International Capital Asset Pricing Model: the case of Asymmetric Information and Short-Sale

Amine Dammak (CRIISEA Amiens university) *

Makram Bellalah (CRIISEA Amiens university)†,

Mondher Bellalah (THEMA Cergy University)

ABSTRACT

In this paper we develop a international capital asset pricing model in the presence of shadow costs of incomplete information and short sale. Our model shows the direct effect of exchange rate risk, information cost and short sale cost on asset prices. In equilibrium this model gives an explicit expression of a two systematic risk premium. The first is linked to exchange rate and the second to international market risk. Our model explains in part the well-known home bias equity, by market segmentation. This model can be seen as an international version of Wu, Li and Wei, (1996) and Merton (1987) model. Our analysis shows that the dispersion in beliefs increases the market inefficiency, and that the short sale can reduce the cost of ignorance, and reduces the home bias equity.

JEL Classification: G15, G11.

Key Words: Portfolio Choice, International Financial Markets, Information Costs, Short sell, Exchange Risk

* CRIISEA Amiens University, makram.bellalah@u-picardie.fr

† CRIISEA Amiens University, makram.bellalah@u-picardie.fr

1.Introduction

International asset management shows that the international diversification does better than portfolio diversification in the national setting. The gains from international diversification have been emphasized by several authors including Solnik (1974a) and De Santise and Bruno (1997) and more recently by Nguyen and al. (2015). Despite the gains from international diversification, most investors hold nearly all of their wealth in domestic assets. This is referred to in international finance as "home bias equity". Many authors tend to explain this bias by market frictions such as transaction costs, taxes, restrictions on foreign ownership, asymmetric information, short sale and exchange risk, etc. Black (1974), Stulz (1981b) and Cooper and Kaplanis (2000) and more recently Arouri and al. (2012) present a model of international asset pricing in the case of market segmentation. The authors show that the deadweight cost, and market restriction on assets has an impact on portfolio choice and market segmentation. In the same way Cooper and Kaplanis (1994) extend the model developed by Adler and Dumas (1983) to account for deadweight costs. The empirical test provided by Cooper and Kaplanis (1994) shows that the effect of inflation rate risk and the differences between the consumption baskets do not explain the home bias equity in international finance. In the same way Lewis (1999), Aboura and Bellalah (2006) uses a similar tax as Black (1974) in order to explain the home bias equity. Errunza and Losq (1985) present a two-country-model to characterize the mild segmentation. The foreign investors called unrestricted can trade on both assets 'eligible' or restricted and 'ineligible' or unrestricted. Domestic investors trade only on the 'eligible' or unrestricted assets. The model presented by Arouri and al. (2012) can be seen as an extended version of

Errunza and Losq (1985, 1989) . The authors shows that market segmentation is justify by restrictions and that the degree of stock market integration varies through time. They show that if some investors do not hold all international assets because of direct and/or indirect barriers, the world market portfolio is not efficient and the traditional international CAPM must be augmented by a new factor capting the local risk undiversifiable in international setting.

In recent studies, most of the literature shows that the asymmetric information explains the less of international diversification, and the bias observed in favour of some assets. In this way the most notable extension is the introduction of information uncertainty and its effects on the pricing of assets. In fact, the acquisition of information and its transmission to other agents are central activities in all areas of finance. Recognition of the different speeds of information diffusion is important in empirical research also. The perfect market model can provide a good description of the financial system in the long run but it fails to account for several anomalies due to omitted factors like information costs and short sales constraints. In addition, The analysis in Merton (1987) shows that a reconciling of finance theory with empirical violations of the complete-information, perfect market model need not imply a departure from the standard paradigm. However, as it appears in Merton (1987), “ It does, however suggest that researchers be cognizant of the insensitivity of this model to institutional complexities and .... I believe that even a modest recognition of institutional structures and information costs can go a long way toward explaining financial behavior that is otherwise seen anomalous to the standard friction-less-market model”.

Wu, Li and Wei, (1996) extend Merton’(1987) model. They propose incomplete information capital market equilibrium with heterogeneous expectations and short sale restrictions, GCAPM shows that the shadow cost of incomplete information and equilibrium security returns are positively related to the divergence of investor beliefs and negatively related to the firm’s investor base.

Wu, Li and Wei (1996) find that short sale restrictions mitigate the inefficiency of the market portfolio due to divergent beliefs. This is because short sales can reduce the opportunity cost of ignorance. In their model, the GCAPM, systematic risk is affected is affected not only by the beta but also the variance of residual return and the size of the company.

The effect of short sales restrictions on equilibrium prices is more evident and more pronounced for smaller and less known securities. The analysis increases the robustness of Merton’s asset pricing model.

Recently, Hishleifer and al.(2015) present a model of asset pricing in the case of asymmetric information. The authors show that asset portfolios have three components: an informationally passive portfolio based upon equilibrium prices; an information-based portfolio based upon private information and equilibrium prices; and the riskfree asset.

The next section presents an international asset pricing model in the presence of the shadow costs of incomplete information and short sale restrictions. This model can be seen as an international version of Merton (1987) and Wu, Li and Wei (1996). Our analysis introduces a systematic risk of international market and exchange rate risk. The third section presents the empirical evidence of the model and explains that the home bias equity is based on the shadow of incomplete information and short sale. Finally, we present some concluding remarks.

2. International asset pricing in the case of the shadow costs of incomplete information and short sale

Following the analysis in Adler and Dumas (1983), we use the following assumptions.

A_1. There K countries and currencies. All returns are stated in nominal terms of the Kth currency (k_p). There are K equity index assets and K-1 risky currency assets.

The price of the ith asset has the following dynamics :

$$\frac{dY_i}{Y_i} = \mu_i dt + \sigma_i dz_i \qquad for\ i = 1,2\ \dots\dots .2n-1 \quad (1)$$

where:

Y_i : is the market value of index asset i in terms of the reference currency of country K denoted by k_p;

μ_i: the expected rate of return of asset i, which can denoted by $E(R_i)$;

σ_i : the standard deviation of asset i;

dz_i: the increment to a standard Wiener process.

A_2. Following the notations in Merton (1987) and Wu, Li and Wei (1996), we assume that there are two "shadow costs" λ_i^k and γ_i^k associated separately with the information constraint and the short-selling constraint

Based on this assumption, relation (1) can be written as :

$$\frac{dY_i}{Y_i} = \left(\mu_i - \lambda_i^k + \gamma_i^k\right)dt + \sigma_i dz_i \qquad for\ i = 1,2\ \dots .2n-1 \qquad (2)$$

Relation (2) is similar to Cooper and Kaplanis (1994) who extended the model of Adler and Dumas (1983) to account for deadweight costs as in Black (1974)[1].

A_3. There are K investor types. The price index P^k of an investor of type k expressed in the reference currency follows the process:

$$\frac{dP^k}{P^k} = \pi^k dt + \sigma_{\pi^k} dz\pi^k \qquad for\ k = 1,2\ \dots\dots k \qquad (3)$$

where:

P^k : the price index;

π^k: the expected value of the instantaneous rate of inflation;

$\sigma\pi^k$: the standard deviation of the instantaneous rate of inflation;

$dz\pi^k{}_{\mathrm{k}}$: the increment to a standard Wiener process.

Using the same method as in Adler and Dumas (1983) and the Bellman principal, we obtain :

$$\mu_i = r + \lambda_i^k - \gamma_i^k + \left(1 - \frac{1}{\alpha^k}\right)\sigma_{i\pi_k} + \frac{1}{\alpha^k}\sum_{j=1}^{2n-1} x_j^k\,\sigma_{ij} \qquad (4)$$

where:

x_j^k : the optimal holding allocated to asset i by investor k;

$\frac{1}{\alpha^k} = A^k$: the investor's risk aversion;

$\sigma_{ij} = cov(R_i, R_j)$: the covariance of the nominal rate of return of asset i and j;

$\sigma_{i\pi_k} = cov(R_i, \pi^k)$: the covariance of the rate or return of asset i and investor's rate inflation.

Relation (4) is similar to equation (8) of Adler and Dumas (1983) in which appears the effect of the shadow costs of incomplete information and short sale.

Relation (4) can be written as follows :

$$E(R_i) = \left(r + \lambda_i^k - \gamma_i^k\right) + (1 - A^k)cov(R_i, \pi^k) + A^k \sum_{i=1}^{2n-1} x_i^k\, cov(Ri, Rj) \qquad (5)$$

Let us derive an explicit international version of asset pricing model in the presence of shadow costs of incomplete information and short sale. To achieve our goal, we multiply relation (5) by $\frac{W^k}{A^k}$ to obtain

$$E(R_i)\frac{W^k}{A^k} = \frac{W^k}{A^k}r + \frac{W^k}{A^k}\lambda_i^k - \frac{W^k}{A^k}\gamma_i^k + W^k\left(\frac{1}{A^k} - 1\right)cov(R_i, \pi^k) + W^k \sum_{i=1}^{2n-1} x_i^k\, cov(Ri, Rj) \qquad (6)$$

where W^k denotes the wealth of investor k.

Relation (6) can be written as follows:

$$E(R_i) = \left(r + \lambda_i^k - \gamma_i^k\right) + \frac{W^k}{\frac{W^k}{A^k}}\left(\frac{1}{A^k} - 1\right) cov(R_i, \pi^k) + \frac{W^k}{\frac{W^k}{A^k}} \sum_{i=1}^{2n-1} x_i^k \, cov(Ri, Rj) \qquad (7)$$

Let us denote by x_i^m the proportion of asset i in the international market portfolio as :

$$x_i^m = \frac{\sum_{k=1}^{n} W^k x_i^k}{\sum_k^n W^k} \qquad (8)$$

Aggregating expression (7) over all investors gives[2]:

$$E(R_i) = (r + \lambda_i - \gamma_i) + A \sum_{i=1}^{n-1} \left(\frac{1}{A^k} - 1\right) cov(R_i, \pi^k) \frac{W^k}{W} + A cov(R_m, R_i) \qquad (9)$$

where:

$A = \frac{\sum_k^n W^k}{\sum_k^n \frac{W^k}{A^k}}$: the global harmonic mean degree of risk aversion;

$\sum_k^n W^k$: the global wealth;

$R_m = \sum_{i=1}^{n} x_i^m$: the rate of return of the global market portfolio;

$\sum_{i=1}^{2n-1} \lambda_i^k = \lambda_i$: the global shadow cost of incomplete information.

$\sum_{i=1}^{2n-1} \gamma_i^k = \gamma_i$ the global shadow cost linked to the short sale

Relation (9) gives that the expected rate of return of security i as a function of the shadow costs of incomplete information, the short sale, the effect of the inflation rate and the international market portfolio. In our model, we have considered that the purchasing power party does not hold, so our international asset pricing model includes K+1 risk premia. The first is linked to the global market portfolio, the second for the valuation currency's own inflation and K-1 additional risk that reflect the other country's uncertain inflation. The effect of foreign inflation rates denominated in the reference currency k_p have two components. The first reflects the inflation in the foreign currency. The second shows the changes in the exchange rate between the foreign currency and the reference one k_p.

To get an explicit version of our ICAPM we assume as Solnik (1974) and Sercu (1980) that the inflation rate in each country's is not random when measured in its own currency. This special case allows us to derive of a model that shows the effect of two systematic risk premiums, and the effect of information costs and short sale. In this situation there is no inflation risk premium for the reference currency and the K-1 risk premium are attributed to nominal foreign exchange risks which can be aggregated in a single currency index.
Based on this hypothesis, relation (9) becomes :

$$E(R_i) = (r + \lambda_i - \gamma_i) + A \sum_{k=k_p}^{n-1} (\frac{1}{A^k} - 1) cov(R_i, e^k) \frac{W^k}{W} + Acov(R_m, R_i) \qquad (10)$$

where e^k refers to the percentage change of currency k relative to currency k_p

A carefull examination of relation (10) shows that the coefficients of the K covariance terms sum to one and that the choice of the reference currency is irrelevant. This result is consistent with Sercu (1980), and O'Brein and Dolde (2000) who shows that the common fund is independent of the choice of the measurement currency.
In order to derive our global currency index capital asset pricing model in the presence of the shadow costs of incomplete information and short sale constraint GCAPMI, we formulate these assumptions:
A_4 : Assume as in Cooper and Kaplanis (1994) and O'Brien and Dolde (2000) that the aggregate risk tolerances are equal across border, which means that A^k= A. This assumption was used by French and Poterba (1991) in their empirical analysis of the home bias equity.

A_5: We consider that the K-1 currency risk factors can be aggregated into a portfolio. The exact weights of this portfolio are unobservable as suggested by Adler and Dumas (1983) and O'Brien and Dolde (2000). This assumption is not critical for the practitioners, who are able to use a proxy currency index.

Based on these assumptions, relation (10) becomes:

$$E(R_i) = r + \lambda_i - \gamma_i + (1 - A)cov(R_i, X) + Acov(R_m, R_i) \qquad (11)$$

where:

$X = \frac{\sum_{k \neq k_p} W^k e_k}{W}$: the wealth-weighted index of the percent changes in all other currencies in terms of the reference currency k_p.

A_6: To derive our global currency index asset pricing model with information costs and short sale, we apply relation (11) to R_m (the internationale market portfolio) and to R_e that reflects the variation in X.

Based on A_6 and relation (11), we get :

$$E(R_m) = r + \lambda_m - \gamma_m + (1 - A)cov(R_m, R_e) + Avar(R_m) \qquad (12\ )$$

Where:

the term λ_m corresponds to the information cost about the market. It can be interpreted as the weighted average of λ_i,

And

γ_m as the weignted averge of γ_i.

Applying relation (11) to R_e we get:

$$E(R_m) = r + (1 - A)var(R_e) + Acov(R_m, R_e) \qquad (13)$$

Relation (13) does not contain the shadow costs of incomplete information about the exchange rate and short sale. In reality we can extend our analysis in to the case of information costs and short sale linked to exchange market. For simplicity we focus our model on the effect of these costs on asset price, and not on exchange market. In our model, these costs are paid by the investor to be informed about the other country in order to trade in foreign markets and take a short or long position.

The international investors are willing to pay this cost in order to get more informations about the other markets and assets. In the case of symmetric information the foreign investors trade in other market and try to get a profit from international diversification. Solving equations (12) and (13) simultaneously for θ and (1-θ) and rearranging gives[3]:

$$E(R_i) = r + \lambda_i - \gamma_i + \beta_{im}(E(R_m) - r - \lambda_m + \gamma_m) + \beta_{ie}(E(R_e) - r) \qquad (14)$$

where:

$$\beta_{im} = \frac{var(R_e)cov(R_i, R_m) - cov(R_m, R_e)cov(R_i, R_e)}{var(R_m)var(R_e) - cov(R_m, R_e)^2}$$

$$\beta_{ie} = \frac{var(R_m)cov(R_i, R_m) - cov(R_m, R_e)cov(R_i, R_m)}{var(R_m)var(R_e) - cov(R_m, R_e)^2}$$

Relation (14) characterizes the global currency index asset pricing model within information uncertainty and constraint on short sale. The most important implication of our model is that the world market portfolio is not efficient and that a complete international diversification is not achievable due to the information costs and short sale. The presence of these costs, shows that international markets are partially integrated, due to the of asymmetric information Relation (14) can be seen as an international version of Merton (1987) model in the case of exchange rate risk and short sale. Our GCAPMI shows that short sale restrictions mitigate the inefficiency of the market portfolio due to divergent beliefs. This is because short sales can reduce the opportunity cost of ignorance. In their model, systematic risk is affected not only by the beta but also the variance of residual return and the size of the company.

This model shows how investors are exposed to the effects of exchange rate risk and incomplete information between the domestic and foreign investors. This model supports the empirical evidence in Kang and Stulz (1997), and Dahlquist and Robertsson (2000) and more recently Nezafat and Wang (2013)) where the home bias equity is explained by asymmetric information and market restriction.

3. Empirical Evidence and the home bias equity

Many authors have shown that despite the gains from international diversification, there is a strong bias in domestic national portfolios. They conclude that although there has been some increase in international investment positions since the 1970s, the share of foreign assets in domestic portfolios is smaller than standard theories would predict.

Tesar and Werner (1995) suggest that a richer model incorporating asymmetric information and institutional constraints can give a good explanation of the home bias.

More recently, Van Nieuwerburgh and Veldkamp , (2009) study Information Immobility and the Home Bias Puzzle. They argue that home bias arises because home investors can predict home asset payoffs more accurately than foreigners can. The model presented by these authors investigate a common criticism of information-based models of the home bias: If home investors have less information about foreign stocks, why don't they choose to acquire foreign information, reduce their uncertainty about foreign payoffs, and undo their portfolio bias? The answer to this question is given by relation (14).

In addition, Our model shows that differences in information are important in financial and real markets. They are used in several contexts to explain some puzzling phenomena like the 'home equity bias', the 'weekend effect', "the smile effect"[4], etc. Kadlec and McConnell (1994) document the effect on share value on the NYSE and report the results of a joint test of Merton's (1987) investor recognition factor and Amihud and Mendelson's (1986) liquidity factor as explanations of the listing effect. The Merton's λ can be seen as a proxy for changes in the bid-ask spread.

In our model we can see that in practice, investors face explicit short-selling prohibition, almost all investors face higher costs for establishing and maintaining short positions. The basic results of our model hold with costly short-selling, though the effects on information acquisition and investment decisions are generally weaker than outright short-prohibition.
Second, our international asset pricing shows how information acquisition affect investment decision of the shorting decisions. Many short-sellers are specialists, and these short-sellers typically do not hold long positions or typically maintain net short positions. Their information acquisition decisions can be very different from those investors who do not face any holding constraints and are willing to take either long or short positions subsequent to information acquisition.

In addition, our international asset pricing is consistent with the empirical work presented by Forester and Karolyi (1999). These authors show that the abnormal returns can be explained by the asymmetric information. In this model the empirical tests provide support for market segmentation hypothesis and Merton's (1987) investor recognition hypothesis. In their empirical tests the authors use a sample from US exchanges for an investor who trade in local market by constructing a diversified portfolio from securities of forgein firms listed in US exchange.

The empirical test provided by Kang and Stulz (1997) shows that the investor portfolio is biased against small firm and that the investors overinvesting in large firms in Japan due to the availability of information about these large firms. The authors find that holdings are relatively large in firms with large export sales, this evidence is consistent with the conjecture that foreigns investors invest in firms that they are better informed about. From this fact the authors suggest that the home bias is derived by informational asymmetries.

Brennan and Cao (1997) develop a model of international equity portfolio investment flows based in informational endowments between foreign and domestic investors. In this model they show that when domestic investor possess information advantage over foreign investors about their domestic market, investor tend to purchase foreign assets in periods when the return in foreign asset is high.

Recently Bryan and Alexander (2012), studies the importance of information asymmetry in asset pricing by using three experiments. The authors find that prices and uninformed demand fall as asymmetry increases. In addition, the results confirm that information asymmetry is priced and imply that a primary channel that links asymmetry to prices is liquidity. This finding is consistent with our model that shows the effect of information costs on expected rate of return.

4.Conclusion

This paper presents an international asset pricing model in the case of exchange rate risk, shadow costs of incomplete information and a short-sale. This model shows that the asymmetric information and short sale explain the home bias equity observed in international and domestic setting. In equilibrium our model gives a two systematic risk premium and shows how costs affect the expected rate of return and asset price. Our model introduces a first component λk is the product of pure information cost due to imperfect knowledge and heterogeneous expectations. The second component γk represents the additional cost caused by the short-selling constraint. The shadow cost associated with the short-selling constraint should come into the picture even in the case of homogeneous beliefs due to the difference in investor j's information set. In the case of divergent beliefs, the shadow cost of short sales would not be the same for all investors. Short-sale restrictions increase the likelihood that an investor will not expend the resources to become informed about a security. This tends to lower the expected payoff from acquiring the information about a security. Testing this model remains a future challenge. In addition this model can be extended in the case of short sale and information costs on exchange market.

Appendix 1:

Aggregating relation (7) over all investors we get:

$$E(R_i) = r + \sum_k \lambda_i^k - \sum_k \gamma_i^k + \frac{\sum_k W^k}{\sum_k \frac{W^k}{A^k}} \sum_k \left(\frac{1}{A^k} - 1\right) cov(R_i, \pi^k) \frac{W^k}{\sum_k W^k} + \frac{\sum_k W^k}{\sum_k \frac{W^k}{A^k}} cov\left(\frac{\sum_k \sum_j W^k x_j^k Rj}{\sum_k W^k}, Ri\right) \qquad (A1)$$

$$E(R_i) = r + \sum_k \lambda_i^k + \frac{\sum_k W^k}{\sum_k \frac{W^k}{\theta^k}} \sum_k \left(\frac{1}{\theta^k} -1\right) cov(R_i, \Pi^k) \frac{W^k}{\sum_k W^k} + \frac{\sum_k W^k}{\sum_k \frac{W^k}{\theta^k}} cov\left(\frac{\sum_k \sum_j W^k x_j^k R_j}{\sum_k W^k}, R_i\right)$$

(A_1)

Rearranging (A_1) and using the definition of x_i^m we obtain:

$$E(R_i) = r + \lambda_i - \gamma_i + \frac{\sum_k W^k}{\sum_k \frac{W^k}{A^k}} \sum_k \left(\frac{1}{A^k} - 1\right) cov(R_i, \pi^k) \frac{W^k}{\sum_k W^k} + \frac{\sum_k W^k}{\sum_k \frac{W^k}{A^k}} cov\left(\sum_j x_j^m Rj, Ri\right)$$

which yields relation (9).

Appendix 2:

We have expressions (12) and (13):

$$E(R_m) - r - \lambda_m + \gamma_m - Avar(R_m) = (1 - A)cov(R_m, R_e) \qquad (12)$$

$$E(R_e) - r - Acov(R_m, R_e) = (1 - A)var(R_e) \qquad (13)$$

Let us look to $\frac{(12)}{(13)}$:

$$\frac{E(R_m) - r - \lambda_m + \gamma_m - Avar(R_m)}{E(R_e) - r - Acov(R_m, R_e)} = \frac{(1 - A)cov(R_m, R_e)}{(1 - A)var(R_e)} \qquad (A2)$$

From A2 we obtain:

$$E(R_m) - r - \lambda_m + \gamma_m - Avar(R_m) = (E(R_e) - r)\frac{cov(R_m, R_e)}{var(R_e)} - A\frac{cov(R_m, R_e)^2}{var(R_e)} \qquad A3$$

Rearranging expression (A_3) gives :

$$\frac{(E(R_m) - r - \lambda_m + \gamma_m)var(R_e) - (E(R_e) - r)cov(R_m, R_e)}{var(R_e)} = A\frac{var(R_m)var(R_e) - cov(R_m, R_e)^2}{var(R_e)} \qquad A4$$

From (A_4) we have:

$$A = \frac{(E(R_m) - r - \lambda_m + \gamma_m)var(R_e) - (E(R_e) - r)cov(R_m, R_e)}{var(R_m)var(R_e) - cov(R_m, R_e)^2} \qquad A5$$

From (13) and (A5), we get:

$$(1-A)=\frac{1}{var(R_e)}$$

$$E(R_e)-r-\frac{(E(R_m)-r-\lambda_m+\gamma_m)var(R_e)-(E(R_e)-r)cov(R_m,R_e)}{var(R_m)var(R_e)-cov(R_m,R_e)^2}cov(R_m,R_e)^2 \quad A6$$

We can write (A_6) as follows:

$$(1-A)=\frac{(E(R_e)-r)(var(R_m)var(R_e)-cov(R_m,R_e)^2)}{var(R_m)var(R_e)^2-cov(R_m,R_e)^2var(R_e)}cov(R_m,R_e)^2-\frac{(E(R_m)-r-\lambda_m+\gamma_m)var(R_e)cov(R_m,R_e)-(E(R_e)-r)cov(R_m,R_e)^2}{var(R_m)var(R_e)^2-cov(R_m,R_e)^2var(R_e)} \qquad (A7)$$

Substituting (A5) and (A7) in (11) we get:

$$E(R_i)=r+\lambda_i-\gamma_i+\frac{(E(R_m)-r-\lambda_m+\gamma_m)var(R_e)-(E(R_e)-r)cov(R_m,R_e)}{var(R_m)var(R_e)-cov(R_m,R_e)^2}cov(R_i,R_m)+(\frac{(E(R_e)-r)(var(R_m)var(R_e)-cov(R_m,R_e)^2)}{var(R_m)var(R_e)^2-cov(R_m,R_e)^2var(R_e)}-\frac{(E(R_m)-r-\lambda_m+\gamma_m)var(R_e)cov(R_m,R_e)-(E(R_e)-r)cov(R_m,R_e)^2}{var(R_m)var(R_e)^2-cov(R_m,R_e)^2var(R_e)}cov(R_i,R_e) \qquad (A8)$$

Relation (A8) can be written as follows:

$$
\begin{aligned}
E(R_i) = r + \lambda_i - \gamma_i \\
&+ \left(E(R_m) - r - \lambda_m + \gamma_m\right)\left[\frac{var(R_e)cov(R_i, m)}{var(R_m)var(R_e) - cov(R_m, R_e)^2}\right. \\
&\left. - \frac{var(R_e)cov(R_m, R_e) - cov(R_i, R_e)}{var(R_m)var(R_e)^2 - cov(R_m, R_e)^2 var(R_e)}\right] \\
&+ (E(R_e) - r)\left[\frac{var(R_m)var(R_e)cov(R_i, R_e) - cov(R_m, R_e)^2 cov(R_i, R_e)}{var(R_m)var(R_e)^2 - cov(R_m, R_e)^2 var(R_e)}\right. \\
&- \frac{cov(R_m, R_e)cov(R_i, R_m)}{var(R_m)var(R_e) - cov(R_m, R_e)^2} \\
&\left. + \frac{cov(R_m, R_e)^2 cov(R_i, R_e)}{var(R_m)var(R_e)^2 - cov(R_m, R_e)^2 var(R_e)}\right] \qquad (A9)
\end{aligned}
$$

Relation (A9) can be written as follows :

$$
\begin{aligned}
E(R_i) = r + \lambda_i - \gamma_i + \frac{var(R_e)cov(R_i, m) - cov(R_m, R_e)cov(R_i, R_e)}{var(R_m)var(R_e) - cov(R_m, R_e)^2} + (E(R_m) \\
- r)\frac{var(R_m)cov(R_i, R_e) - cov(R_m, R_e)^2 cov(R_i, R_m)}{var(R_m)var(R_e) - cov(R_m, R_e)^2}
\end{aligned}
$$

This relation is equation (14).

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[1] The model presented by Black (1974) has the same structure as the CAPM with incomplete information of Merton (1987).

[2] The derivation of this relation is provided in the appendix 1.

[3] The derivation of expression (13) is provided in the appendix 2.

[4] See the models in Bellalah and Jacquillat (1995) and Bellalah (1999 a, b)