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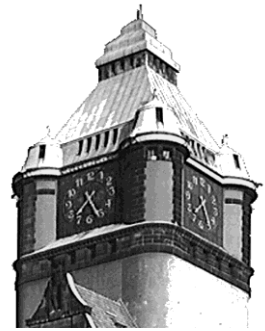
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Information value, export and hedging

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Dresden Discussion Paper in Economics No. 03/11

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Information value, export and hedging

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Abstract:

The paper analyzes the interactions between the precision of information, trade and welfare within a decision framework of an exporting firm. Information in a financial market is described in terms of a publicly observable signal. With higher transparency, the signal conveys more precise information about the random foreign exchange rate. More precise information about exchange rate changes has ambiguous effects on trade and welfare which depend critically on technology of the firm and the degree of risk aversion.

JEL-Classification: : F11, F23, G14, G15

Keywords: Exchange rate risk, trade, futures market, market transparency, value of information

Information value, export and hedging

The paper analyzes the interactions between the precision of information, trade and welfare within a decision framework of an exporting firm. Information in a financial market is described in terms of a publicly observable signal. With higher transparency, the signal conveys more precise information about the random foreign exchange rate. More precise information about exchange rate changes has ambiguous effects on trade and welfare which depend critically on technology of the firm and the degree of risk aversion.

1 Introduction

In an uncertain economic global environment national and international firms choose actions based on the currently available information. In order to model information one can use a signaling approach, i.e. firms observe random signals which are correlated to an unknown state of nature or a market price, and update their beliefs before actions take place. The link between the quality of a public signal and decision making can be interpreted as market transparency. This paper deals with transparency in financial markets and its role for decision making of an exporting firm under exchange rate risk.

In our study a publicly observable signal is correlated with the random foreign exchange rate; hence the signal conveys information about the unknown foreign exchange rate. The signal allows market participants to update their beliefs (in a Bayesian manner). The risk-averse firm has access to a foreign exchange futures market in which it can hedge its net exposure connected with its export activities.¹ Prices and contracts traded on the foreign exchange futures market depend upon market transparency.

In the literature, there are different analytical concepts measuring the degree of informativeness and proposing an order of the underlying information systems. The concept proposed by Blackwell, 1953, is widely used. The notion of transparency in our study is adopted from the work by Eckwert and Zilcha, 2001, Drees and Eckwert, 2003, Eckwert and Zilcha, 2003. They

¹For international firms, see, Kawai and Zilcha, 1986, Friberg, 1998, Broll et al. 2001, Wong, 2003, Bacchetta and van Wincoop, 2005, Friberg and Wilander, 2008, Hens and Rieger, 2010, to name just a few.

characterize market transparency by using a criterion which is conceptually related to the literature that emerged from the seminal work by Blackwell, 1953.² More transparency or more reliable information means that market participants can make better economic decisions. When the information is of public nature, rather than privately owned by some individuals, it will be used by other agents, too. Under such circumstances the information may affect endogenous market mechanisms.

When individuals make decisions in isolation from others, more reliable information is generally beneficial, i.e. in the expected utility framework the value of information is always nonnegative. However, more information can have detrimental effects if the information affects risk sharing arrangements in the economy (Hirshleifer, 1971, 1975, Schlee, 2001) or if agents interact strategically using private information and public information simultaneously. We abstract from informational asymmetries but we allow for risk sharing through a competitive foreign exchange futures market. While market transparency does not affect the risk premium on this market, it does have implications for the amount of risks that will be shared in equilibrium (Morris and Shin, 2002).

We demonstrate that the impact of more precise information on the firm's ex ante expected production for export depends on the demand conditions in the market abroad (i.e. elasticities of demand). However, more transparency, always leads to an increase in the ex ante expected profit of the firm. Implications for the ex ante expected utility of the firm are also discussed. We claim that it is possible that the firm will be worse off when more information is derived from each signal.

The rest of the paper is organized as follows. Section 2 develops a model of an international firm under exchange rate risk with hedging opportunities. In section 3, we introduce the concept of market transparency that underlies the analysis. Section 4 derives the main results. The final section concludes.

²For other concepts of information and market transparency that have been used in the economic literature, see Wahl, 1983, Heinemann and Illing, 2002, Krebs, 2005, De Haan et al. 2005.

2 The exporting firm

Consider a risk-averse international firm that makes decisions under exchange rate uncertainty in a one-period horizon with three dates (indexed by $t = -1$, $t = 0$ and $t = +1$). At $t = 0$, the firm produces a single homogeneous good in the home country according to a constant marginal cost c ; total cost are given by cq where q is the level of total output for export. The firm sells its output at $t = 1$ in the world market.

We assume that the firm enjoys some monopoly power in the foreign market. The revenues from foreign sales are governed by a strictly increasing and concave function, $r(q)$, with $r(0) = 0$, $r'(0) = \infty$, and $r'(\infty) = 0$. Revenues r are denominated in the foreign currency.³ The firm faces exchange rate uncertainty in that the spot exchange rate at $t = 1$, denoted by \tilde{e} and expressed in units of the home currency per unit of the foreign currency, is not known at $t = 0$.⁴ The random spot exchange rate, \tilde{e} , has a prior probability density function, $f(e)$, over support $[\underline{e}, \bar{e}]$, where $0 < \underline{e} < \bar{e} < \infty$.

There is a public signal, \tilde{y} , released by the government, the central bank or specialized agencies at $t = -1$ before the firm makes its decisions on production and risk management. Let $n(y)$ be the prior probability density function of \tilde{y} over support $[y, \bar{y}]$, where $-\infty < y < \bar{y} < \infty$. The signal, \tilde{y} , is correlated with the random spot exchange rate, \tilde{e} , and thus contains valuable information about \tilde{e} . Let $\nu(e|y)$ be the posterior probability density function of \tilde{e} conditioned on $\tilde{y} = y$ over support $[\underline{e}, \bar{e}]$. At $t = 0$, the firm makes its decisions using the conditional expectation operator, $E(\cdot|y)$, with respect to $\nu(e|y)$. The firm updates its belief in a Bayesian manner.

The firm has access to a foreign exchange futures market for hedging purposes. The foreign exchange futures market opens at $t = 0$ after the public signal has been revealed. Let e_f be the futures exchange rate that is determined at $t = 0$ and is expressed in units of the home currency per unit of the foreign currency. The firm sells (purchases if negative) h units of the currency futures at $t = 0$, which are settled at $t = 1$ at the then prevailing spot exchange rate. Thus, the firm's profit at $t = 1$, denominated in the

³The currency of the customer is the most used, both for trade within and across company groups; see Friberg and Wilander, 2008.

⁴Throughout the paper, random variables have a tilde while their realizations do not.

home currency, is given by

$$\tilde{\pi} = \tilde{e}r(q) - cq + (e_f - \tilde{e})h. \quad (1)$$

We assume that the foreign exchange futures market is unbiased, i.e.,

$$e_f = E(\tilde{e}|y) = \int_{\underline{e}}^{\bar{e}} e\nu(e|y)de, \quad (2)$$

for all $y \in [\underline{y}, \bar{y}]$. Hence, Eq. (2) implies that the futures exchange rate, e_f , is a function of the signal, y , in general and a linear function of the posterior probability density function, $\nu(e|y)$, in particular.

The firm possesses a von Neumann Morgenstern utility function, $u(\pi)$, defined over its home currency profit at $t = 1$, π , with $u'(\pi) > 0$ and $u''(\pi) < 0$, indicating risk aversion. At $t = 0$, the firm chooses a level of exports, q , and a futures position, h , so as to maximize the expected utility of its random home currency profit at $t = 1$:

$$\max_{q, h} E[u(\tilde{\pi})|y] = \int_{\underline{e}}^{\bar{e}} u[er(q) - cq + (e_f - e)h]\nu(e|y)de, \quad (3)$$

where $\tilde{\pi}$ is defined in Eq. (1). The first-order conditions for program (3) are given by

$$E\{u'(\tilde{\pi}^*)[\tilde{e}r'(q^*) - c]|y\} = 0, \quad (4)$$

$$E[u'(\tilde{\pi}^*)(e_f - \tilde{e})|y] = 0, \quad (5)$$

where an asterisk (*) signifies an optimal level.

The solution to Eqs. (4)-(5) can be characterized by the following system of equations:

$$e_f r'(q^*) = c, \quad (6)$$

$$h^* = r(q^*). \quad (7)$$

In fact Eq. (7) implies that

$$\pi^* = e_f r(q^*) - cq^*, \quad (8)$$

which is non-stochastic.

Eq. (6) implies that the firm's optimal output for trade, q^* , is uniquely determined by equating the marginal foreign revenue, $r'(q^*)$, converted into the home currency using the futures exchange rate, e_f , to marginal cost c . Thus, we have established for our model the separation and full-hedging hypotheses.⁵ These hypotheses claim that, in the presence of a currency exchange forward market, production for export is independent on attitudes towards risk and, for the special case of an unbiased forward market, that exchange rate risks will be fully hedged.

3 Information and more market transparency

We describe transparency in the foreign exchange market by means of the informativeness of the signal, \tilde{y} , that is publicly observable. The signal's informativeness depends on the information system. An information system, denoted by g , specifies for each state of the nature, e , a conditional probability density function, $g(y|e)$, over the set of signals, $[\underline{y}, \bar{y}]$. The function, $g(y|e)$, which generates the signal for a given spot exchange rate at $t = 1$, e , is common knowledge.

Given the information system, g , the prior probability density function, $n(y)$, of \tilde{y} can be written as

$$n(y) = \int_{\underline{e}}^{\bar{e}} g(y|e)f(e)de, \quad (9)$$

for all $y \in [\underline{y}, \bar{y}]$. By Bayes' rule, the posterior probability density function, $\nu(e|y)$, of \tilde{e} conditioned on $\tilde{y} = y$ is given by

$$\nu(e|y) = \frac{g(y|e)f(e)}{n(y)}, \quad (10)$$

for all $y \in [\underline{y}, \bar{y}]$, where $n(y)$ is given by Eq. (9). Blackwell (1953) suggests the following criterion that ranks different information systems according to their informational content.

Definition 1 *Let g^1 and g^2 be two information systems for the random spot exchange rate at $t = 1$, \tilde{e} . We say that g^1 is more informative than g^2 , expressed by $g^1 \succ_{inf} g^2$, if there exists an integrable function, $\lambda(y', y)$, such*

⁵See, for example, Kawai and Zilcha, 1986, Friberg, 1998, Wong, 2003a,b.

that

$$\int_{\underline{y}}^{\bar{y}} \lambda(y', y) dy' = 1, \quad (11)$$

for all $y \in [\underline{y}, \bar{y}]$, and

$$g^2(y'|e) = \int_{\underline{y}}^{\bar{y}} g^1(y|e) \lambda(y', y) dy, \quad (12)$$

for all $e \in [\underline{e}, \bar{e}]$.

According to Definition 1, $g^1 \succ_{inf} g^2$ holds if g^2 can be obtained from g^1 through a process of randomization. Eq. (11) states that $\lambda(y', y)$ is a probability density function that transforms the signal, y , into a new signal, y' . It is evident from Eq. (12) that the information system, g^2 , can be interpreted as being obtained from the information system, g^1 , by adding random noise. Since $\lambda(y', y)$ does not depend on the realization of \tilde{e} , the signals under the information system, g^2 , cannot convey any information about the random spot exchange rate at $t = 1$, which is not conveyed by the signals under the information system, g^1 . As a result, g^1 must contain more information about \tilde{e} than g^2 .

Our notion of transparency in the foreign exchange market is based on the informational content of the signal, y , about the random spot exchange rate at $t = 1$, \tilde{e} . We describe the foreign exchange market as more transparent if y conveys more precise information about \tilde{e} .

Definition 2 Let g^1 and g^2 be two information systems for the random spot exchange rate at $t = 1$, \tilde{e} . We say that the foreign exchange market is more transparent under g^1 than under g^2 if $g^1 \succ_{inf} g^2$.

The following Lemma formulates an alternative transparency criterion that is equivalent to the condition stated in Definition 2, which is useful in our subsequent economic analysis.

Lemma 1 Let g^1 and g^2 be two information systems for the random spot exchange rate at $t = 1$, \tilde{e} . The foreign exchange market is more transparent under g^1 than under g^2 if, and only if

$$\int_{\underline{y}}^{\bar{y}} F[\nu^1(\cdot|y)] n^1(y) dy \geq \int_{\underline{y}}^{\bar{y}} F[\nu^2(\cdot|y)] n^2(y) dy, \quad (13)$$

for any given convex function, $F(\cdot)$, defined on the set of probability density functions over support $[\underline{e}, \bar{e}]$.

A proof of Lemma 1 can be found in Kihlstrom, 1984. Since $\nu^1(\cdot|y)$ and $\nu^2(\cdot|y)$ are the posterior beliefs under the two information systems, g^1 and g^2 , respectively, Lemma 1 implies that more transparency in the foreign exchange market (weakly) raises the expectations of any convex functions of posterior beliefs. If $F(\cdot)$ is any given concave function defined on the set of probability density functions over support $[\underline{e}, \bar{e}]$, inequality (13) is reversed.

4 Economic implications of higher market transparency

The key variable of interest in the comparative static exercise is e_f since the forward exchange rate is a function of the signal, y , in general and a linear function of the posterior probability density function, $\nu(e|y)$, in particular, as is evident from Eq. (2). Rewrite Eq. (6) as

$$e_f r'(q^*(e_f)) - c = 0. \quad (14)$$

Differentiating Eq. (14) with respect to e_f yields

$$q^{*'}(e_f) = -\frac{r'(q^*(e_f))}{e_f r''(q^*(e_f))} > 0. \quad (15)$$

Eq. (15) implies that an increase in the futures exchange rate, e_f , makes exports more attractive and raising the level of exports, $q^*(e_f)$. The firm's profit is given by

$$\pi^*(e_f) = e_f r(q^*(e_f)) - c q^*(e_f). \quad (16)$$

Proposition 1 *Let \bar{q}^* be the expected level of export before observing the signal, y :*

$$\bar{q}^* = \int_{\underline{y}}^{\bar{y}} q^*(e_f) n(y) dy. \quad (17)$$

More transparency in the foreign exchange market leads to a higher (lower) expected level of export, \bar{q}^ , if the marginal revenue function, $r'(q)$, is convex (concave).*

Proof By Eq. (2), e_f is linear in the posterior belief, $\nu(\cdot|y)$. It then follows from Eq. (16) and Lemma 1 that \bar{q}^* increases (decreases) with more transparency if $q^*(e_f)$ is convex (concave) in e_f . Differentiating Eq. (15) with respect to e_f yields

$$q^{*''}(e_f) = -\frac{r'''(q^*(e_f))}{r''(q^*(e_f))^3}. \quad (18)$$

The desired results then follow from Eq. (18).

q.e.d

The intuition of Proposition 1 is as follows. Let us say that signal y' is ‘better’ than signal y , if it corresponds with a higher conditionally expected exchange rate, i.e., $e_f(y') > e_f(y)$. The firm’s exports are increasing in e_f and, hence, are higher for good signals than for bad signals. But with more transparency, a good signal becomes even better because it is more reliable. As a consequence, production for export rises. For the same reason, a bad signal becomes worse in a more transparent foreign exchange market and, consequently, production for export declines. If the marginal revenue in foreign currency is decreasing at a decreasing (an increasing) rate, the transparency-induced increase in exports for good signals is larger (smaller) than the transparency-induced decrease in exports for bad signals. As such, the expected level of production and sales for international trade goes up (down) if the marginal revenue function is convex (concave).

Suppose that the exporting firm has the following inverse demand function $p_D(q)$ in the foreign market, where q is the amount of export. Since $r(q) = p_D(q)q$, the marginal revenue function is convex or concave, depending on whether $3p_D''(q) + p_D'''(q)q$ is positive or negative, respectively. Suppose that $p_D(q) = q^{-\eta}$, where $1/\eta \in (0, 1)$ is the constant elasticity of demand.⁶ In this example, the marginal revenue function is convex so that more transparency in the foreign exchange market increases the expected level of foreign sales. On the other hand, if the inverse demand function is linear, the marginal revenue function is also linear. In this example, making the foreign exchange market more transparent has no effect on the expected level of exports.

Proposition 2 *Let $\bar{\pi}^*$ be the firm’s expected profit before observing the signal, y :*

$$\bar{\pi}^* = \int_{\underline{y}}^{\bar{y}} \pi^*(e_f)n(y)dy. \quad (19)$$

More transparency in the foreign exchange market leads to an increase in the expected profit of the firm.

Proof By Eq. (2), $e_f(y)$ is linear in the posterior belief, $\nu(\cdot|y)$. It then follows from Eq. (18) and Lemma 1 that $\bar{\pi}^*$ increases with more transparency if $\pi^*(e_f)$ is convex in e_f . Differentiating Eq. (15) with respect to e_f and using

⁶We require $1/\eta < 1$ to ensure that the revenue function, $r(q)$, is concave.

the envelope theorem yields

$$\pi^{*'}(e_f) = r(q^{*'}(e_f)). \quad (20)$$

The desired result then follows from Eq. (14). q.e.d

To see the intuition of Proposition 2, note that

$$\pi^{*'}(e_f) = r(q^{*'}(e_f)). \quad (21)$$

An increase in e_f has a first-order effect on the firm's maximum profit through the export revenues. Since the firm exports more when e_f increases, this first-order effect on $\pi^*(e_f)$ is stronger for larger e_f and weaker for lower e_f . As a result, the firm's profit function is unambiguously convex in e_f . A more transparent foreign exchange market makes e_f more sensitive to changes in the public signal. Thus, the firm benefits from increased transparency in that its expected profit is always higher.

One might expect that less uncertainty due to more market transparency would generally be welfare enhancing. However, in our model we show that this is not necessarily the case. The firm's optimal utility level for a given futures exchange rate, e_f , conditional on the observed signal, y , is given by $U[\pi^*(e_f)]$, where $\pi^*(e_f)$ is given by Eq. (16). Define ex ante expected utility, \bar{U}^* , by

$$\bar{U}^* = \int_{\underline{y}}^{\bar{y}} U[\pi^*(e_f(y))]n(y)dy. \quad (22)$$

With more transparency, from an ex ante perspective the forward rate becomes more risky as it reacts more sensitively to random signal changes. Higher transparency therefore imposes welfare costs on the risk-averse firm. This risk effect is sometimes called the 'Hirshleifer-effect'. On the other hand, the greater informational content of the signal permits better production and export decisions which result in welfare gains. The total impact of higher transparency on the ex ante welfare of the firm consists of these two opposing effects. In the following we claim

Proposition 3 *More transparency in the foreign exchange market increases the firm's ex ante expected utility if the firm is risk-neutral or if (partial) risk aversion is sufficiently small. If the firm is highly risk-averse, the transparency-induced negative risk effect may dominate the positive trade effect and, hence, ex ante expected utility may decline with higher transparency.*

Proof By Lemma 1, \bar{U}^* increases (decreases) with more transparency if $U[\pi^*(e_f)]$ is convex (concave) in e_f . Differentiating $U[\pi^*(e_f(y))]$ twice with respect to e_f yields

$$\gamma \frac{\partial^2 U[\pi^*(e_f)]}{\partial e_f^2} = \frac{U''[\pi^*(e_f)]}{U'[\pi^*(e_f)]} (\pi^* + cq^*) + \eta_{r,q} \eta_{q,e_f}, \quad (23)$$

where $\gamma = e_f/rU'[\pi^*(e_f)]$ and Eqs. (13)–(16) are used. Elasticities with respect to foreign revenues and exports are $\eta_{r,q}$ and η_{q,e_f} respectively. \square

The first term on the right-hand side of Eq. (23) captures the negative risk effect (Hirshleifer effect). This effect vanishes if the firm is risk-neutral and is otherwise increasing in the firm's (partial risk) aversion towards risk. The second term in Eq. (23) captures a positive trade effect which results from the firm's improved foreign market position (Blackwell effect).

The (negative) risk effect is stronger the more risk-averse the firm is; and the (positive) trade effect is stronger the more elastic the amount of exports is to changes in the forward exchange rate. Hence, we can conclude that the international firm is made better off with more transparency in the foreign exchange market if the firm is not too risk-averse and/or the amount of exports is sufficiently elastic to changes in the forward exchange rate.

The conclusion from Proposition 3 is that revealing more information to the market does not always guarantee improving the situation of those risk-averse agents in the market. In fact, more information results in two effects which do not always work in the same direction. On the one hand more precise information results in a better distribution of random exchange rate used in the process of maximizing expected profits from exports. On the other hand, it affects the demand for futures contracts, and changes in the forward exchange rate. This change in the futures exchange rate can reduce welfare of the risk-averse firm and outweigh the advantages derived from the better distribution due to higher market transparency.

5 Conclusion

Our paper develops a theoretical framework to examine the interaction between market transparency, risk sharing opportunities and production of goods for exports under exchange rate uncertainty. The aim of our study is to discuss the economic value of information. The uncertainty to which

the international firm is exposed when it decides about its resource allocation for production to international markets depends on the observed signal as well as on the information system within which the signal can be interpreted. We characterize the foreign exchange market as more transparent if the signal conveys more precise information about the unknown foreign exchange rate. Thus, more transparency means that the exchange rate uncertainty is reduced through the disclosure of more reliable information. We show that the effects of more transparency in the foreign exchange market on exports critically depend on the demand conditions in the foreign market. More transparency, however, always leads to an increase in the expected profit of the firm. We also offer reasonable conditions under which the ex ante expected utility of the exporting firm is improved by making the foreign exchange market more transparent.

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