ were equal to zero. In particular, if $\mu_L < 0$, then traditional investors overestimate the mean return of the firm generating a cost of capital which is too low. On the other hand if $\mu_L > 0$, traditional investors underestimate the mean return of the firm generating a cost of capital which is too high.

Secondly, consider the case when the firm passes the SRI screen.

In this case, there are two components to the mean return channel. The first component reflects the unconditional mean of the firm's value, $\bar{\phi}\mu_H$, while the second component reflects the extent to which socially responsible investors take into account the fact that the firm's mean return is non-zero.

In particular, in line with what was said above, the equilibrium price will not reflect the true mean value of the firm if the investors trading the firm's shares do not agree with the true underlying $\bar{\phi}$. In fact if $\phi^S = \bar{\phi}$, so that socially responsible investors agree with the true underlying relationship and if $\lambda^S = 1$ so that only socially responsible investors trade the firm's shares, then the mean return component drops away.

Furthermore, under the assumption that $\mu_H > 0$, the question on whether the cost of capital is under or overestimated depends on the extent to which $\bar{\phi}$ is lower than ϕ^S and the remaining model parameters. In particular, under the initial model assumption that $\bar{\phi} < \phi^S$, and if only socially responsible investors are present, then the cost of capital would always be weakly underestimated. The reason for this is that socially responsible investors put upward pressure on the equilibrium price of the firm which is however not warranted given the true mean return of the firm.

However, in reality not only socially responsible but also traditional investors trade the firm's shares. That is why even though socially responsible investors tend to put pressure towards underestimating the firm's true cost of capital, the firm's cost of capital may well still be overestimated if the number of socially responsible investors is too small. In particular, even when socially responsible investors' beliefs are in line with the true underlying relationship, $\phi^S = \bar{\phi}$, then because not all investors incorporate this into their trading strategies, the equilibrium cost of capital of the firm will be overestimated. This result is summarized in 1.

Lemma 1. *If $\bar{\phi} \in [0, \phi^S]$, then the equilibrium cost of capital is overestimated if*

$$\lambda^S < \frac{\bar{\phi}}{\phi^S} \frac{\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U}{\tau_\Theta + \tau_\epsilon + \tau_P^I}.$$

6.3 Cost of capital

After having discussed the two channels through which the cost of capital is affected when the firm passes the SRI screen, we now turn to an analysis of the cost of capital itself and examine conditions under which passing the SRI screen will not necessarily lower the firm's cost of capital. In order to make the analysis as clear as possible, the analysis will proceed in two steps.

First the mean return channel will be artificially shut down by assuming that $\bar{\phi} = 0$ and $\mu_H = 0$. Next, the impact of passing the SRI screen will be analyzed under general parameter assumptions.

6.3.1 Cost of capital: risk compensation channel only

When $\bar{\phi} = 0$ and $\mu_H = 0$, then the cost of capital of the firm is entirely determined by the risk compensation channel. The interesting question is now if it is possible that passing the SRI screen will increase the firm's cost of capital rather than lowering it as is generally assumed. That is, is it possible that

$$\mathbb{E}^F [\tilde{V} - \tilde{P}] = \frac{\Omega}{\gamma n [\tau_{\Theta} + \tau_{\epsilon} + \tau_P]} \stackrel{?}{<} \frac{\Omega}{\gamma n [\tau_{\Theta} + \tau_{\epsilon} + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U]} = \mathbb{E}^P [\tilde{V} - \tilde{P}].$$

After performing some straightforward algebra the condition for the above condition to hold is given by

$$\lambda^{TU} \left(1 - \frac{\tau_P^U}{\tau_P} \right) > (\lambda^{TI} + \lambda^S) \left(\frac{1}{\lambda^{T^2}} - 1 \right). \quad (C1)$$

A necessary condition for this is that

$$\lambda^{TU} > (\lambda^{TI} + \lambda^S) \left(\frac{1}{\lambda^{T^2}} - 1 \right),$$

which after some algebraic manipulations reduces to.

$$\lambda^{TU} > 1 - \lambda^{T^2}. \quad (C2)$$

In other words a necessary condition for the cost of capital to increase after passing the SRI screen there need to be a sufficiently large number of uninformed investors. Intuitively, the negative effect on the cost of capital comes from the higher risk premium uninformed traditional investors demand compared to informed traditional investors and socially responsible investors.

If C2 holds then as ϕ^S increases, τ_P^U approaches 0 such that eventually C1 will hold.

In short, under the parameter assumptions such that only the risk compensation channel matters, we need a sufficiently large number of uninformed traditional investors and sufficiently strong beliefs held by socially responsible investors for the cost of capital of the firm to increase when it passes the SRI screen.

The above is summarized in proposition 6

Proposition 6. *Assume $\bar{\phi} = 0$ and $\mu_H = 0$.*

Then if λ^{TU} satisfies

$$1 > \lambda^{TU} > 1 - \lambda^{T^2}$$

*there exists a belief threshold $\phi^{**} > \phi^* > 0$ such that*

$$\mathbb{E}^P [\tilde{V} - \tilde{P}] > \mathbb{E}^F [\tilde{V} - \tilde{P}].$$

*ϕ^{**} is given by*

$$\phi^{**} = \frac{1}{\sigma_\delta} \left(\frac{\tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I}{\lambda^S (\tau_\Theta + \tau_\epsilon + \tau_P^I)} \right) \frac{\rho}{\gamma \lambda^T \tau_\epsilon} \sigma_z \left(\frac{1}{1 - \left(\frac{1}{\lambda^{TU}} - 1 \right) \left(\frac{1}{(\lambda^T)^2} - 1 \right)} - (\lambda^T)^2 \right)^{\frac{1}{2}}.$$

6.3.2 Cost of capital: mean return and risk compensation channel

In this section the gap between the cost of capital of the firm when it passes the SRI screen and when it fails the SRI screen will be analyzed in full generality. That is, the findings regarding the impact of the risk compensation channel of the previous section will be combined with the findings on the mean return channel.

In the previous section it was shown how the risk compensation channel alone already contributes to pushing the cost of capital of the firm when it passes the SRI screen above the cost of capital when it fails it. Now the question remains whether the risk compensation and mean return channel combined can generate this result.

Indeed it was already indicated above that disagreement among investors about the mean return of the firm can both push the cost of capital when the firm passes the SRI screen both higher or lower. In what follows it will be therefore be examined under what conditions the mean return channel can amplify or dampen the effects of the risk compensation channel on the firm's cost of capital.

In order to simplify the analysis, the simplifying assumption will be made that $\mu_L = 0$. Although this is not entirely without loss of generality, it allows for an easier derivation of the conditions leading to a widening or shrinking of the cost of capital gap. Under this assumption, the cost of capital gap becomes,

$$\begin{aligned} \mathbb{E}^P [\tilde{V} - \tilde{P}] - \mathbb{E}^F [\tilde{V} - \tilde{P}] = & \\ & \underbrace{\mu_H \left(\bar{\phi} - \phi^S \frac{\lambda^S (\tau_\Theta + \tau_\epsilon + \tau_P^I)}{\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U} \right)}_{\text{Mean return channel}} + \\ & \underbrace{\frac{\Omega}{\gamma n [\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U]} - \frac{\Omega}{\gamma n [\tau_\Theta + \tau_\epsilon + \tau_P]}}_{\text{Risk compensation channel}}. \end{aligned}$$

Under this additional assumption, the extent to which the mean return channel amplifies or dampens the risk compensation channel depends in large part on whether socially responsible investors overestimate the cash flow importance of corporate social performance, $\bar{\phi} < \phi^S$ or whether their beliefs

are in line with the true underlying relationship $\bar{\phi} = \phi^S$.

First consider the case in which socially responsible investors correctly assess the importance of corporate social performance. In this case the mean return channel becomes,

$$\phi^S \mu_H \left(1 - \underbrace{\frac{\lambda^S (\tau_\Theta + \tau_\epsilon + \tau_P^I)}{\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U}}_{<1} \right).$$

Since the term between brackets is always positive, it is easy to see that when socially responsible investors' beliefs are aligned with the true relationship, the mean return channel unambiguously amplifies the risk compensation channel.

Moreover, when $\lambda^{TU} > 1 - \lambda^{T2}$ and $\phi^S > \phi^{**}$ then both the mean return and risk compensation channel positively contribute to pushing cost of capital of the firm when it passes the SRI screen above the cost of capital when it fails it. Traditional investors first charge a risk premium for trading the shares of the firm when the price is less informative about the cash flow fundamental $\tilde{\Theta}$. Secondly, because only socially responsible investors believe that $\phi^S > 0$, the equilibrium price does not fully reflect the true expected value of the firm. To the extent that the firm's expected corporate social performance is strictly positive, this leads traditional investors to underestimate the firm's expected performance thus leading to an overestimation of its equilibrium cost of capital.

These findings are summarized in proposition 7

Proposition 7. *Assume $\mu_L = 0$.*

*Then if $\bar{\phi} = \phi^S$, $\phi^S > \phi^{**}$ and $\lambda^{TU} > 1 - \lambda^{T2}$, the firm's cost of capital when it passes the SRI screen unambiguously exceeds the cost of capital when it fails the SRI screen. That is,*

$$\mu_H \left(\bar{\phi} - \phi^S \frac{\lambda^S (\tau_\Theta + \tau_\epsilon + \tau_P^I)}{\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U} \right) > 0$$

and

$$\frac{\Omega}{\gamma n [\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U]} - \frac{\Omega}{\gamma n [\tau_\Theta + \tau_\epsilon + \tau_P]} > 0.$$

Secondly, assume traditional investors are correct in that the firm's social performance does not affect its financial performance. In particular, $\bar{\phi} = 0$ and $\phi^S > 0$. The mean return channel in this case can be rewritten as,

$$-\phi^S \mu_H \frac{\lambda^S (\tau_\Theta + \tau_\epsilon + \tau_P^I)}{\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U}.$$

When there is no underlying relationship between social and financial performance, the trading of socially responsible investors puts a downward pressure on the firm's cost of capital when it passes the SRI screen. Even though the true mean return of the firm is zero, socially responsible investors hold

artificially high expectations of the future return of the firm and push the equilibrium price downwards underestimating the cost of capital.

Nevertheless, when $\bar{\phi} = 0$, but $\phi^S > 0$ socially responsible investors still have a negative externality on traditional investors through the risk compensation channel. Therefore, in this situation there are two counteracting forces at work. On the one hand the mean return channel pushes the equilibrium cost of capital when the firm passes the SRI screen lower while on the other hand the risk compensation channel pushes for a premium relative to when the firm fails the SRI screen. The question then remains which of the two forces will dominate.

The main conclusion is that eventually the mean return channel should be expected to dominate.

For large ϕ^S , eventually the mean return channel can be expected to dominate. To see this it should be noted that the contribution of the risk compensation channel to the cost of capital gap is bounded below. Indeed, in the limit as ϕ^S becomes larger, τ_P^U approaches zero and the gap due to the risk compensation channel becomes

$$\begin{aligned} & \frac{\Omega}{\gamma n [\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I]} - \frac{\Omega}{\gamma n [\tau_\Theta + \tau_\epsilon + \tau_P]} \\ &= \frac{\Omega}{\gamma n [\tau_\Theta + \tau_\epsilon + (1 - \lambda^{TU}) \tau_P^I]} - \frac{\Omega}{\gamma n [\tau_\Theta + \tau_\epsilon + \lambda^{T^2} \tau_P^I]}. \end{aligned}$$

This is strictly positive for $\lambda^{TU} > 1 - \lambda^{T^2}$ as was indicated above and represents the upper bound for the cost of capital gap resulting from the risk compensation channel. The mean return channel however is unbounded below as ϕ^S increases. The mean return channel can therefore be expected to eventually dominate the risk compensation channel and the cost of capital when the firm passes the SRI screen can be lower than when the firm fails the SRI screen.

7 Conclusion.

Owing to the growing popularity of socially responsible investment (SRI), researchers have increasingly started to look into its real effects. That is, is SRI merely a tool which allows investors to align their investment savings decision with their personal values or does it also stimulate firms into adopting more responsible business practices.

The current paper revisits this question by analyzing how socially responsible investors may affect a firm's equilibrium cost of capital. Traditionally, socially responsible investment screens were believed to lower the cost of capital of high corporate social performance (CSP) firms relative to low CSP firms. Since a firm's equity cost of capital is also the internal rate of return it uses to make its investment decisions, SRI screens are claimed to have the potential to stimulate investment by firms exhibiting responsible business practices.

Empirical evidence on this claim however is mixed and this paper provides a possible explanation for this. In particular, socially responsible investors not only screen firms on their CSP they also trade on information regarding a firm's CSP. That is, socially responsible investors believe CSP information is relevant to predict a firm's future financial performance. Moreover, traditional investors do not appear to follow this logic and view most CSP information as irrelevant for cash flow prediction.

The paper then shows how this open disagreement generates two novel channels through which socially responsible investors can affect the cost of capital of high CSP firms relative to low CSP firms. First, socially responsible investors have a negative externality on traditional investors when the latter are not informed about the CSP information the former trade on. In the eyes of traditional investors, socially responsible investors contaminate the equilibrium price with an additional source of noise making it less informative and causing traditional investors to charge a higher risk premium for trading the shares of high CSP firms. This risk compensation channel therefore negatively affects

Secondly, depending on the true underlying relationship between CSP and CFP, the expected equilibrium price is either too high or too low relative to the expected fundamental. In particular, when in reality there is no relationship between CSP and CFP, the equilibrium price is too high relative to the fundamental causing the equilibrium cost of capital to be too low. On the other hand when socially responsible investors are correct in their assumed relationship between CSP and CFP, then the equilibrium price is too low because the equilibrium price does not fully reflect the unconditional expectation of the firm's fundamental.

The paper analyzes when the

Overall, adding the assumption of disagreement on the relationship between CSP and CFP leads to a rich set of additional predictions regarding the gap between the expected cost of high and low CSP firms.

A Appendix.

A.1 Proof proposition 1.

Proof. Using the expressions for the share demands of the different investor classes, we obtain the equilibrium condition for trading in the financial market,

$$\begin{aligned} & \lambda^T n \gamma \left(\tau_\epsilon \tilde{\Theta} + \tau_P \left(\frac{\tilde{P} - q_0}{q_1} \right) - (\tau_\Theta + \tau_\epsilon + \tau_P) \tilde{P} \right) \\ & - \rho n \tilde{z} \\ & = \Omega. \end{aligned}$$

By collecting terms on the different random variables and a constant we can rewrite this as,

$$\begin{aligned} & - \frac{\Omega}{\gamma n} - \lambda^T \tau_P \frac{q_0}{q_1} \\ & + \lambda^T \tau_\epsilon \tilde{\Theta} \\ & - \frac{\rho \tilde{z}}{\gamma} \\ & = \left[\tau_\Theta + \tau_\epsilon + \tau_P - \lambda^T \tau_P \frac{1}{q_1} \right] \tilde{P}. \end{aligned}$$

By matching coefficients with the conjectured price we can then solve for the equilibrium price coefficients,

- q_1

$$\begin{aligned} q_1 &= \lambda^T \tau_\epsilon \left[\tau_\Theta + \tau_\epsilon + \tau_P - \lambda^T \tau_P \frac{1}{q_1} \right]^{-1} \\ \Leftrightarrow q_1 &= \frac{\lambda^T \tau_\epsilon + \lambda^T \tau_P}{\tau_\Theta + \tau_\epsilon + \tau_P} \end{aligned}$$

- $\frac{q_2}{q_1}$

$$\frac{q_2}{q_1} = - \frac{\rho}{\gamma \lambda^T \tau_\epsilon}$$

- $\frac{q_2}{q_1}$ and q_1 then determine q_2 .

- q_0

$$q_0 = - \left(\frac{\Omega}{\gamma n} + \lambda^T \tau_P \frac{q_0}{q_1} \right) \left[\tau_\Theta + \tau_\epsilon + \tau_P - \lambda^T \tau_P \frac{1}{q_1} \right]^{-1}$$

$$\Leftrightarrow q_0 = - \frac{\Omega}{\gamma n [\tau_\Theta + \tau_\epsilon + \tau_P]}$$

□

A.2 Proof proposition 2.

Using the expressions for the share demands of the different investor classes, we obtain the equilibrium condition for trading in the financial market,

$$\begin{aligned} & \lambda^{TI} n \gamma \left(\tau_\epsilon \tilde{\Theta} + \tau_P^I \left(\frac{\tilde{P} - p_0 - p_2 \tilde{\Xi}}{p_1} \right) - (\tau_\theta + \tau_\epsilon + \tau_P^I) \tilde{P} \right) \\ & + \lambda^{TU} n \gamma \left(\tau_\epsilon \tilde{\Theta} + \tau_P^U \left(\frac{\tilde{P} - p_0 - p_2 \mu_H}{p_1} \right) - (\tau_\theta + \tau_\epsilon + \tau_P^U) \tilde{P} \right) \\ & + \lambda^S n \gamma \left(\tau_\epsilon \tilde{\Theta} + \tau_P^I \left(\frac{\tilde{P} - p_0 - p_2 \tilde{\Xi}}{p_1} \right) + (\tau_\Theta + \tau_\epsilon + \tau_P^I) \phi \tilde{\Xi} - (\tau_\theta + \tau_\epsilon + \tau_P^I) \tilde{P} \right) \\ & - n \rho \tilde{z} \\ & = \Omega \end{aligned}$$

By collecting terms on the different random variables and a constant we can rewrite this as,

$$\begin{aligned} & - \frac{\Omega}{\gamma n} - \left[((\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U) \frac{p_0}{p_1} + \lambda^{TU} \tau_P^U \frac{p_2}{p_1} \mu_H \right] \\ & + \tau_\epsilon \tilde{\Theta} \\ & + \left(- (\lambda^{TI} + \lambda^S) \tau_P^I \frac{p_2}{p_1} + \lambda^S \phi (\tau_\Theta + \tau_\epsilon + \tau_P^I) \right) \tilde{\Xi} \\ & - \frac{\rho}{\gamma} \tilde{z} \\ & = \left[\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U - ((\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U) \frac{1}{p_1} \right] \tilde{P} \end{aligned}$$

By matching coefficients with the conjectured price we can then solve for the equilibrium price coefficients,

- $\frac{p_2}{p_1}$

$$\begin{aligned}\frac{p_2}{p_1} &= \frac{1}{\tau_\epsilon} \left(-(\lambda^{TI} + \lambda^S) \tau_P^I \frac{p_2}{p_1} + \lambda^S \phi (\tau_\Theta + \tau_\epsilon + \tau_P^I) \right) \\ \Leftrightarrow \frac{p_2}{p_1} &= \frac{\phi \lambda^S (\tau_\Theta + \tau_\epsilon + \tau_P^I)}{\tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I}\end{aligned}$$

- $\frac{p_3}{p_1}$

$$\frac{p_3}{p_1} = -\frac{\rho}{\gamma \tau_\epsilon}$$

- p_0

$$\begin{aligned}p_0 &= \left[-\frac{\Omega}{\gamma n} - \left((\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U \right) \frac{p_0}{p_1} - \lambda^{TU} \tau_P^U \frac{p_2}{p_1} \mu_H \right] \times \\ &\quad \left[\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U - \left((\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U \right) \frac{1}{p_1} \right]^{-1} \\ \Leftrightarrow p_0 &= -\frac{\Omega}{\gamma n [\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U]} - \frac{\lambda^{TU} \tau_P^U \mu_H}{[\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U]} \frac{p_2}{p_1}\end{aligned}$$

- p_1

$$\begin{aligned}p_1 &= \tau_\epsilon \left[\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U - \left((\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U \right) \frac{1}{p_1} \right]^{-1} \\ \Leftrightarrow p_1 &= \frac{\tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U}{\tau_\Theta + \tau_\epsilon + (\lambda^{TI} + \lambda^S) \tau_P^I + \lambda^{TU} \tau_P^U}\end{aligned}$$

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