Review of Business and Economics Studies

REVIEW OF BUSINESS AND ECONOMICS STUDIES (ROBES) is the quarterly peer-reviewed scholarly journal published by the Financial University under the Government of Russian Federation, Moscow. Journal's mission is to provide scientific perspective on wide range of topical economic and business subjects.

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ISSN 2308-944X

Вестник исследований бизнеса и экономики

Издательство Финансового университета
125993, Москва, ГСП-3,
Ленинградский проспект, 51,
корп. 3, к. 104.
Тел. 8 (499) 943-95-23.
Интернет: www.robes.fa.ru.

Журнал «Review of Business and Economics Studies» («Вестник исследований бизнеса и экономики») зарегистрирован в Федеральной службе по надзору в сфере связи, информационных технологий и массовых коммуникаций 9 июля 2013 г. Свидетельство о регистрации ПИ № ФС77-54658.

Подписано в печать: 24.03.2014.
Формат 60 × 84 1/8.
Заказ № 39 от 24.03.2014.
Отпечатано в ООП Издательства Финуниверситета (Настасьинский пер., д. 3, стр. 1).
16+

Review of Business and Economics Studies

Volume 2, Number 1, 2014

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№ 1, 2014

СОДЕРЖАНИЕ

A Multi-Modality Approach to Examine Reward Satisfaction amongst Mid-Level Managers*

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Abstract. Limited research addresses the perceptions of mid-level managers as recipients of desirable rewards. In contrast to CEO "tailor-made" compensation schemes, mid-level manager reward schemes are treated as homogeneously acceptable to motivate individuals. However, in large corporations, mid-level managers are organized in several echelons where size of business unit, functions or geographic locations create an organizational hierarchy. Data from 1,771 mid-level managers across five echelons in a single company are analysed to discover reward satisfaction employing instrumental, affective and cognitive modalities (Elizur, 1984). Our findings reveal systematic patterns in satisfaction with different rewards across managers from different organisational echelons. Significant differences in managerial perceptions are identified for satisfaction with work conditions and pay (instrumental modality), relations with co-workers, superior managers and direct supervisors, supervisory behaviour, recognition and esteem (affective modality), and opportunities for authority/responsibility, personal growth, use of ability and knowledge, job interest, meaningfulness of work and pride to work for the organization (cognitive modality). All in all, the multi-modality approach adopted in this study appears effective in identifying echelons of managers for which different rewards have different perceived value and therefore different motivational force. With this extended approach to capturing reward satisfaction, patterns of desirable incentives emerge that can help specify the design of schemes for mid-level managers.

Аннотация. Немного исследований посвящены тому, как менеджеры среднего звена воспринимают вознаграждения. В отличие от индивидуально «настроенных» компенсационных пакетов генеральных директоров предприятий, считается, что схемы вознаграждения менеджеров среднего звена приемлемы в равной степени для мотивации всех сотрудников. Однако в крупных корпорациях менеджеры среднего звена подразделяются на несколько эшелонов, в которых размер бизнес-единицы, функции или географическое расположение определяют создание собственной организационной иерархии. Наши результаты раскрывают систематические закономерности в удовлетворенности различными видами вознаграждений среди менеджеров из разных организационных эшелонов. Найдены значительные различия в восприятии менеджерами удовлетворенности условиями труда и заработной платы (инструментальная модальность), отношений с коллегами, менеджерами более высокого уровня и прямыми руководителями, признания и уважения (эмоциональная модальность), факторов власти, ответственности, личного роста, использования способностей и знаний, интереса к работе, значимости работы, гордости от работы на данном предприятий (когнитивная модальность). В целом многомодальный подход, примененный в этом исследовании, показал свою эффективность в выявлении эшелонов менеджеров, для которых ценность различных вознаграждений воспринимается по-разному и, следовательно, имеет различную силу мотивации. При таком расширенном подходе к определению удовлетворенности вознаграждением возникают модели стимулирования, которые помогают оптимизировать схемы вознаграждения менеджеров среднего звена.

Key words: mid-level management, organizational level, reward system design, reward satisfaction.

* Многомодальный подход к анализу удовлетворенности вознаграждениями среди менеджеров среднего звена.

1. INTRODUCTION

Management control systems (MCS) are intended to provide motivation for organizational members to take actions and make decisions that will accomplish the organization's objectives (Merchant and Van der Stede, 2012). Since the pivotal works of Hopwood (1974) and Otley (1987), researchers in management accounting have acknowledged that reward systems are one of the main mechanisms through which an organization can persuade managers to exert themselves toward organizational goals (Emmanuel *et al.*, 1990). When direct control is hindered by the distance between supervisors and mid-level managers who have access to more relevant and up-to-date decision information, reward schemes are essential to achieve goal congruence (Merchant, 1989). In such contexts, motivational contracts (that is, written and unwritten promises of rewards for the attainment of pre-set performance results) are intended to bridge the *a priori* conflict of interests between managers and the organization itself. In this respect, the significance of rewards for management control purposes has been recently reaffirmed (Otley, 1999; Malmi and Brown, 2008; Ferreira and Otley, 2009).

This study relates to prior research that investigates the design and impact of reward systems for mid-level managers. Management control scholars have long recognized that managers who are highly motivated are more likely to be high performers (Ferris, 1977; Rockness, 1977; Brownell and McInnes, 1986). This is in line with a well-established stream of organizational behaviour literature (Lawler and Porter, 1967a; Porter and Lawler, 1968). At the same time, empirical studies based on expectancy-valence theory consistently demonstrate that different types of rewards contribute to increase managers' work motivation (Ronen and Livingstone, 1975; Jiambalvo, 1979; Kominis and Emmanuel, 2007). Merchant (1989) adds another relevant dimension to the provision of rewards to mid-level managers. He argues that the ideal motivational contract for these managers should offer rewards that are desirable to recipients. It follows that effective reward system design should take into account the rewarded manager's perspective in order to determine patterns of preferences for different types of inducements. Provision of a more satisfactory set of rewards, in turn, is likely to affect managers' performance positively. However, much of the literature in management control takes the standpoint of incentive scheme designers (Merchant and Otley, 2007), while substantially "*… disregarding how managers effectively react to rewards' provision within performance evaluation schemes*" (Ahn *et al.*, 2010, p. 390). To date, little is known about the desirable design features of reward systems for mid-level managers in practice (Uyterhoeven, 1972; Ehrenberg and Milkovich, 1987; Fisher, 1992). A body of literature explores the performance measures that are employed in the bonus contracts (Bushman *et al.*, 1995; Keating, 1997; Abernethy *et al.*, 2004; Bouwens and van Lent, 2007; Abernethy *et al.*, 2010). Another stream of research examines the link between delegation and compensation choices for business unit managers (Baiman *et al.*, 1995; Nagar, 2002). However, only a limited number of studies investigate how middle level managers actually perceive different elements of the reward systems they are offered (Vancil, 1979; Kominis and Emmanuel, 2007).

The work of Merchant (1985; 1989) suggests that different groups of individuals may react differently to the provision of the same reward. Satisfaction with different rewards may vary across groups of managers according to contextual characteristics or individual needs and preferences (Lawler and Porter, 1967b; Campbell *et al.*, 1970; Lawler, 1994). Prior research in management accounting mainly concentrates on compensation schemes for executives, suggesting that executive incentive schemes should be "tailor-made" in order to enhance their motivational impact (Pavlik *et al.*, 1993; Murphy, 1999). Perhaps more importantly, reward choices reflect the hierarchical stratification of executives with implications for management control system designs (Widener, 2006). Instead, reward preferences of mid-level managers are assumed to be essentially homogeneous (Bourguignon, 2004). In large corporations, mid-level managers are organized in several echelons according to business unit, functions or geographic locations, creating an organizational hierarchy, therefore the design of appropriate incentive schemes may be hampered by the layering of agency problems down the echelons of the organization (Baker *et al.*, 1988; Indjejikian, 1999). The resultant adoption of a "one-size fits all" reward approach for mid-level managers is questionable (Lawler, 2000).

Additionally, much of extant research in management accounting focuses only on a subset of the reward system elements potentially desirable to organizational members (Ittner and Larcker, 2001; Malmi and Brown, 2008). Reward systems can encompass both financial and non-financial components, but the traditional approach of this stream of research concentrates exclusively on financial inducements only (Kunz and Pfaff, 2002). Merchant *et al.* (2003) note that much of organizational incentive research disregards the role of an array of intangible rewards such as recognition, autonomy or supervisory support as those are difficult to measure and to evaluate. It can be argued that these difficulties are a consequence of the theoretical perspective employed by manage-

ment accounting researchers in order to investigate the construct of work outcomes (Kunz and Pfaff, 2002). So far, the literature addressing a broader spectrum of rewards relies predominantly on the extrinsic/intrinsic reward dichotomy, both in theoretical contributions (Ansari, 1977; Flamholtz *et al.*, 1985; Malmi and Brown, 2008) and in empirical studies (Ferris, 1977; Rockness, 1977; Kominis and Emmanuel, 2007). However, the construct validity of this dichotomy has been called into question by some commentators suggesting that it may be inadequate to gauge the multidimensionality of the reward construct in real organizational settings (Broedling, 1977; Guzzo, 1979; Elizur, 1984; Kunz and Pfaff, 2002). In practice, individuals are likely to fail to unambiguously categorize rewards based on this definitional distinction (Dyer and Parker, 1975; Kanungo and Hartwick, 1987). In management control literature, the influence of extrinsic inducements on work behaviour is seen to be qualitatively different compared with that of intrinsic rewards (Flamholtz *et al.*, 1985). It follows that the unequivocal capability to distinguish between different forms of rewards becomes critical for the study of the design of desirable reward schemes and their effect on managers in organisations.

An alternative approach to work outcomes (Elizur, 1984), as perceived by mid-level managers, identifies instrumental, affective and cognitive modalities. This more comprehensive conceptualization aims to capture a range of work values that extends the extrinsic/intrinsic dichotomy in order that differences and similarities of desirable rewards can be more accurately gauged. We intend to examine mid-level manager satisfaction of rewards using this extended identification.

This perception-based research examines whether reward satisfaction varies across different layers of the mid-level management hierarchy. Evidence from a multinational company operating in the service sector are provided by examining the perceptions of 1,771 mid-level managers collected and analysed through a survey instrument in 2009. The aim is to detect patterns of reward satisfaction by hierarchical position in the organization. At the same time, this study represents the first attempt to provide a more comprehensive picture of the array of rewards perceived as potentially desirable by mid-level managers by using the "modality" of the reward construct elaborated by Elizur, (1984) and Elizur *et al.* (1991). By this means, the possibility of a more flexible reward scheme that can gain acceptance across echelons of mid-level managers is uncovered.

The remainder of the paper is structured as follows. The next section provides a discussion of our theoretical background, while in the third section we review the relevant theoretical and empirical research in the area of reward satisfaction for mid-level managers with the derived hypotheses. Section four presents the research setting and the data for this study. Empirical tests and results are reported in section five with a concluding discussion presented in section six.

2. THEORETICAL BACKGROUND

Desirable rewards are heterogeneous by nature, ranging from expressions of recognition by supervisors and senior managers, through provision of autonomy in decision-making, to financial rewards and promotion (Merchant *et al.*, 2003). The dominant construct of extrinsic/intrinsic in management control is questionable and calls for a more comprehensive approach to identifying rewards have been made (Kunz and Pfaff, 2002; Ferreira and Otley, 2009). Viewing reward schemes as the provision of financial incentives alone is partial and incomplete since the design of reward systems that encompass non-financial inducements has been extensively documented (Merchant, 1989; Ezzamel and Willmot, 1998).

Attempts to operationalize the extrinsic/intrinsic dichotomy have generated a plethora of alternative notions of these constructs, none, however, seems to offer a clear differentiation (Guzzo, 1979). As a consequence, studies adopting the extrinsic/intrinsic paradigm have somewhat arbitrarily collapsed work outcomes such as supervisory support or feelings of esteem and recognition, to either of these two categories, leading to inconsistent classifications, which have subsequently led to confounding results. For reward scheme designers, independent assessment of rewards within an organization using an unequivocal classificatory scheme becomes necessary, since distinctive design choices need to be made according to the type of rewards the organization intends to offer to managers (Ansari, 1977).

An alternative conceptualization of the reward construct may be needed to allow a broader and more accurate approach to reward recognition. A multifaceted approach to work values provides the main theoretical basis for the research reported here (Elizur, 1984; Elizur *et al.*, 1991). Elizur (1984) conceptually established and tested a structure for the construct of work values based on two independent facets: the modality of work outcomes and the relation with task performance. Independence of facets (Elizur, 1984) allows us to focus this research on the first facet, that is, the modality of work outcomes. Desirable work outcomes for managers are classified into: instrumental-material, affective-social, or cognitive-psychological (Elizur, 1984; Elizur and Sagie, 1999). Under the first classification, outcomes relate to material aspects of work, including pay, benefits and work conditions. The sec-

ond modality pertains to interpersonal relations and social features of work, such as feelings of esteem as a person, recognition for performance and relations with colleagues and supervisors. Finally, the cognitive modality encompasses several psychological aspects associated with the work itself, such as interest, responsibility, or a sense of achievement.

Using this multi-modality framework, identification of an assortment of desirable work outcomes grounded conceptually on five content theories of work motivation informs this study (Elizur *et al.*, 1991). Content theories of motivation concentrate on "the specific identity of what it is within an individual or his environment that energizes and sustain behaviour". Therefore, these perspectives attempt to define specific entities within a general class of variables such as work rewards (Campbell *et al.*, 1970). The assumption is that people will behave in ways that they think will satisfy their underlying needs and motives. Instrumental outcomes are derived from the works of Maslow (1954), Herzberg (1966), and Alderfer (1972). Affective and cognitive modalities draw on these three theories and a further selection of outcomes based on McClelland (1961) and Hackman and Oldham (1980). There is a common thread linking the five content theories adapted from the work of Elizur. Lower-order needs correspond to existence and affiliation or relatedness needs and to hygiene factors (including pay). Higher-order needs relate to growth and achievement needs, and to the job content factors identified by Herzberg, Hackman, and Oldham. Even though content theories appear to share some common shortcomings, they appear appropriate to address the use of managerial policies in handling issues relating to control systems and human resources, since they are concerned with motivational aspects of groups of individuals (Shields, 2007).

Drawing on content perspectives, Elizur (1984) identifies a set 21 valuable work outcomes, that are later extended to encompass 24 outcomes (Elizur *et al.*, 1991). Pay, hours of work, security, benefits and work conditions are classified as instrumental. Relations with supervisors, co-workers, recognition, esteem and opportunity to interact with people are categorized as affective, while responsibility, use of ability, advancement, achievement, influence, interest, feedback, meaningful work, independence, pride to work for the company, status and contribution to society are classed as cognitive.

Structural correspondence between the proposed approach and some existing extrinsic/intrinsic classification was established both theoretically and empirically by Borg (1990). Intrinsic outcomes are included in the cognitive modality, whereas extrinsic rewards are either instrumental or affective, however the modality facet allows reconciliation of the ambiguous classification of certain outcomes within the extrinsic/intrinsic dichotomy. Thus, it appears to be more generalizable as demonstrated by further validation in different national and cultural settings (Borg, 1986; Elizur *et al.*, 1991) and with reference to different groups of organizational members (Elizur and Sagie, 1999). In addition, the proposed structure expands the array of potentially desirable rewards, reducing the risk that important outcomes are overlooked. For these reasons, the multi-modality approach is employed in this study to investigate the relationship between preferences for different work outcomes and relevant personal and organizational characteristics.

3. RELEVANT LITERATURE AND HYPOTHESES

The development of motivational contracts that are capable of directing mid-level managers' effort and behaviour towards organizational objectives entails the identification of those work outcomes that are more desirable to recipients (Merchant, 1989). When reward packages are to be tailored, organizations assume a diagnostic stance with respect to their members' rewards preferences, selecting a set of rewards that is perceived as desirable and structuring the reward scheme accordingly (Lawler, 1994). If the perceived desirability of rewards is overlooked, the reward scheme is unlikely to contribute to motivation (Merchant and Van der Stede, 2012). Should the organization develop reward packages that concentrate on areas of less importance to managers, the efficiency of the reward scheme is compromised and reduces managerial effort.

When organizations make decisions about which MCS and reward schemes to adopt, their choices typically reflect the values and the preference of those in charge of designing those control systems. There is, however, little guarantee that those choices are similarly valued by all managers subject to such systems, as demonstrated in previous studies in the performance measurement and incentive compensation areas (Shields and White, 2004; Bento and White, 2006). Such discrepancies between the rewards effectively desired by organizational members and those top-management considers desirable and includes in the company's reward package become a distinct possibility.

The work motivation literature provides rationales for differences in reward perception by exploring the importance of human needs or motives relative to the design and implementation of reward schemes. According to the content perspective of motivation (Maslow, 1954; McClelland, 1961), reward effectiveness strongly depends on whether the reward is valued and desirable to the recipient. As Lawler (1994) points out,

large differences among groups of individuals exist in the importance assigned to different work outcomes as need-satisfiers. These differences relate in meaningful ways to a number organizational factors, most notably management level. Organizational level is found to be associated with reward level, reward satisfaction, and managerial perceptions of the satisfaction with rewards relative to those of subordinates and superiors (Porter and Lawler, 1965).

3.1. INSTRUMENTAL OUTCOMES

Content theories of work motivation postulate that individuals at different levels in the organisational hierarchy are driven by different needs. Those in higher positions are more likely to be motivated by higher order needs, whereas those in lower situations tend to be more concerned with the satisfaction of lower order needs, such as physical or security needs (Porter, 1961, 1962, 1963; Slocum, 1971). This is consistent with the notion of a hierarchical order of prepotency according to which higher-order needs become important only after the lower-order needs have been satisfied.

The provision of instrumental rewards, such as pecuniary inducements, perquisites, and favourable work conditions, are generally associated with the satisfaction of the latter group of needs (Porter, 1961). It is argued that as individuals attain lower-order extrinsic rewards, the importance attached to and the motivational impact of such rewards tend to decrease (Porter and Lawler, 1965; Herman and Hulin, 1972, 1973). Individuals in higher-level positions consistently appear to report a higher level of perceived gratification with instrumental rewards than managers at lower organizational levels (Rosen and Weaver, 1960). This is even more visible when pecuniary inducements are considered (Lawler and Porter, 1963, 1966). Similar studies based on the motivation/hygiene perspective suggested by Herzberg *et al.* (1959) find that instrumental outcomes, such as pay and work conditions are of major concern for individuals at lower echelons in the company (e.g., Lahiri and Srivastva, 1967).

Mid-level managers comprise a potentially diverse group, although each may have subordinates reporting to him/her and responsibility for a clearly delineated sub-unit or function within the organization. Within mid-level management, the size of sub-unit and level of responsibility varies making it necessary to identify different echelons. The higher echelon of mid-level managers expect to be provided with higher instrumental rewards and to be more satisfied with those rewards compared with their lower echelon counterparts for whom lower level needs appear to be more urgent (Porter and Lawler, 1965). Departing from Maslow's need-hierarchy concept, Herman and Hulin (1972; 1973) demonstrate that different groups of mid-level managers from a single organizational setting are significantly different in their perception of pay and benefits with higher-level managers being comparatively more satisfied with instrumental rewards in comparison with lower echelon managers and first line supervisors. In a similar vein, Rosen (1961) surveyed satisfaction with a number of work outcomes — except monetary inducements — reported by managers from four echelons in a single plant. Significant differences among managers at different organizational levels are found for a number of items connected with work conditions and organization of work.

The above discussion leads us to propose the following hypothesis (stated in the null form):

H1: There is no association between hierarchical level in the organization and level of satisfaction with instrumental outcomes.

Consistent with Elizur *et al.* (1991) instrumental outcomes encompass: (a) pay, (b) work conditions, (c) convenient hours of work and (d) benefits.

3.2. AFFECTIVE OUTCOMES

The conceptualization of work outcomes has become more differentiated over time and more specific dimensions of the rewards of work have emerged. Some researchers identify a number of affective elements that are generated by the interaction with other individuals in the workplace (Katz and Van Maanen, 1977; Mottaz, 1985). Others distinguish intrinsic rewards from altruistic and social concomitants (Rosenberg, 1957; Pryor, 1987). Affective outcomes are of concern in the design of the reward system, especially for managers at the mid-level, since the effective enactment of their role appears to be mediated by their socialization process in the organization (Vancil, 1979; Gomez-Mejia *et al.*, 1985). Proponents of content theories of work motivation conceive affective outcomes as lower-order needs' satisfiers (Maslow, 1954; McClelland, 1961; Alderfer, 1972). Borg (1990) illustrates the substantial correspondence between the affective modality identified by Elizur (1984), Alderfer's relatedness and Maslow's esteem and affiliation needs.

Extant research does not provide, however, a univocal proposition as to the relationship between perception of affective outcomes and managers' level in the organization. The perception of some affective outcomes, such as relations with peers and opportunities to help others while at work, seems not to be influenced by the hierarchical level of managers (Porter, 1962; Porter and Lawler, 1964). On the other hand, the perceived importance of esteem and recognition

obtained for doing a good job varies depending on the hierarchical level of the individual. For example, there is evidence to suggest that hierarchical ascent is characterized by greater recognition that contributes to individual satisfaction (Porter, 1962; Porter and Lawler, 1964; Rinehart *et al.*, 1969; Slocum, 1971). Lower echelon managers and first-line supervisors may feel that the disapproval of relevant-others in the company for their results jeopardizes their opportunity to stay with or advance within the firm. The need to obtain recognition for work done, compared with managers at higher levels who are in more established positions becomes a more pressing need and presumably a more powerful motivator. Similarly, relations with superiors are perceived differently by managers at different echelons (Rosen and Weaver, 1960; Rosen, 1961; Saleh *et al.*, 1975), possibly as a consequence of differences in tasks and responsibility of managers and different styles of leadership (Gomez-Mejia *et al.*, 1985).

The above leads to the following hypothesis (stated in the null form):

H2: There is no association between hierarchical level in the organization and level of satisfaction with affective outcomes.

Consistent with Elizur *et al.* (1991) affective outcomes encompass: (a) relations with co-workers, (b) opportunity to interact with people at work, (c) supervisory support, (d) recognition, (e) esteem.

3.3. COGNITIVE OUTCOMES

Higher-order needs are likely to emerge when satisfaction of lower-order needs is achieved by individuals (Maslow, 1954). Managers at different organizational levels are found to attribute different importance to their high-order needs. McClelland (1961) observes that lower echelon managers tend to be primarily motivated by the need for achievement, while the need for power becomes more prominent at higher echelons of the hierarchy. Managers attribute growing importance to different types of cognitive outcomes, such as autonomy, responsibility and opportunities for personal growth and for being influential in the work context (Lahiri and Srivastva, 1967). This may be attributed to the fact that as managers move up the organisational ladder, they tend to perform substantially different functions with increasing emphasis on administrative and external monitoring responsibilities compared to the more technical tasks performed at lower levels of management (Gomez-Mejia *et al.*, 1985). The heterogeneous nature of tasks and skills inherent in these occupations may generate different opportunities for managers to satisfy certain higher-order needs, thus impacting on the perceived satisfaction of those outcomes.

A number of studies based on the pivotal work of Porter (1961) demonstrate that organizational level is related to the amount of perceived deficiencies in need fulfilment, with lower echelon managers being more dissatisfied than middle echelon managers in attempting to fulfil higher-order needs such as autonomy and self-actualization, presumably because higher cognitive outcomes are more attainable at higher echelons (Porter, 1961, 1962; Haire *et al.*, 1963; Porter and Lawler, 1964; Slocum, 1971). As a consequence, higher echelon managers are likely to be more satisfied with several cognitive dimensions such as, the opportunity for personal growth and for exerting their influence in the organization, as well as with the amount of responsibility and the possibility of using their abilities and knowledge in their job (Porter, 1962; Porter and Lawler, 1964). All in all, these studies suggest a trend where satisfaction with higher-order outcomes increases at higher echelons of hierarchy. This is seen as a consequence of the decreasing difference between what is desired and what is obtained in reality. Porter's (1961; 1962) results are in line with those reported by Rosen and Weaver (1960) and Rosen (1961) who identified the same trend in relation to two other cognitive dimensions, namely feedback and pride of being employed by the company.

The above discussion leads to the following hypothesis (stated in the null form):

H3: There is no association between hierarchical level in the organization and level of satisfaction with cognitive outcomes.

Consistent with Elizur *et al.* (1991) cognitive outcomes encompass: (a) pride to work for the company, (b) work meaningfulness, (c) feedback, (d) opportunity for personal growth, (e) influence in work, (f) advancement, (g) responsibility, (h) use of ability and knowledge, (i) job interest.

4. METHODS

4.1. RESEARCH SETTING AND SAMPLE

Data for this research were collected in an overseas subsidiary of a large US-based corporation operating in the service sector. Since its establishment in Italy (where deregulation of the industry occurred in 1997), the organization experienced stable profit and revenue growth in all years and did not incur any major restructurings. Its workforce grew steadily by an average of 15.5% per annum since 2000.

The perceptions of 1,771 mid-level managers across five echelons from the subsidiary were collected from the company's annual survey questionnaire. Management layers were identified according to the job title of the respondent reflecting their responsibility.

The choice of a single research setting is advantageous for the present study as comparable responses were obtained in terms of the reward package offered to employees and the environmental conditions to which they were exposed (Bourguignon, 2004; Kominis and Emmanuel, 2007). Preliminary investigations confirmed that all managers were subject to common human resources policies and management control practices such as training and performance appraisal.

The material reward package offered to mid-level managers comprises of three major components: a fixed-pay component, an individual cash bonus determined by the performance review and other non-cash benefits related to the performance of the business unit the manager works in. Base pay differs across mid-level managers. Base pay stratification encompasses seven pay levels, which correspond closely to the echelons of the company's hierarchy. The performance-related cash bonus is intended to foster the attainment of pre-set performance targets and is linked to the performance review, which is conducted on a trimester basis. At the time of the research, this review was based on a set of three financial measures derived from the company's and business unit's financial statements. The process of measurement and the remuneration rules was the same for all the respondents. Provision of non-cash bonuses was based on the attainment of specific non-financial objectives (for example, acquisition of a pre-set number of new clients within a given time period) and it took the form of "competitions" between business units. In 2009, base pay was the only means through which the material reward system distinguished among groups of managers at different echelons. Mid-level managers in the sample could reach their position either through career advancement within the organization or through selective recruitment. Preliminary fieldwork demonstrated that, irrespective of the career pathway, all managers were subject to formal induction courses and on-the-job induction training, which took place within the first three months after employment.

The organization conducts an employee opinion survey annually; the present research is based on the analysis of the survey questionnaire employed in 2009, referred to as EOS-09. EOS-09 is directed only to those mid-level managers with at least three months of tenure: 1925 managers in total. Our preliminary discussions with executives from the company indicated that EOS-09 was used by the headquarters to compare different national settings. The questionnaire intended to gather middle managers' perceptions in three areas, namely the reward system in use, the perceived supervisory and peer support and a broad set of dimensions collected under the umbrella term of "engagement" that encompasses items such as "job interest" and "meaningfulness of work". The original questionnaire includes 97 items, which gauge managers' perceptions using a five-point Likert response format (ranging from "strongly agree = 5" to "strongly disagree =1").

Table 1. Overview of the sample

Occupational Group	Absolute Number	% of Total Sample
Level 1 Managers	23	1,30%
Level 2 Managers	66	3,73%
Level 3 Managers	286	16,14%
Level 4 Managers	301	17,0%
Level 5 Managers	1.095	61,83%
Total *n.* = 1,771		

The content of the survey was defined by top management, although discretion was allowed to national divisions to include further items for special purposes. Respondents returned their completed questionnaires through the organization's internal mail service. Completed questionnaires were returned by 1771 managers, which represents a return rate of 92%. Eighty percent of the sample was female, and 20% male. The majority of those who responded were aged 35 or less (71%), while 29% were more than thirty-five years old. All respondents in the sample came from five echelons of the organization's mid-level management. It is noted that the sample of this research is not random in the strict statistical sense. In order to assure comparability of the results, the sample includes those managers who: (1) were identified as mid-level managers (Mangaliso, 1995); (2) received the EOS-09; and (3) had at least 3 months of tenure in their managerial position. Table 1 offers an overview of the sample.

4.2. RESEARCH INSTRUMENT

The data employed in this study was derived from a subset of 50 items included in the EOS-09. The choice of these items and their classification to work outcomes was based on the comparison between the items included in EOS-09 *vis-à-vis* the 24 work outcomes forming the "work values questionnaire" (WVQ) used by Elizur *et al.* (1991).

In order to meaningfully classify the items contained in the EOS-09 into work outcome modalities, the rationale behind the construction of the WVQ was preliminary investigated. It appeared that each item in the WVQ was identified as a need satisfier in (at least) one of the content theories on which the framework is grounded. For instance, Elizur *et al.* (1991) reports that "the job characteristic model of Hackman and Oldham (1980) is represented by items like: variety, use of ability, meaningful

Table 2. Classification of items in the EOS-09: abbreviated illustration

EOS-09 Item	Comparable Item in the Original Instrument	Underlying Content Theory of Work Motivation	Item Description (Elizur *et al.*, 1991)	Modality of Outcome (Elizur *et al.*, 1991)
My compensation is satisfactory since it is competitive with similar jobs in other companies	Compared to similar jobs in other places, my pay is poor (disagree)	ERG Theory (Alderfer 1972)	Pay, the amount of money you receive	Instrumental
I am satisfied with the pay I received last year since I was adequately compensated for the work I was required	Considering the work required, the pay for my job is what it should be (agree)	ERG Theory (Alderfer 1972)	Pay, the amount of money you receive	Instrumental
I am satisfied with the equipment and materials I receive to do my job	Working conditions. This category was used for stories in which the physical conditions of work, the amount of work or the facilities available for doing the work were mentioned […]	Motivation-Hygiene Theory (Herzberg 1966)	Work Conditions	Instrumental
I am proud of working in this organization since here people help each other when they are in need	I can count on my co-workers to give me a hand when I need it	Achievement motivation theory (McClelland 1961)	Co-workers	Affective
I feel satisfied of the way in which my manager coaches and mentors my development	Supervision-technical. […] Statements about the supervisor's willingness or unwillingness to delegate responsibility, or his willingness or unwillingness to teach, would be classified under this category	Motivation-Hygiene Theory (Herzberg 1966)	Supervisor, a fair and considerate boss	Affective
I am happy when I do a good job since I receive praise and recognition from my Manager	My boss gives me credit when I do good work (agree)	ERG Theory (Alderfer 1972)	Recognition for doing a good job	Affective
Overall I am satisfied with my present job	Generally speaking I am very satisfied with this job	Job Characteristics Model (Hackman and Oldham 1980)	Meaningful Work	Cognitive
I find my work challenging and fulfilling	Work itself. This category was used when the respondent mentioned the actual doing of the job or the tasks of the job as source of good or bad feelings about it	Motivation-Hygiene Theory (Herzberg 1966)	Job Interest	Cognitive
I am satisfied with the opportunities my organization offers to meet my career goals	Advancement. This category was used […] when there was an actual change in the person's status or position in the company	Motivation-Hygiene Theory (Herzberg 1966)	Advancement changes for promotion	Cognitive

work, independence, feedback, recognition". Therefore, correspondence between the items defined by Elizur *et al.* (1991) and a number of statements/questions appearing in the EOS-09 questionnaire underlying the five content perspectives could be established. The items included in the EOS-09 were also compared with those adopted by Maslow (1954), McClelland (1961), Herzberg (1966) and Alderfer (1972). For instance, we could establish a correspondence between the item: "My compensation is satisfactory since it is competitive with similar jobs in other companies" in EOS-09 and the item: "Compared with similar jobs in other places my pay is poor (disagree)" in the Existence-Relatedness-Growth (E.R.G.) questionnaire used by Alderfer (1972). The next step included identifying carefully and grouping together items from the EOS-09 questionnaire in terms of the three modalities of work outcome identified by Elizur *et al.* (1991). For example, since Elizur *et al.* (1991) derived the item "pay, the amount of money you receive" from the work of Alderfer (1972) and classified it as instrumental by Elizur *et al.* (1991), we also labelled the item "my compensation is satisfactory since it is competitive with similar jobs in other companies" in the EOS-09 questionnaire as "instrumental" and grouped it together with other work outcomes of similar instrumental nature. Table 2 summarizes the process of classification.

Classification was informed by a number of procedural guidelines. First, Elizur *et al.* (1991) puts forward that two need theories, namely Maslow (1954) and Alderfer (1972), were jointly considered in order to determine four items in the WVQ. However, it can be observed that these items (that is, pay, esteem, recognition, growth) are derived mainly from the E.R.G. theory (Alderfer, 1972). To maintain consistency in the classification of the items in EOS-09, we took into consideration both E.R.G. items and Maslow items as they were developed by Alderfer (1972). Second, Elizur *et al.* (1991) is not specific about which items were derived from the work of Herzberg (1966). Cross-checking Herzberg items with those in the WVQ identifies 12 items, which were used with minor changes. Third, some of the items in the WVQ are common to more than one content theory. For instance, Elizur *et al.* (1991) suggested that the item "recognition" was included in the questionnaire as it appeared both in Alderfer (1972) and Hackman and Oldham (1980). Similarly, Herzberg (1966) items partially "overlap" with those in Alderfer (1972), Hackman and Oldham (1980) and McClelland (1961). Thus, when more than one reference was identified for an item in the EOS-09, each single source was considered as a potential means of categorization. In the end, our use of the EOS-09 questionnaire was limited to those items with clear correspondence to Maslow (1954), Alderfer (1972), McClelland (1961) or Hackman and Oldham (1980).

A distinct procedure was followed to identify and classify the items grounded in the work of Herzberg (1966). For each item in EOS-09 grounded in Herzberg's work, we identified the underlying category. We chose to operate a classification only of those items for which we can find a specific driver of identification within each category. For instance the item "I am satisfied with the equipment and materials I receive to do my job" in EOS-09 was classified as "work conditions" according to Herzberg (1966) based on the following code description provided by the author: "This category was used for stories in which the physical conditions of work, the amount of work or the facilities available for doing the work were mentioned [...]" (Herzberg, 1966). However, this procedure required some degrees of interpretation from the researchers, therefore whenever possible we introduced a "confirmatory step", by identifying at least one supporting item among the remaining content perspectives.

The classification of the EOS-09 was independently undertaken by two of the researchers. After providing the first tentative classification, the researchers met to compare and mutually discuss and reconcile differences. A second meeting to finalise the classification of subset of ambiguous items was performed a few weeks later adopting the same procedure (Miles and Huberman, 1984).

4.3. VARIABLE MEASUREMENT AND EMPIRICAL TESTS

Non-parametric tests of independence were performed to find out whether differences between managers' perception of desirable rewards may be associated with the organizational level of respondents. The type of data and the sample size dictates the specific test of independence employed. Hypotheses are tested using Pearson's Chi-square test of independence, with the organizational level serving as the independent variable and a nominal, Likert-type scale, expressing (dis)agreement with an item, serving as the dependent satisfaction variable. Hypotheses are analysed by considering a 99.9% confidence interval. As the survey generated primarily ordinal data, Chi-square is an appropriate choice to assess the relationships between level in the hierarchy and managerial perception of rewards (Siegel and Castellan, 1988). When necessary and conceptually meaningful, adjacent levels of variables were combined to meet the minimum cell expected frequency requirement for the Chi-square test. Specifically, the five levels of agreement with an item were at times collapsed to three levels (agree; not agree nor disagree and disagree) to facilitate the analysis.

5. FINDINGS

Descriptive statistics suggest that managers in general express at least as favourable attitudes toward items belonging to the cognitive and the affective modalities as those included in the instrumental modality. This pattern is consistent across all groups of managers. The evidence suggests that the environment of the five echelons of management studied is relatively rich in terms of desired outcomes.

5.1. INSTRUMENTAL OUTCOMES

In relation to the first hypothesis (H1), the results indicate statistically significant differences for 5 out of 9 items relating to the instrumental facet across echelons (Table 3). There are no meaningful differences in terms of opinion expressed on the design features of the bonus system (item 7 and 8) and on the convenience of working hours (item 9). Because of the non-significant results for these three items, H1c and H1d cannot be rejected. At the same time, respondents expressed homogeneous opinions on the "internal" adequacy of compensation (item 1).

Results of the Chi-square tests of 4 items dealing with work conditions indicate that the patterns are not random ($p<0.001$). Overall, echelon 1 and echelon

5 managers appear more likely to express satisfaction with work conditions compared with other mid-level managers. In contrast, the analysis reveals that a larger than expected number of negative perceptions of work conditions is expressed by level 2 managers. Thus, H1b is rejected. Significant differences in managerial perceptions are also identified for satisfaction with pay (item 1). The largest proportion of positive comments on this statement are expressed by level 1 managers followed by level 5 managers, while the lowest rates of satisfaction are reported for level 2 and level 3 managers. Hypothesis H1a is therefore rejected.

5.2. AFFECTIVE OUTCOMES

Hypothesis 2 investigates whether managerial level is related to satisfaction with affective outcomes. The Chi-square tests (Table 4) show that responses regarding the "opportunity to meet people and to interact with them" do not differ significantly across managers of different echelons. Consequently, H2b cannot be rejected. Similarly, no statistically significant differences are detected for two items included in the "supervision" dimension (item 10 and 18) and for one item dealing with "recognition" (item 28).

Hypothesis H2a examines whether managers are equally satisfied with their relations with co-workers irrespective of their position in the organization. The analysis indicates that, for the items included under the affective facet, echelon 1 and echelon 5 managers express significantly higher rates of satisfaction compared with other groups, while the lowest level of satisfaction is reported by echelon 2 and 3 managers. Thus, H2a is rejected. Table 4 shows that these significant differences in satisfaction extend over items included in the "esteem" dimension, leading to the rejection of H2e.

Finally, out of fourteen items relating to perceptions of supervision, statistically significant differences are associated with 12 items ($p < 0{,}001$). Similar differences emerge in relation to the items dealing with the assessment of senior management behaviour, direct supervision, and supervisory behaviour (that is, item 12, 14, 15, 16, 17 and 20). Hence, H2c is rejected. In line manner, the items included under the "recognition" dimension (item 34, 35) show a variety of perceptions, with echelon 3 managers reporting the lowest rates of agreement. Hypothesis H2d is therefore rejected.

5.3 COGNITIVE OUTCOMES

Hypothesis 3 investigates the relationship between perceptions of cognitive/psychological outcomes and managers' level in the hierarchy. No significant dif-

Table 3. Instrumental modality – Observed frequency distributions across managerial levels and chi-square test results

Managerial level:	**level 1 managers**					**level 2 managers**					**level 3 managers**					**level 4 managers**					**level 5 managers**					**Chi-square**	**p-value**
Level of agreement:	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	*df* = 16	
Item description:																											
Pay, the amount of money you receive																											
1-compensation: internal reference	2	6	8	4	3	2	8	12	22	22	9	35	43	84	115	9	48	51	112	81	77	241	208	306	263	66,036	< 0,001
2-compensation: external reference	2	10	4	6	1	5	15	13	15	18	20	71	49	72	74	18	85	52	85	61	112	254	221	265	243	22,040	NS
Work conditions																											
3-information to perform job well	2	13	5	2	1	1	18	17	20	10	40	92	57	66	31	35	117	60	60	29	184	490	206	162	53	69,797	< 0,001
4-provision of trainig	6	8	6	1	2	4	17	17	16	12	37	79	51	57	62	34	100	70	67	30	175	416	186	230	88	72,241	< 0,001
5-work processes well organized	2	6	9	4	2	1	13	15	26	11	23	91	66	80	26	22	124	64	79	12	164	504	219	164	44	118,863	< 0,001
6-provision of equipment	4	14	2	1	2	3	25	12	19	7	32	117	66	57	14	45	135	72	41	8	199	506	199	145	46	50,292	< 0,001
Benefits																											
7-benefit system: transparent	11	9	0	1	2	15	36	4	7	4	72	106	40	37	31	70	139	40	40	12	232	473	156	166	68	34,526	NS
8-benefit system satisfactory	9	6	1	5	2	7	19	15	14	11	46	84	55	38	63	32	99	60	63	47	173	326	206	217	173	31,109	NS
Convenient hours of work																											
9-reasonable hours of work	4	8	3	7	1	5	31	6	17	7	28	122	57	51	28	30	133	60	63	15	120	482	186	208	99	17,455	NS

NS: Chi-square test not significant at level 0,001. *: Combination of cells (Siegl and Castellan, 1989)

Table 4. Affective modality – Observed frequency distributions across managerial levels and chi-square test results

Managerial level:	level 1 managers					level 2 managers					level 3 managers					level 4 managers					level 5 managers					Chi-square	p-value
Level of agreement:	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	***df* = 16**	
Item description:																											
Supervisor, a fair and considerate boss																											
10- supervisor leads by example	12	6	3	1	1	16	24	11	7	8	94	112	34	26	20	90	126	48	20	17	427	416	109	88	55	30,395	NS
11- supervisor good at motivating	7	6	5	2	3	8	26	9	13	10	69	95	55	32	35	67	100	55	52	27	385	396	134	101	79	68,175	< 0,001
12- supervisor cares about workers	9	8	1	4	1	13	19	14	11	9	84	106	43	18	35	85	97	52	43	24	458	348	151	85	53	74,113	< 0,001
13- supervisor competent	8	10	2	2	1	16	27	10	9	4	95	112	46	15	18	84	123	44	39	11	515	394	98	55	33	83,875	< 0,001
14- supervisor good in coaching	11	6	3	3	0	16	25	13	7	5	103	86	51	20	26	94	115	43	34	15	396	429	167	68	35	42,935	< 0,001
15- supervisor makes time for workers	5	10	4	3	1	12	28	8	11	7	86	103	43	23	31	94	109	49	31	18	427	405	153	77	33	59,018	< 0,001
16- supervisor trustworthty	12	8	2	1	0	23	22	9	6	6	120	74	49	17	26	124	105	39	21	12	515	372	120	55	33	43,827	< 0,001
17- supervisor helpful	10	8	4	1	0	14	30	9	9	4	109	103	37	17	20	121	117	36	18	9	534	392	107	42	20	59,669	< 0,001
18- supervisor role model	13	4	3	3	0	16	30	9	5	6	89	89	68	14	26	94	103	70	22	12	383	383	197	77	55	34,101	NS
19- supervisor mentors development	6	8	6	2	1	3	15	16	18	14	35	103	81	49	18	51	124	66	57	3	252	504	219	87	33	153,694	< 0,001
20- senior management competent	7	8	4	2	2	7	27	8	11	13	57	86	74	37	32	51	121	57	51	21	252	460	208	109	66	58,183	< 0,001
21- senior management role model	7	13	3	0	0	9	21	19	10	7	54	111	71	31	19	65	141	69	23	3	359	469	195	63	9	118,515	< 0,001
22- senior management reliable	7	10	5	1	0	8	21	13	13	11	49	94	72	40	31	75	115	81	27	3	306	438	252	66	33	113,644	< 0,001
23- senior management helpful	9	9	5	0	0	10	17	17	10	12	37	80	89	49	31	45	96	112	39	9	241	405	296	98	55	88,858	< 0,001
24- senior management acts with integrity	13	8	2	0	0	20	33	12	0	1	65	108	94	11	8	85	154	58	4	0	331	517	221	13	13	50,088*	< 0,001
25- senior management trustworthy	12	9	1	1	0	17	31	15	2	1	71	86	103	17	9	87	151	57	6	0	350	482	230	22	11	70,267*	< 0,001
Recognition for doing a good job																											
26- praise from supervisor	7	7	6	2	1	19	21	13	7	6	78	98	58	17	35	81	103	69	30	18	386	407	177	68	57	41,828	< 0,001
27- praise from senior management	10	8	4	1	0	15	17	17	10	7	43	86	83	43	31	49	109	97	40	6	219	427	296	109	44	63,092	< 0,001
28- recognition for a good job	6	13	4	0	0	7	23	10	14	12	43	95	41	52	55	36	103	57	63	42	186	372	186	197	154	25,916	NS
Esteem																											
29- fair treatment	12	9	2	0	0	12	39	9	4	2	46	126	58	32	24	69	151	57	15	9	315	447	206	96	31	64,073	< 0,001
30- respect from others	14	7	2	0	0	16	36	7	5	2	83	112	51	20	20	78	157	51	9	6	361	493	153	66	22	52,416	< 0,001
Opportunity to meet people and interact																											
31- opportunity to meet others at work	8	13	1	0	1	11	38	12	3	2	69	120	60	29	8	157	120	15	6	3	681	364	36	14	0	25,373*	NS
Co-workers																											
32- Co-workers helpful	5	8	8	1	1	2	20	20	19	5	14	94	92	63	23	38	126	87	45	5	153	515	263	131	33	91,746	< 0,001
33- Co-workers cooperative	6	12	3	2	0	4	33	15	12	2	40	111	85	39	11	51	136	84	24	6	208	536	241	88	22	41,542	< 0,001

NS: Chi-square test not significant at level 0,001. *: Combination of cells (Siegl and Castellan, 1989)

ferences are found for two dimensions in the cognitive modality, namely the opportunity for promotion and the influence in the job (Table 5) and therefore the hypotheses H3e and H3f cannot be rejected. At the same time, all groups express comparable levels of being proud to work for the organization (item 36). All other tests of the items included in seven dimensions of the cognitive modality indicate that the patterns are not random, and significant differences exist between the observed and expected (no effect) distributions. Generally, managers at echelon 1 express the highest rate of satisfaction with the four dimensions included under the cognitive modality, namely: "opportunity for personal growth", "use of ability and knowledge", "job interest","responsibility", and those in echelon 3 report the lowest level of agreement. Thus, hypotheses H3d, H3g, H3h and H3i are rejected.

For H3b, echelon 1 managers report the higher level of satisfaction with "meaningfulness of work" (items 38 and 39), whilst negative attitudes are reported by managers at echelons 2 and 3. H3b is therefore rejected.

Statistically significant differences are associated with 3 items included in the "company" dimension. The group of managers at echelon 1 are more likely to express greater appreciation and pride to work for the organization compared with other groups. In contrast, level 3 managers appear to report significantly lower levels of satisfaction with these dimensions (items 34, 35, 37). All in all, H3a can be rejected. For the "feedback" dimension, managers at echelons 4 and 5 report the highest rates of satisfaction with the all the items included in this dimension, whereas managers at echelon 2 (item 42) and echelon 3 (items 41 and 43) appear significantly less satisfied. H3c is therefore rejected.

6. CONCLUDING DISCUSSION

The study addresses the question of whether a homogenous reward scheme for mid-level managers can be effective in delivering desirable outcomes, which can instigate and sustain managerial motivation and subsequent performance. A rich conceptualization of reward outcomes based on modalities proposed by Elizur (1984) and Elizur *et al.* (1991) is used to compare the perceptions of 1,771 managers in the Italian subsidiary of a large US-based company. Chi-square results demonstrate significant differences in satisfaction across echelons within mid-level management. These differences suggest that reward schemes need to be tailored for mid-level manages of different hierarchical echelons.

All three modalities offer a level of satisfaction to mid-level manager in this research setting. Upper and lower mid-level managers at echelons 1 and 5 are the most likely to express adequate satisfaction with the existing provision of affective, cognitive and instrumental outcomes. In comparison, the remaining managers report lower satisfaction with certain outcomes in the three modalities. Managers at echelon 4 remain unfulfilled in terms of the instrumental and affective dimensions of their jobs. While the motivational contract offered to this group of managers appears to be satisfactory in psychological terms, expressions of dissatisfaction with affective and instrumental outcomes are associated with the perception of pay, work conditions and supervision-related items. This group of managers reportedly would appreciate and therefore be motivated by a contract which emphasizes fixed pay and training opportunities as well as supervisory support in terms of mentoring. Similarly, managers at echelons 2 and 3 express dissatisfaction with each of the three modalities of work outcome. For the cognitive modality, dissatisfaction with feedback, responsibility and work meaningfulness are issues. Lack of supervisor and co-worker supportiveness is reported for the affective modality, while for the instrumental modality deficiencies attributed to pay and work conditions are observed. Managers at echelons 2, 3 and 4 share concerns about base-pay and training provided by the organization. A reward package that accommodates these demands for relations with peers and supervisors, feedback and empowerment-related outcomes may provide additional motivational drive to the mid-level managers it is offered to.

Our findings suggest that mid-level management views alternative rewards as desirable. At different echelons managers have different reactions to a comparable set of rewards. This suggests that hierarchical level in the organization should be viewed as a contingent variable that can mediate managers' perception of the reward system in use, corroborating the idea that mid-level management should not be viewed as a homogeneous group in terms of reward satisfaction (Merchant, 1989).

Perhaps more importantly, this study represents an attempt to integrate the rewarded manager perspective in the motivational contract discourse (Merchant, 1989). To this extent, our results complement well the findings of Shields and White (2004) and Bento and White (2006). These studies compare the perceived congruence between performance evaluation and compensation. Bento and White (2006) find that rewarded managers perceive a discrepancy between the actual and the preferred deployment of different reward practices, but this stream of research does not document the impact hierarchical position may have in determining the perception of the desirability of such rewards. The present study adds a different dimension to the "user-perception" (that is, evaluated and rewarded managers) literature. How-

Table 5. Cognitive modality — Observed frequency distributions across managerial levels and chi-square test results

Managerial level:	level 1 managers					level 2 managers					level 3 managers					level 4 managers					level 5 managers					Chi-square	p-value
Level of agreement:	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	**5**	**4**	**3**	**2**	**1**	***df* = 16**	
Item description:																											
Company																											
34- favourable opinion on the organization	16	7	0	0	0	41	19	3	3	0	109	107	49	12	9	160	126	12	3	0	534	425	107	20	9	60,047*	< 0,001
35- reccomend organization as great place	12	7	3	1	0	19	25	13	4	5	75	84	75	26	26	87	124	63	18	9	383	383	219	77	33	47,512	< 0,001
36- proud of working for the organization	17	4	2	0	0	27	25	11	2	1	100	91	73	11	11	133	105	54	6	3	447	403	184	41	20	34,342	NS
37- willing to remain with the organization	13	4	6	0	0	19	25	13	4	5	63	101	52	35	35	96	106	57	36	6	372	361	230	88	44	66,881	< 0,001
Meaningful work																											
38- satisfaction with the job	12	7	4	0	0	14	25	17	5	5	66	115	44	38	23	69	145	54	27	6	329	460	153	120	33	51,151	< 0,001
39- proud when job is well done	13	9	1	0	0	27	25	10	3	1	109	97	46	26	8	136	120	39	6	0	460	405	164	55	11	31,646*	< 0,001
40- understand job expectations	8	13	1	1	0	20	31	11	2	2	68	157	45	11	5	111	177	9	2	2	353	660	68	14	0	76,010*	< 0,001
Feedback on the results of your work																											
41- regular feedback about performance	5	8	6	2	2	11	28	8	11	8	61	109	49	35	32	87	135	42	20	17	416	416	153	77	33	85,984	< 0,001
42- feedback received by others	6	5	8	3	1	13	22	9	15	7	74	102	57	19	34	75	112	69	30	15	383	383	186	88	55	62,679	< 0,001
43- feedback provided timely	9	5	6	3	0	13	23	13	11	6	69	106	54	29	28	79	112	64	25	21	383	405	186	77	44	47,311	< 0,001
Opportunity for personal growth																											
44- job favours long term development	11	5	7	0	0	8	29	12	10	7	60	97	60	35	34	54	115	72	48	12	230	427	241	120	77	40,978	< 0,001
45- updated with developments	10	9	3	1	0	12	32	10	8	4	34	112	74	37	29	46	154	55	37	9	153	526	241	131	44	50,069	< 0,001
Influence in work																											
46- opinions are valued	8	8	4	1	2	3	34	13	12	4	41	109	61	49	26	33	109	93	42	24	131	427	296	153	88	29,382	NS
Advancement, changes for promotion																											
47- opportunity to meet career goals	10	5	7	1	0	12	25	15	10	4	57	80	60	46	43	54	120	60	47	20	230	416	208	142	99	37,236	NS
Responsibility																											
48- work independently and take risk	10	8	3	1	1	8	30	17	8	3	43	97	71	46	29	54	139	75	27	6	188	495	276	101	35	62,559	< 0,001
Use of ability and knowledge in your work																											
49- encouraged to be creative	9	10	2	1	1	9	29	15	9	4	58	109	61	35	23	75	148	54	18	6	263	514	208	88	22	53,327	< 0,001
Job interest																											
50- interesting and fulfilling job	11	8	4	0	0	20	23	14	5	4	74	97	63	29	23	90	151	45	9	6	372	438	175	77	33	56,999	< 0,001

NS: Chi-square test not significant at level 0,001. *: Combination of cells (Siegl and Castellan, 1989)

ever, that stream of research limits its attention to monetary/material inducements only, whilst the findings of this study suggests that significant differences between groups of managers can be associated to instrumental, cognitive and affective outcomes.

The employment of the modality approach proposed by Elizur (1984) encompasses a wide perspective on valuable work outcomes, allowing us to observe that mid-level managers differ in the perception of satisfaction and desirability across material and immaterial rewards. To date, researchers have observed that immaterial rewards are underutilized in the design of control systems (Flamholtz *et al.*, 1985; Malmi and Brown, 2008), even though they appear to have an impact on managerial motivation equal to extrinsic rewards (Kominis and Emmanuel, 2007). This study suggests that the adoption of a more comprehensive framework of analysis enlarges our understanding of the differences between groups of managers' satisfaction in rewards outcomes. In addition, the emerging observation of differences associated with the provision of affective outcomes indicates that the study of reward desirability may not revolve around a dual approach of the extrinsic and intrinsic. For control system designers, a more comprehensive approach to rewards may facilitate the identification of unfulfilled needs and corresponding rewards to fulfil them at different organizational echelons more directly. This not only contributes to devise more desirable reward systems but also helps in identify precisely those modalities or work outcomes that managers perceive as unsatisfactory. For instance, our findings suggest that managers at echelons 2 and 3 are the least likely to be satisfied with the actual provision of affective and cognitive outcomes. Attention to such outcomes in the design of the company's reward package can provide powerful motivational drivers for these mid-level managers

Finally, our findings carry implications for the design and use of reward systems for management control purposes in practice. A single universal reward package for mid-level managers appears to be ill-advised since different patterns in mid-level managers' reward satisfaction are likely to emerge. The inclusion of various inducements in a reward package, both in absolute and in relative terms, will be appreciated differently by groups of organizational members, therefore a more tailored and flexible reward system may be suitable in order to accommodate diversity of views across echelons (Ehrenberg and Milkovich, 1987; Lawler, 2000). To this extent customized reward plans such as "cafeteria system" or "flexible benefit plans" (Barringer and Milkovich, 1998) may represent an opportunity to accommodate diverging manager attitudes toward material and non-material inducements by allowing individuals a choice in the rewards that they receive (Lawler, 2000). Notwithstanding that these systems can be costly, it should still be possible to customize reward schemes that apply to managers who share common positions in the organisation's hierarchy.

Certain limitations of this study should be noted. These weaknesses indicate possible avenues for future research on the perception of effective reward schemes. First of all, the instrument employed for this research was not purposely devised to measure the modality of outcome facet (Elizur, 1984). The use of data collected through the EOS-09 questionnaire provides the distinct advantage of gathering reward perceptions from a large sample of mid-level managers, the construct validity of the instrument is however doubtful. Although the list of items included in the company's survey instrument is large enough to capture a broad set of rewards in the mid-level manager's environment, it is acknowledged that the final selection of the rewards included in the analysis is linked to the theoretical framework employed, and, at least in part, is not free from our subjectivity. In addition, to the extent that the study's sample is limited to one company and one industry, its findings may pertain solely to the firm and industry sampled, implying the need for validation of the findings in different settings. Finally, the present study is cross-sectional and it is questionable whether the results hold over time. Future research could adopt a longitudinal approach in order to verify whether (and how) managers' perceptions of dis/satisfaction with different rewards are stable over time.

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Time-Varying Term Structure of Risk Premium, Estimated with Credit Default Swaps*

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Abstract. The paper estimates the time-variation and term structure of forward-looking equity premium of Australia, Asia excluding Japan, and CEEMEA region. Methodology is based on Berg and Kaserer (2009) approach which employs structural models of default within Merton framework (1974) to convert credit spread from CDS into equity premium. The paper extends the Berg and Kaserer (2009) approach for equity risk premium (ERP) estimation in the following ways. Firstly, the forward-looking equity premium is calculated for developing markets, which to our best knowledge has not been done in the literature yet. Second, the use of monthly data allows observing time variation of equity premium. Finally, the availability of CDS data for 5-, and 10-year CDS maturities provides the term structure of equity premium for CEEMEA region since 2010. Term structure is downward sloping which implies that short-term risks are priced higher than long-term, and the slope becomes more angled during financial turmoil. Historical equity premium dynamics demonstrate apparent relationship with stock market behavior.

Аннотация. В статье оценивается статическая и динамическая структура ожидаемой риск-премии обыкновенных акций на рынках Австралии, Азии, Центральной и Восточной Европы, Ближнего Востока и Африки. Методология оценки основана на подходе Berg, Kaserer (2008), предполагающем использование структурной модели дефолта Мертона для конвертации кредитного спреда по CDS в риск-премию. Эта работа расширяет подход Berg, Kaserer в трех аспектах. Во-первых, премия рассчитывается для развивающихся рынков, что, насколько нам известно, не делалось в литературе до нас. Во-вторых, использование месячных наблюдений позволяет рассмотреть вариацию риск-премии во времени. Наконец, доступность данных по CDS с 5- и 10-летним сроком истечения дает возможность оценить временную структуру риск-премии. Результаты исследования показывают нисходящий уклон риск-премии: ближайшие риски оцениваются инвесторами сильнее, чем более далекие, и разность увеличивается во время кризиса. Временная динамика премии тесно связана с динамикой фондового рынка.

Key words: equity premium, credit default swap, developing markets, structural models of default.

INTRODUCTION

The equity risk premium (ERP) is an extremely important concept of the modern theory of finance. Basically, it is the price that investors charge for bearing extra risk from holding risky assets compared to risk-free securities. At each point in time and for each asset of each maturity there exists a price for risk which is determined by the market participants. ERP has numerous important practical and theoretical implications in risk and return financial models, corporate finance valuation and analysis, portfolio management, investing activities, as well as in the composition of savings and spending plans, etc.

The part of the confusion about the equity risk premium is the entire meaning of this concept to different users. The literature and practical implications may assume one of the following meanings, such as historical, required, expected, and implied premium. In this study the equity premium is considered as fundamental judgment of the degree of risk that market participants see in the market and of the price that they assign to this risk. This, in turn, determines the value of the asset and its expected return. Consequently, it influences the capital dis-

* Временная динамика премии за риск, рассчитанной с использованием кредитных дефолтных свопов.

tribution among different asset classes as well as the choice of specific securities within the chosen asset class.

For a long time academics and practitioners used to think that the risk premium is constant over time leading to belief that historical returns best explain the future ones. Later the empirical studies revealed the time-variation of equity premium; this gave grounds for various theories of equity premium assessment. Despite the knowledge, access to information, developed analytical tools and techniques, neither academics nor practitioners have reached the consensus on equity premia valuation approach so far.

Recent literature suggests only few estimation methods that allow to obtain forward-looking risk premium: extracting it from bond spreads (Campello *et al.,* 2007), option prices (Bhar and Chiarella, 2004), and credit default swap (CDS) spreads (Berg and Kaserer, 2007). The crux of the Berg and Kaserer method is the link of credit valuation with the expected equity premium. The credit default swap valuation appears to be a proxy for credit valuation. The equity premiums are extracted from CDS spreads in the following manner: the structural models of default within the Merton (1974) framework specify that the difference between the risk-neutral and actual default probabilities depends on the assets' Sharpe ratio. The real world and risk-neutral default probabilities specified by the structural model of default in the Merton framework differ in terms of drift: the firm's assets have to fall by $(\mu - r) \times T$ compared to the risk-neutral world to reach the default (where μ — is a real world drift, r — risk-neutral drift, T — time to maturity). The real world, or actual, default probability may be estimated from rating or taken from statistics, while the risk-neutral default probability is approximated from CDS spreads. This approximation is based on the intuition that CDS spread may be decomposed into two parts: price that compensates for expected loss and the risk premium demanded by investors. The difference between risk-neutral and actual default probabilities yields the asset's Sharpe ratio which in turn may be transformed into the market Sharpe ratio according to the continuous time CAPM. Finally, the equity risk premium may be easily derived from the general measure of risk aversion for each point in time.

The Sharpe ratio estimator of Berg and Kaserer is based on the observable parameters, which makes it simple to estimate and available for practitioners. The use of CDS data in the model allows for capturing time-variation of equity premium value. Moreover these credit instruments discover the term structure of the risk premium due to availability of different maturities.

The majority of researches devoted to equity premium estimation represent results on broad US market owing to the availability of historical data for extensive time period (some data time series are known since 1870) while the rest ones describe premiums for developed European countries.

The interest in emerging countries has grown substantially over the two recent decades from the direction of the international and domestic investors. Nevertheless the academic literature doesn't provide us with estimations of expected risk premium in developing countries. There are only few papers that estimate *ex post* risk premiums for broad stock index of emerging economies or the Eastern countries (e.g. Cohen, 2010; Donadelli and Prosperi, 2011).

The purpose of the study is to test Berg and Kaserer equity premium estimator to the least examined in the literature markets, such as CEEMEA (Central Eastern Europe, Middle East, Africa), Asia (excluding Japan), and Australia. Although we are interested in forward-looking premium, it is important to assess it on historical data in order to prove adequacy of results and to capture equity premium properties — time-variation and term structure (where possible). To our best knowledge, this is the first research that employs this approach to determine equity premium term structure for the mentioned markets.

The study is naturally limited by the data availability. CDS instruments are young and poorly introduced in developing markets, such as CEEMEA and Asia excluding Japan. Only investment rated firms may have CDS on their foreign debt. The paper employs MARKIT® CDS indices, which combine the most liquid corporate CDSs and cover considered regions. Among them only CEEMEA market CDS data let us examine term structure properties as there are two maturities for index available.

The need to determine the actual default probability in the model involves another limitation that may influence results. Berg and Kaserer estimate real world default probabilities out of Moody's EDF data, which are of limited access. In this paper the average historical default probabilities from Moody's ratings are used as a proxy for the expected ones. This approach reflects the means of most investors that use historical probabilities for forecasting.

Some other limitations are connected to the theoretical framework of the model, which is built on Merton (1974); they are described in the second section.

The paper is structured as follows. The first section discusses the model of forward-looking equity premium estimation. The second section describes dataset of the research and model parameters estimation methods. The third section discusses results, their properties and implications, and limitations of the study. Finally, the conclusion summarizes empirical findings and applications of results, proposes developments for future research.

MODEL SETUP

This section describes the methodology for extracting equity premium from CDS spread. The crux of the approach is that default and equity risk premiums are intrinsically linked because equity and debt are both contingent claims on the same assets (Merton, 1974). Building on this argument, the debt valuation is linked to equity valuation through structural model of default, which allows deriving the difference between the risk-neutral and actual default probabilities, which in turn produces the dynamics of the asset value process, the asset Sharpe ratio; given the correlation it may be transformed into market Sharpe ratio.

The market Sharpe ratio estimator, developed by Berg and Kaserer (2009), is calculated only from observable parameters: risk-neutral and actual default probabilities, maturity, correlation, and volatility. The maturity and the risk-neutral default probability is extracted from CDS spreads, the actual default probabilities from Moody's data, the correlation from equity prices, and the market volatility from market benchmark indices data. The important advantage of this estimator is that it doesn't require calibration process to evaluate actual and risk-neutral default probabilities. The fact that only difference between them is required simplifies the model significantly; neither the asset value process nor the default barrier should be calibrated as well as expected dividends and earnings growth.

The derivation of the market Sharpe ratio starts with the determining of the real world default probability. Merton (1974) framework defines firm's debt as one zero-coupon bond *D*, which defaults at maturity time *T*, if the asset value *A* falls below the nominal debt value. The asset value process A_t is modeled as a geometric Brownian motion with volatility σ: $dA_t^P = \mu A_t dt + \sigma A_t dB_t$ for actual drift μ_V, and $dA_t^Q = rA_t dt + \sigma A_t dB_t$ for risk-neutral drift *r,* where B_t denotes a standard Wiener process. According to this the real world default probability P^d for the period between *t* and *T* may be presented as follows:

$$P^d(t;T) = P\left[A_t < D\right] = P\left[A_t e^{\left(\mu - \frac{1}{2}\sigma^2\right)\cdot(T-t) + \sigma\cdot(B_T - B_t)} < D\right]$$

$$P^d(t;T) = N\left\{\frac{\ln\frac{D}{A_t} - \left(\mu - \frac{1}{2}\sigma^2\right)(T-t)}{\sigma\sqrt{T-t}}\right\} \quad (1)$$

N stands for cumulative standard normal distribution function.

Accordingly, the risk-neutral default probability Q^d can be calculated as:

$$Q^d(t;T) = N\left\{\frac{\ln\frac{D}{A_t} - \left(r - \frac{1}{2}\sigma^2\right)(T-t)}{\sigma\sqrt{T-t}}\right\} \quad (2)$$

The next step is to express the risk-neutral default probability through the actual one:

$$Q^d(t;T) = N\left\{\begin{matrix} N^{-1}\left(P^d(t,T)\right) + \\ + \frac{\mu - r}{\sigma}\cdot\sqrt{T-t} \end{matrix}\right\} \quad (3)$$

From formula (3) one can easily derive the asset's Sharpe ratio which can be simply estimated from risk-neutral and actual default probabilities and maturity:

$$SR_A = \frac{\mu_A - r}{\sigma_A} = \frac{N^{-1}\left\{Q^d(t,T)\right\} - N^{-1}\left\{P^d(t,T\right\}}{\sqrt{T-t}} \tag{4}$$

The asset's Sharpe ratio may be modified into market Sharpe ratio in accordance with the continuous time CAPM, taking into account the correlation of the assets with the market portfolio, assumed to be non-zero $\rho_{A,M} \neq 0$:

$$\mu_A = r + \frac{\mu_M - r}{\sigma_M} \cdot \rho_{A,M} \cdot \sigma_A \leftrightarrow \frac{\mu_M - r}{\sigma_M} = \frac{\mu_A - r}{\sigma_A} \cdot \frac{1}{\rho_{A,M}} \tag{5}$$

For correlation estimation the following approximation holds: $\rho_{A,M} \approx \rho_{E,M}$, which assumes that the correlation between equity and market returns is taken rather than assets and market.

The market Sharpe ratio derived in the Merton framework is determined as the following:

$$SR_M = \frac{\mu_M - r}{\sigma_M} \approx \frac{N^{-1}\left\{Q^d(t,T)\right\} - N^{-1}\left\{P^d(t,T)\right\}}{\sqrt{T-t}} \cdot \frac{1}{\rho_{E,M}} \tag{6}$$

The last parameter required for the equity risk premium estimator is the volatility of the market portfolio. Putting all together yields an estimator for the equity premium:

$$ERP = \frac{N^{-1}\left\{Q^d(t,T)\right\} - N^{-1}\left\{P^d(t,T)\right\}}{\sqrt{T-t}} \cdot \frac{\sigma_M}{\rho_{E,M}} \tag{7}$$

Let's discuss all required parameters in particular. The market volatility is estimated from market equity index for concerned regions. The correlation coefficient is defined as the weighted average of median correlations for most highly capitalized firms from each industry with the market index. Median industry correlations are taken for robustness reasons. Since the correlation appears in the denominator of the formula (7), estimation errors result in an upward biased equity premium. Industry medians have lower standard errors than each company separately. The real world default probability is taken from Moody's ratings. The following approximation is used to obtain the risk-neutral default probability: $CDS = \lambda^Q \cdot LGD$, where λ^Q — is the risk-neutral default intensity[1], *LGD* — loss given default — is the percentage amount of loss due to default over the total exposure. *LGD* may be rewritten as *1-RR*, where *RR* — the recovery rate, the percentage amount of total exposure which may be recovered during bankruptcy procedures in event of default. According to the default intensity model the risk-neutral cumulative default probability is derived from default intensity through the following relationship:

$$Q^d(T,t) = 1 - e^{-\lambda^Q (T-t)} \tag{8}$$

Rewriting the formula 8 for CDS spread input parameter yields:

$$Q^d(T,t) = 1 - e^{-\left[\frac{CDS}{1-RR}(T-t)\right]} \tag{9}$$

Putting this relation into the equity premium estimator produces the final formula for equity premium, which includes all required observable parameters:

[1] The risk-neutral default intensity is the risk-neutral probability of default per unit time.

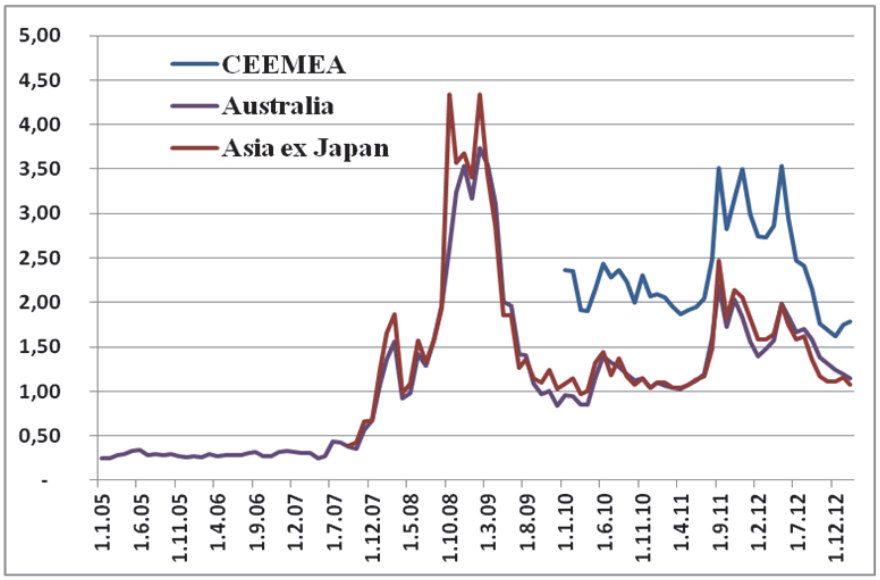

Figure 1. Monthly average Markit iTraxx CDS indices spreads (in percent) for CEEMEA, Australia, and Asia (excluding Japan)

$$ERP = \frac{N^{-1}\left\{1 - e^{-\left[\frac{CDS}{1-RR}(T-t)\right]}\right\} - N^{-1}\left\{P^{d}(t,T)\right\}}{\sqrt{T-t}} \cdot \frac{\sigma_{M}}{\rho_{E,M}} \quad (10)$$

CDS spreads are taken from the historical data in Bloomberg while the recovery rates — from Markit statistics for each particular CDS index.

Although the derived in the Merton framework estimator for the market Sharpe ratio generates adequate results, it is the subject for criticism concerning default timing and the assumption about complete information. Berg and Kaserer (2009) expand the simple Merton framework to more advanced first passage time models, which allow for default before maturity, for the observable and unobservable asset values. Comparison of three approaches discovers immaterial results differences. They conclude that their market Sharpe ratio estimator is robust with respect to model changes because it comprises the relation between actual and risk-neutral probabilities, which itself is not submitted to the influence due to model changes. This study employs simple Merton Sharpe ratio estimator for deriving equity premium. The following sub-section describes model parameters estimation and descriptive statistics.

DATA AND PARAMETERS ESTIMATION

Current section describes data and statistics employed by the research. The basis of the research are the CDS spreads, which have 5- and 10-year maturities. Such periods are too enduring for developing markets; moreover hardly someone could be interested in estimating 5-year forward-looking equity premium. Market conditions change much more often: high volatility and uncertainty force investors to rebalance their portfolios often. Taking into consideration crisis years 2008–2009, when investor sentiments varied frequently, we decide to estimate 1-month forward-looking equity premium. The calendar month is considered as a period. This idea is supported by the assumptions that investors are sensitive to calendar timing due to necessity of periodic reporting, quarterly and annual returns calculation.

The empirical study requires a number of input parameters, which compose the equity premium estimator and are mentioned in the previous section. They may be divided into two types: the raw data and parameters to be calculated.

The raw data include corporate CDS spreads, actual default probabilities and recovery rates. Due to the fact that credit markets, particularly CDS, are underdeveloped in emerging countries, there is a lack of liquid CDS indices traded. As the only developed country in this research, Australia nevertheless has single 5-year maturity CDS index although it has the longest CDS index history.

Table 1. Average Cumulative Issuer-Weighted Global Default Rates by Alphanumeric Rating, 1998–2012*

Rating/ Year	1	2	3	4	5	10
Aaa	0.000	0.037	0.037	0.037	0.037	0.037
Aa1	0.000	0.000	0.000	0.000	0.000	0.000
Aa2	0.000	0.014	0.224	0.472	0.644	1.539
Aa3	0.055	0.164	0.233	0.344	0.525	1.499
A1	0.153	0.359	0.617	0.951	1.342	3.361
A2	0.116	0.336	0.614	0.829	1.113	4.441
A3	0.086	0.278	0.570	0.864	1.307	3.742
Baa1	0.188	0.436	0.663	0.874	1.102	2.662
Baa2	0.216	0.528	0.900	1.369	1.747	3.928
Baa3	0.307	0.821	1.415	1.985	2.720	7.354
Ba1	0.411	1.576	2.998	4.321	5.791	13.71
Ba2	0.708	1.692	3.036	4.586	5.843	13.36
Ba3	1.101	3.304	5.938	8.794	10.6	22.68
B1	1.592	5.247	9.373	12.94	15.9	31.1
B2	3.196	8.365	13.76	18.85	22.67	38.43
B3	4.739	11.81	19.39	25.39	30.48	49.41
Caa1	8.278	18.32	27.42	35.05	42.20	64.43
Caa2	17.63	30.30	39.91	46.93	52.62	69.95
Caa3	28.39	44.48	54.31	61.34	66.89	69.37
All rated	2.072	4.255	6.283	7.934	9.240	14.16

* Data in percent

The study employs Markit iTraxx type of CDS indices that appear in tradable credit default swap family of indices and cover the following regions: Asia excluding Japan, Australia, and CEEMEA. The Markit iTraxx indices are traded 5-year maturities (including 10-year maturity for CEEMEA) by series. A new series is determined on the basis of liquidity every 6 months — if there is enough liquidity the next series is rolled for the following half-year.

The sample includes generic daily mid-day spreads time-series for the corporate CDS indices: MARKIT iTRAXX CEEMEA 5- and 10-year maturity index, MARKIT iTRAXX ASIA excluding JAPAN IG (investment grade) 5-year maturity, and MARKIT iTRAXX AUSTRALIA 5-year maturity.

Daily roll-adjusted mid-quotes are obtained from Bloomberg (Figure 1).

The use of aggregate CDS index is stipulated by the fact that index is more liquid, covers the concerned region, and provides us with the equity premium for these regions rather than particular companies which is consistent with the purpose of the study. The employed iTraxx Markit indices represent standardized public financial instruments which are priced in U.S. dollars, significantly liquid, and accepted as a key benchmark of the overall market credit risk. The presence of such characteristics contributes a reliable unified platform for assessing risk premium to the study.

The CEEMEA index is composed from 25 most liquid corporate underlying debt securities (bonds or LPN[2]) of mainly Russian, United Arab Emirates, and Turkish firms. Spreads are available since January 2010 for 5- and 10-year maturities. 10-year CDS index is rather illiquid, it is lacking for trades in May-September 2012 and May-July 2011. Regardless of this fact it is used to provide insight into term structure of equity premium. The Asian index excludes Japan and consists of 37 investment grade companies' 5-year maturity CDS[3]; it starts in Octo-

[2] Loan participation note, or LPN, is common juridical form of Eurobond issue.

[3] The total amount is 40, three of which are CDS on sovereign debt and are not considered in this study.

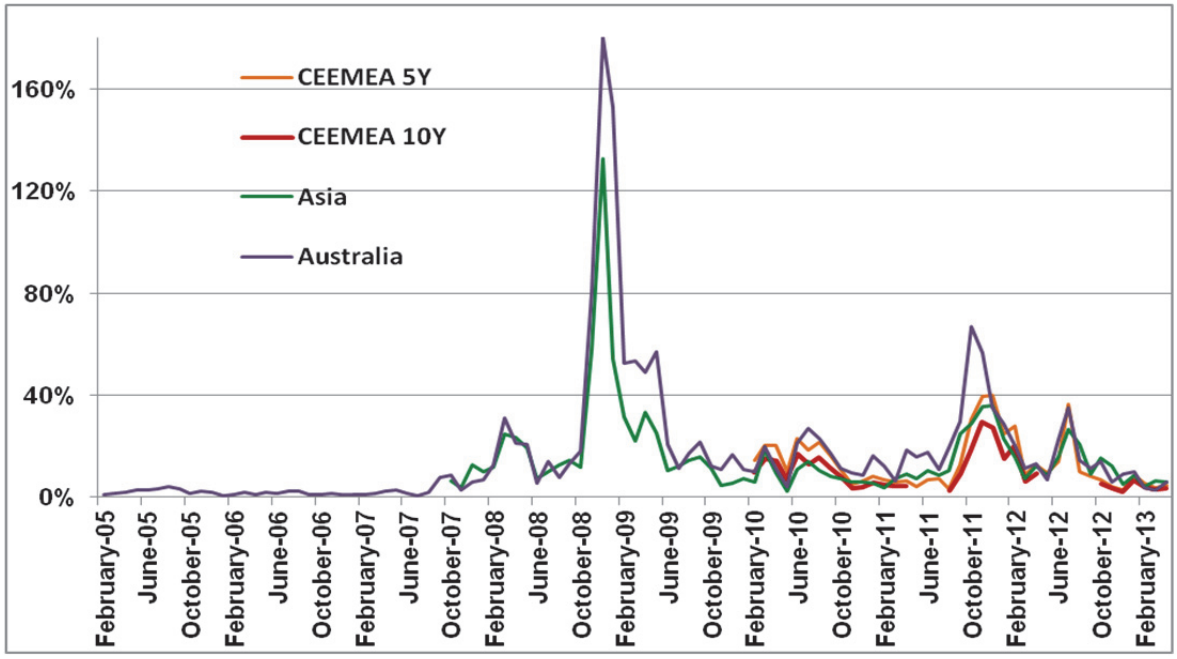

Figure 2. Time-variation of equity premium estimations for Australia, Asia, 5-year CEEMEA, and 10-year CEEMEA CDS.

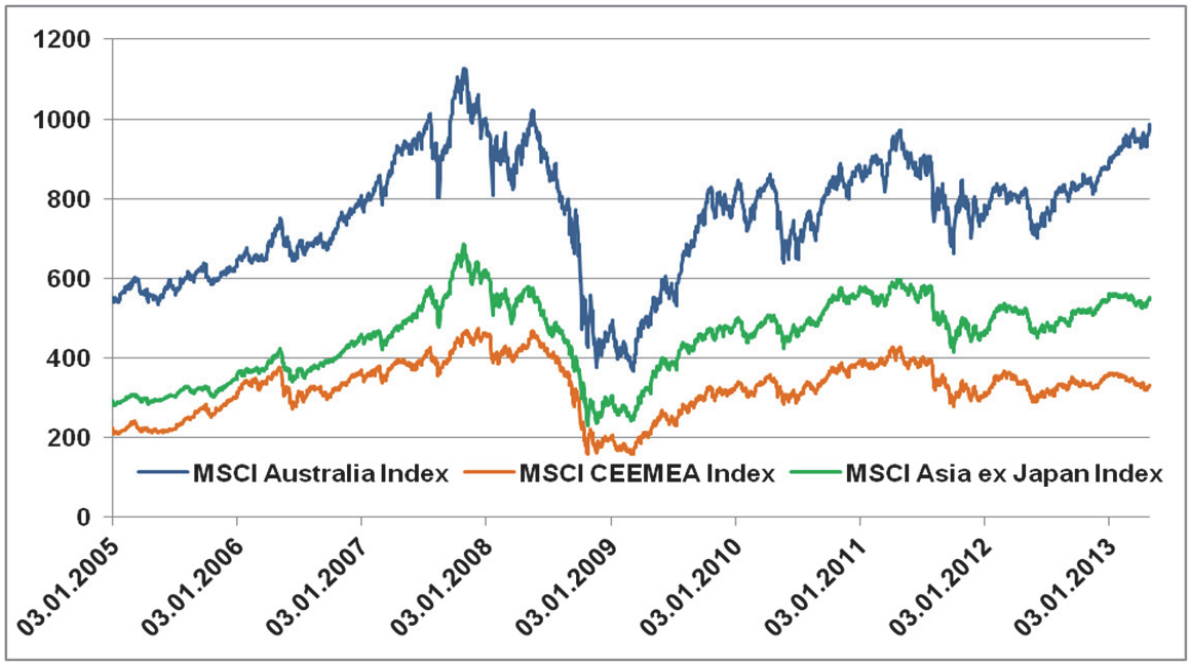

Figure 3. Historical daily chart of MSCI Australia index, MSCI CEEMEA index, and MSCI Asia excluding Japan, January 2005 — April 2013.
Source: Bloomberg.

ber 2007. The Australian index has the history since January 2005 and includes 25 names CDS of various Australian firms' debts for 5-year maturities.

As all underlying debt securities which comprise indices are rated by Moody's rating agency[4], the average default rate for the each region is used as a proxy for actual default probability. Since the CDS indices have 5-year maturity, only the 5-year default rates are considered; except for CEEMEA region, there are two CDS of 5- and 10-year maturities for which 5-year and 10-year default rates are taken accordingly.

The average cumulative issuer-weighted global default rates for 1998–2012 (Table 1), estimated by Moody's for each alphanumeric rating and adjusted

[4] There are only three exceptions when debts are rated by S&P, the relevant Moody's rating is taken for those.

Table 2. Australian model parameters and estimates.

Table of average yearly parameters for Australia								
Year	CDS Spread	Q	P	market σ	mean ρ	ERP p.a.	Asset Sharpe Ratio	Market Sharpe Ratio
1Q 2013	1.1%	9.2%	1.0%	4.2%	0.41	5.7%	40.5%	99.4%
2012	1.6%	12.5%	1.0%	9.7%	0.35	16.1%	48.5%	137.3%
2011	1.4%	10.3%	1.0%	17.0%	0.36	25.5%	43.0%	129.2%
2010	1.1%	8.4%	1.0%	16.7%	0.47	14.6%	38.1%	81.8%
2009	2.1%	17.2%	1.0%	17.8%	0.43	39.7%	56.0%	140.5%
2008	1.7%	11.3%	1.0%	22.9%	0.41	34.3%	44.5%	107.3%
2007	0.4%	2.8%	1.0%	11.7%	0.53	3.2%	13.7%	26.2%
2006	0.3%	2.3%	1.0%	8.4%	0.56	1.5%	10.2%	18.7%
2005	0.3%	2.3%	1.0%	8.2%	0.40	2.4%	10.8%	28.4%

for rating withdrawals, are taken for proxy for actual default probabilities. In their study Berg and Kaserer estimate actual default probabilities from Moody's KMV EDF rates which are available only for Moody's subscribers and are chargeable.

The recovery rates are taken from ISDA CDS standard contract terms[5] for the each region: 0.25 for CEEMEA, 0.4 for Australia, 0.4 for Asia excluding Japan. This approach provides consistency of data and seems to be more practical and applicable for market participants who don't have access to Moody's EDF.

The parameters that require calculations include the correlation of the equity returns with market portfolio and the market volatility. For each region the relevant MSCI Index is chosen as a proxy for market portfolio — EM EMEA, Asia excluding Japan, and Australia. The estimation of correlation involves several steps. First, since the CDS indices engage companies of different industries, each industry weight in particular CDS index is defined. The top-10 stocks by market capitalization for each industry sector are selected in Bloomberg. Then, for each stock and each MSCI index 20-day rolling returns are calculated which constitute the basis for calculation of 20-day rolling correlation for each cross-section of stock and MSCI index. The averaging daily data for 20-day rolling correlations yields the monthly average values. Finally, the sum of weighted mean monthly correlations for industry sectors represents the final correlation figure for each calendar month of the sample. Market volatility is estimated as average monthly standard deviation of 20-day rolling MSCI index returns.

Correlation and volatility calculations are made in RStudio and Microsoft Excel. Mean industry correlation is more objective and smoothed than that of particular company, it has lower errors, and mirrors market more accurate. The industry sector classification is based on Global Industry Classification Standard (GICS).

The CDS spreads, stocks prices, MSCI data are taken from Bloomberg in U.S. dollars for data uniformity.

When all parameters are defined, we put them into the model as of formula (10) and estimate the expected equity premium for the next month over the whole period of each CDS index. The last calculated value in the sample (timestamped March 2013) represents the expected equity premium for April 2013.

RESULTS AND INTERPRETATION

Based on the Sharpe ratio estimator, as of equation (6), derived by Berg and Kaserer in the Merton framework, we estimate implied equity premium, as of equation (7), from CDS spreads of generic iTraxx CDS indices of Australia, Asia excluding Japan, and CEEMEA region. Appendix 1 provides the results for monthly asset Sharpe ratio, market Sharpe ratio, and equity premium, denoted as per annum percents, for Australia, Asia excluding Japan, CEEMEA 5-year, and CEEMEA 10-year.

Figure 2 demonstrates graphically the time-variation of estimated equity premium.

Obtained results are consistent with empirical market observations. For the period 2005–2007

[5] The recovery rate is specified in ISDA CDS standard contract terms, http://www.cdsmodel.com/cdsmodel/fee-computations.page.

Table 3. CEEMEA model parameters and estimates for 5-year and 10-year CDS.

Table of average yearly parameters for CEEMEA (5-year)								
Year	CDS Spread	Q	P	market σ	mean ρ	ERP p.a.	Asset Sharpe Ratio	Market Sharpe Ratio
1Q 2013	1.7%	10.9%	4.1%	5.1%	0.27	5.6%	22.9%	87.5%
2012	2.5%	15.9%	4.1%	11.2%	0.37	13.9%	33.1%	98.2%
2011	2.4%	14.1%	4.1%	15.4%	0.40	14.3%	29.7%	78.6%
2010	2.2%	13.5%	4.1%	13.0%	0.29	15.3%	28.7%	109.1%
Table of average yearly parameters for CEEMEA (10-year)								
1Q 2013	1.9%	22.7%	9.7%	5.1%	0.27	4.3%	17.5%	66.8%
2012	2.4%	28.5%	9.7%	11.2%	0.37	8.8%	23.4%	67.0%
2011	2.5%	27.6%	9.7%	15.4%	0.40	11.8%	22.4%	62.5%
2010	2.2%	25.5%	9.7%	13.0%	0.29	10.8%	20.5%	78.3%

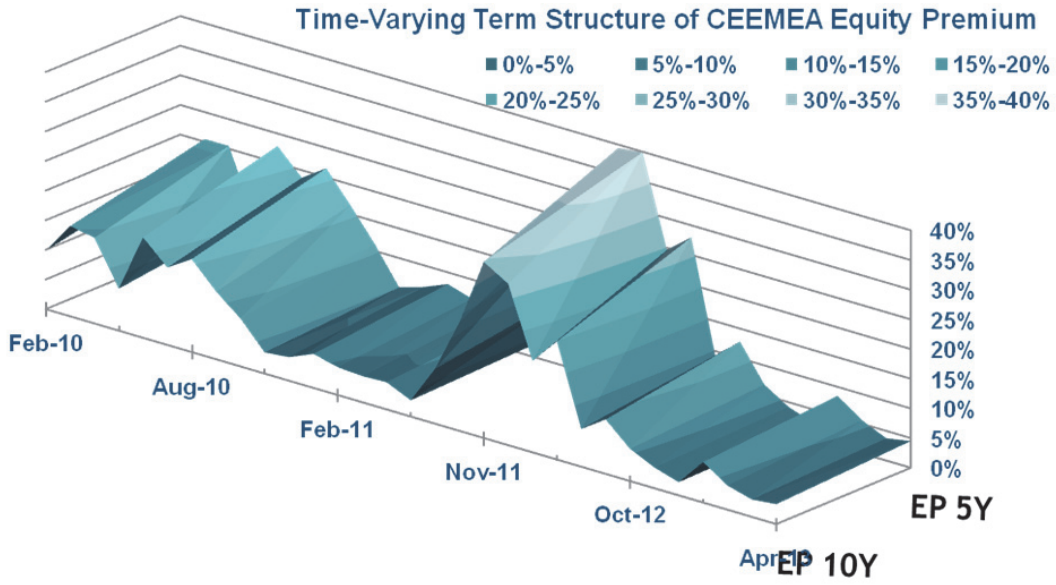

Figure 4. Term structure dynamics of CEEMEA equity premium.

Australian premium curve is flat and close to zero. Volatility starts growing in 2008. From October 2008 to February 2009 Australian and Asian equity premiums significantly exceed 100%. Australian premium reaches its peak of 9% per month or 180% per annum in December 2008 when MSCI index for Australia drops 58% during four months to 377 on November 20, 2008 from its maximum in July 2008–890; and when the largest monthly slump of 38% takes place in October 2008. Asian equity premium reaches 7.3% per month or 133% per annum in December 2008 after monthly stock fall by 38% during October 2008.

In spite of the fact that CEEMEA data starts considerably later and unfortunately does not cover the crisis, its patterns since 2010 are very similar to Australian and Asian ones.

Figure 3 provides an insight of stock market behavior since 2005. It may be clearly noticed that equity premium movements correspond to stock indices raises and downturns.

In order to assess performance of stock index we should estimate its returns relative to the first value of the corresponding period: the base value for Australia is of 03.01.2005, for Asia — of 01.10.2007, and for CEEMEA — 01.01.2010.

Table 4. Asian model parameters and estimates.

Table of average yearly parameters for Asia excluding Japan								
Year	CDS Spread	Q	P	market σ	mean ρ	ERP p.a.	Asset Sharpe Ratio	Market Sharpe Ratio
1Q 2013	1.1%	8.6%	1.0%	4.2%	0.35	6.3%	43.5%	124.8%
2012	1.6%	12.5%	1.0%	8.6%	0.38	14.3%	53.0%	141.2%
2011	1.4%	10.5%	1.0%	13.2%	0.45	15.6%	47.9%	105.6%
2010	1.1%	8.9%	1.0%	10.5%	0.57	8.9%	44.3%	80.1%
2009	2.2%	17.4%	1.0%	14.4%	0.59	20.1%	60.9%	101.5%
2008	2.0%	13.1%	1.0%	20.8%	0.53	28.1%	52.4%	100.3%
4Q 2007	0.6%	4.0%	1.0%	14.3%	0.52	7.6%	25.4%	49.1%

AUSTRALIA

The evidence of high-volatile Australian equity premium is supported by illustration of MSCI Australia index behavior: Australian stocks are more volatile than that of other regions. The standard deviation of Australian equity premium is 15% for the whole period and 18% since 2008, while the volatility of Asian equity premium is 10%, of CEEMEA 5-year — 8%, of CEEMEA 10-year — 6%.

The average annual estimations and input parameters for Australia are displayed in Table 2.

The estimations yield the average equity premium for the whole period around 15% for Australia, average market Sharpe Ratio is 85%, average yearly market volatility is 13%. CDS spreads are rather low, compared to other regions, the mean since 2008 is 1.5%, including per-crisis period — 1.1%. Based on CDS spreads estimations of risk-neutral default probabilities vary significantly: from 2.3% before crisis to 17.2% during crisis. Correlations are rather low, approximately 0.44 on average, in contrast to the consideration that during turmoil correlations should increase. In general, Australian stock market shows itself as highly-volatile when sharp rises replace large slumps. The evidence of this is demonstrated in the Appendix 2. The graphical view displays clear inverse relation between stock market performance and estimated equity premium. This relation implies that during downturns investors demand much higher price for increased risk and therefore premiums jump;

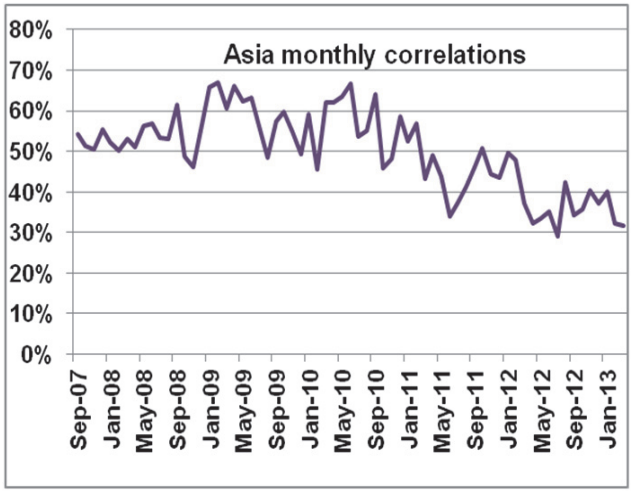

Figure 5. Monthly correlation estimates for Asia excluding Japan.

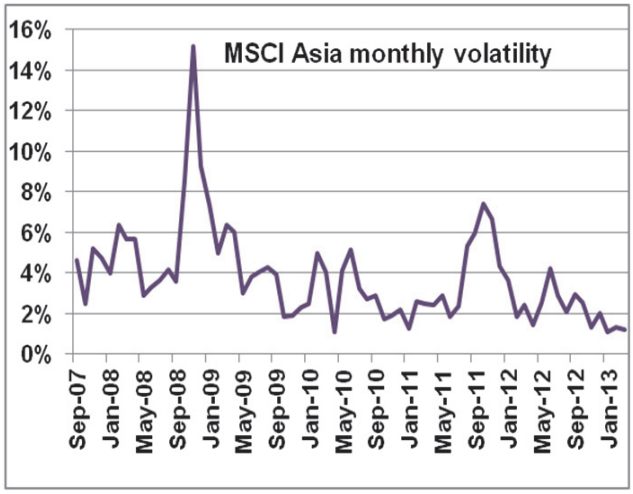

Figure 6. Monthly volatility estimates for MSCI Asia excluding Japan.

when volatility is low and the market demonstrates steady growth — equity premiums are lower.

CEEMEA

Average annual CEEMEA model parameters and estimated values are presented in the Table 3 for two cases: estimations based on 5-year and 10-year default swaps.

Although CDS spreads on average seem to be very similar for both CEEMEA cases, the difference in implied risk-neutral probabilities is significant: they are twice as high for 10-year period (13.6% versus 26%). These estimations may be supported by the evidence that actual default probabilities differ for the same level approximately (4.1% versus 9.7%). Correlations for CEEMEA are 0.33 on average; mean annual market volatility is 11.2%. Five-year CDS-based estimations yield average 12.3% equity premium while 10-year — only 9%. The same effect is reflected in market Sharpe ratio figures: long-term ratios are 25% lower than medium-term ones (93% versus 69%). This leads to conclusion that the term structure of equity premium is downward sloping: long-term assets are considered to be less risky than medium-term. Figure 4 provides insight into variation of term structure of CEEMEA equity premiums estimated using 5-year and 10-year CDS.

10-year CDS index is rather illiquid: the data on trades during May-July 2011 and May-September 2012 is absent. Despite the lack of data the pattern of positive difference between 5-year and 10-year estimated is obvious.

Appendix 3 demonstrates inverse relation between movements of market (MSCI CEEMEA Index) and estimated equity premiums for CEEMEA.

ASIA

Along with Australian, the Asian data allows observing equity premium before, during, and after the crisis. Estimations for Asia and input model parameters are displayed in Table 4. The average CDS spread is 1.4% with its peak 2.2% in 2009. Risk-neutral probabilities of default vary significantly from year to year: from 4% in 2007 to 17.4% in 2009 with mean 10.7%. MSCI Asia excluding Japan Index volatility, or market volatility, follows financial markets behavior increasing in critical stages of economy, e.g. 20.8% in 2008, with mean 12.3%. During the peak of economic turmoil correlation increases to 0.59 while in 2012 it is 0.38 and continues to reduce in 2013.

Equity premiums reach the highest level in 2008–28.1% on average, in contrast to other examined regions with maximums in 2009. Appendix 4 displays inverse relation between movements of market (MSCI Asia excluding Japan Index) and estimated equity premiums.

DISCUSSION

The estimated values constitute the upper limits for equity premiums due to several reasons. First, due to assumption that 100% of CDS spread is attributable to credit risk. Another major issue that impacts results is parameters estimations.

First parameter that needs to be defined is real world default probability. Average cumulative issuer-weighted global default rates by alphanumeric rating for the period 1998–2012 as of Moody's were taken as a proxy for expected default probabilities due to lack of Moody's EDF data. Real world default probabilities are time-varying. The average values are underestimated in the periods of turmoil. As a result the Sharpe ratios and equity premiums are biased upwards, because the difference between risk-neutral probabilities of default, which are time varying, and actual default probabilities is overestimated. The literature on modeling expected real world default probabilities is developing. The time-varying cumulative default probabilities are required for further research in order to obtain more accurate data on Sharpe ratios and equity premiums.

Methods of correlation and market volatility estimation may also affect results due to their high variability from month to month. Historical monthly values of Asian correlations and stock market volatility are demonstrated on Figures 5 and 6 respectively.

Volatility and correlation parameters' estimates have direct crucial influence on equity premium results. More precise and robust calculation approach will lead to more accurate equity premium and Sharpe Ratio outcomes.

The use of constant recovery rates is implied by the default intensity model although recovery rates may vary over time. Current paper uses conservative rates implied in Markit iTraxx CDS indices which yields upper limit for risk-neutral default probability as well as Sharpe ratio and equity premium.

Although due to possible upward bias discussed above, the overall size and behavior of regarded economies equity premium is consistent with market data.

CONCLUSION

This paper estimates expected equity premium for developing markets using the methodology of Berg and Kaserer (2009). The approach is based on the idea that risk premium may be extracted from CDS spread as it consists of expected loss of price and premium for bearing credit risk. Structural model of default within Merton framework is applied to define actual and risk-neutral probabilities. Basically, the only difference between them is the drift: for risk-neutral default probability it is risk-free rate, and for real world default probability it is return. Expressing risk-neutral default probability by the means of actual yields the relation which contains such parameter is asset Sharpe ratio. Then having estimated risk-neutral default probability from CDS spread according to default intensity model and received market default rates, we are able to derive asset Sharpe ratio, convert it into market Sharpe ratio and thus obtain equity premium. As a result, the simple estimator for equity premium is based on risk-neutral and actual default probabilities, the maturity, corresponding stock market volatility, and equity correlations. The major advantage of the model is that it is based only on observable parameters and doesn't require forecasts or calibrations. Either Sharpe ratio estimation dispenses from risk-free rate calculation which is rather arguable concern.

The empirical analysis of most liquid CDS indices spreads for Australia, Asia excluding Japan, and CEEMEA region results in quite homogenous time series of equity premiums with similar properties. Australia has the longest CDS history which allows estimating equity premium from 2005. Before crisis in 2008 average yearly equity premium value is 2.3% per annum, during crisis 2008–2009 premium rise sharply to 37% (reaching 9% for December 2008 or 180% in annual terms), from 2010 by the present it is very volatile, around 15% yearly on average. Other regions' results demonstrate behavior identical to Australian and respond to the same economic and financial events, but are less volatile. Asian CDS index starts from October 2007. It reaches its maximum of 7.3% for month, or 133% annually, in December 2008. Since 2010 the average monthly premium in annual terms per year is approximately 11%. Data of CEEMEA CDS indices for 5-, and 10-year maturities are available since 2010 although the 10-year CDS is rather illiquid (it has no trades for May-September 2012 and May-July 2011). The dynamics is the same for both maturities. On average yearly for 2010–2012 equity premium is 14.5% for 5-year CDS and 10.5% for 10-year CDS. The term structure curve is downward sloping, or inverse, that may indicate that financial turmoil is still in place when short-term risks are higher than long-term.

This paper's contribution is threefold. Firstly, we estimate expected equity premiums for Australia and emerging markets of Asia excluding Japan, and CEEMEA, which to our best knowledge has not been done in the literature yet. Secondly, it estimates equity premiums for each calendar month during the life of CDS index used as a proxy for CDS spread, whereas Berg and Kaserer estimate yearly premiums. As a result we get historical time-variation of equity premium, which allows for its behavior assessing in different economic and financial conditions including pre- and post-crisis 2008. Finally, the paper provides an insight into term structure of equity premium by the example of CEEMEA market.

Empirical observations prove adequacy of estimated results of the study. The following conclusions regarding the equity premium are to be made:

1) Equity premium for Australia and two emerging markets (CEEMEA and Asia) are countercyclical;

2) Term structure of equity premium is inverse — which implies that investors price medium-term risks higher than long-term ones;

3) Term structure varies over time — curve slope changes; negative slope increases when stock market declines.

The numerical results appear to be the upper limit for equity premiums. To evaluate equity premiums more accurately there are several possibilities of approach improvement. The major one is to determine time-varying expected real world default probabilities. In addition, robust estimations of equity correlations and stock market volatility that comply with default probabilities and premiums timing will produce more reliable estimations. Nevertheless, one should bear in mind that "the complexity is often traded off against parsimony for practical reasons of implementation" (Balduzzi, Das, Foresi, and Sundaram 1996, p.43.) Estimated equity premiums dynamics reflects financial markets events and behavior rather well and may be used for trading purposes.

The brief look on relation between stock market movements and equity premium behavior does not lead to agreement upon the concern what affects what. Establishing the relationship between stock market behavior and estimated equity premium in order to understand whether the model may be used for returns prediction may expand practical implementation.

Appendix 1. Monthly asset Sharpe ratio (ASR), market Sharpe ratio (MSR), and equity premium (EP) estimations, denoted as *per annum,* for Australia, Asia excluding Japan, and CEEMEA.

	Australia			Asia excluding Japan			CEEMEA 5Y			CEEMEA 10Y		
Month	**ASR**	**MSR**	**EP**	**ASR**	**MSR**	**EP**	**ASR**	**MSR**	**EP**	**ASR**	**MSR**	**EP**
April-13	40%	110%	6%	44%	138%	6%	25%	104%	4%	18%	78%	3%
March-13	40%	95%	3%	44%	137%	6%	23%	74%	4%	18%	58%	3%
February-13	40%	88%	4%	43%	107%	4%	23%	88%	6%	17%	64%	4%
January-13	42%	105%	10%	44%	118%	9%	21%	83%	9%	17%	67%	7%
December-12	45%	130%	9%	45%	113%	5%	22%	40%	3%	18%	32%	2%
November-12	46%	124%	6%	47%	130%	12%	23%	42%	4%	19%	35%	3%
October-12	47%	130%	14%	48%	141%	15%	28%	61%	7%	23%	49%	5%
September-12	48%	152%	11%	52%	122%	9%	31%	91%	8%			
August-12	51%	131%	15%	54%	188%	21%	32%	94%	10%			
July-12	53%	161%	35%	57%	162%	27%	36%	148%	36%			
June-12	51%	172%	23%	56%	169%	16%	42%	111%	14%			
May-12	47%	116%	7%	53%	165%	9%	36%	94%	10%			
April-12	45%	143%	13%	51%	138%	12%	34%	129%	13%	25%	94%	9%
March-12	46%	135%	11%	53%	112%	7%	35%	88%	9%	25%	64%	6%
February-12	50%	128%	21%	59%	118%	16%	37%	155%	28%	27%	114%	20%
January-12	53%	124%	29%	60%	137%	23%	41%	126%	25%	27%	81%	15%
December-11	53%	122%	35%	60%	136%	36%	39%	140%	40%	27%	100%	27%
November-11	53%	149%	57%	61%	120%	35%	35%	115%	39%	28%	90%	30%
October-11	53%	205%	67%	57%	123%	29%	42%	101%	31%	26%	63%	18%
September-11	47%	126%	30%	50%	121%	25%	32%	56%	13%	24%	41%	9%
August-11	41%	175%	20%	45%	121%	10%	27%	51%	4%	21%	40%	3%
July-11	40%	133%	11%	44%	131%	9%	25%	53%	7%			
June-11	38%	115%	18%	43%	98%	10%	25%	51%	7%			
May-11	38%	87%	16%	42%	86%	7%	24%	56%	4%			
April-11	38%	144%	18%	43%	100%	9%	25%	82%	6%	19%	60%	5%
March-11	38%	68%	6%	43%	76%	7%	27%	73%	6%	19%	52%	4%
February-11	38%	111%	12%	43%	82%	4%	27%	80%	7%	19%	56%	5%
January-11	38%	117%	16%	43%	73%	6%	27%	84%	8%	19%	60%	6%
December-10	38%	117%	9%	42%	88%	6%	30%	78%	6%	19%	49%	4%
November-10	40%	96%	9%	43%	95%	6%	26%	78%	5%	18%	55%	4%
October-10	41%	64%	11%	46%	72%	7%	29%	74%	11%	21%	54%	8%
September-10	42%	78%	17%	47%	85%	8%	31%	89%	17%	22%	63%	11%
August-10	44%	118%	23%	48%	89%	10%	30%	134%	22%	22%	99%	16%
July-10	44%	80%	27%	49%	74%	14%	31%	86%	19%	22%	61%	13%
June-10	38%	84%	21%	46%	73%	11%	28%	111%	23%	21%	84%	17%
May-10	32%	65%	4%	40%	65%	2%	25%	178%	10%	18%	126%	7%
April-10	33%	59%	12%	41%	66%	10%	25%	122%	20%	18%	88%	14%
March-10	36%	76%	20%	45%	99%	18%	30%	119%	20%	23%	90%	15%
February-10	33%	69%	10%	40%	68%	6%	31%	131%	15%	21%	90%	10%
January-10	35%	78%	11%	43%	88%	7%						
December-09	36%	123%	17%	44%	81%	5%						
November-09	37%	141%	11%	43%	72%	5%						
October-09	41%	108%	12%	46%	80%	12%						
September-09	46%	99%	22%	49%	100%	16%						
August-09	52%	75%	17%	54%	96%	14%						
July-09	52%	96%	12%	56%	89%	12%						
June-09	59%	138%	21%	60%	97%	11%						
May-09	68%	169%	57%	71%	108%	25%						
April-09	74%	162%	49%	79%	131%	33%						
March-09	69%	179%	53%	78%	116%	22%						
February-09	67%	166%	53%	72%	109%	32%						

	Australia			Asia excluding Japan			CEEMEA 5Y			CEEMEA 10Y		
Month	**ASR**	**MSR**	**EP**	**ASR**	**MSR**	**EP**	**ASR**	**MSR**	**EP**	**ASR**	**MSR**	**EP**
January-09	72%	231%	153%	78%	138%	54%						
December-08	63%	166%	180%	77%	167%	133%						
November-08	61%	142%	81%	77%	158%	58%						
October-08	49%	121%	18%	55%	90%	12%						
September-08	46%	131%	13%	51%	95%	15%						
August-08	46%	95%	8%	51%	96%	13%						
July-08	40%	79%	14%	48%	84%	10%						
June-08	35%	64%	6%	41%	73%	8%						
May-08	41%	100%	21%	47%	92%	20%						
April-08	50%	114%	21%	57%	108%	23%						
March-08	42%	136%	31%	51%	101%	25%						
February-08	35%	93%	13%	43%	81%	12%						
January-08	26%	46%	7%	33%	59%	10%						
December-07	22%	36%	6%	34%	67%	13%						
November-07	14%	23%	3%	21%	41%	4%						
October-07	17%	32%	9%	21%	39%	7%						
September-07	18%	33%	8%									
August-07	13%	30%	2%									
July-07	9%	17%	1%									
June-07	10%	20%	1%									
May-07	12%	27%	3%									
April-07	12%	27%	3%									
March-07	12%	22%	2%									
February-07	13%	23%	1%									
January-07	12%	24%	1%									
December-06	8%	16%	1%									
November-06	11%	18%	2%									
October-06	12%	18%	1%									
September-06	11%	16%	1%									
August-06	11%	16%	2%									
July-06	11%	16%	2%									
June-06	10%	16%	2%									
May-06	11%	19%	2%									
April-06	10%	25%	1%									
March-06	9%	23%	2%									
February-06	10%	24%	1%									
January-06	9%	18%	1%									
December-05	11%	20%	2%									
November-05	11%	19%	2%									
October-05	11%	26%	2%									
September-05	11%	31%	3%									
August-05	12%	41%	4%									
July-05	14%	38%	3%									
June-05	13%	44%	3%									
May-05	11%	27%	3%									
April-05	8%	29%	2%									
March-05	8%	19%	1%									
February-05	8%	17%	1%									

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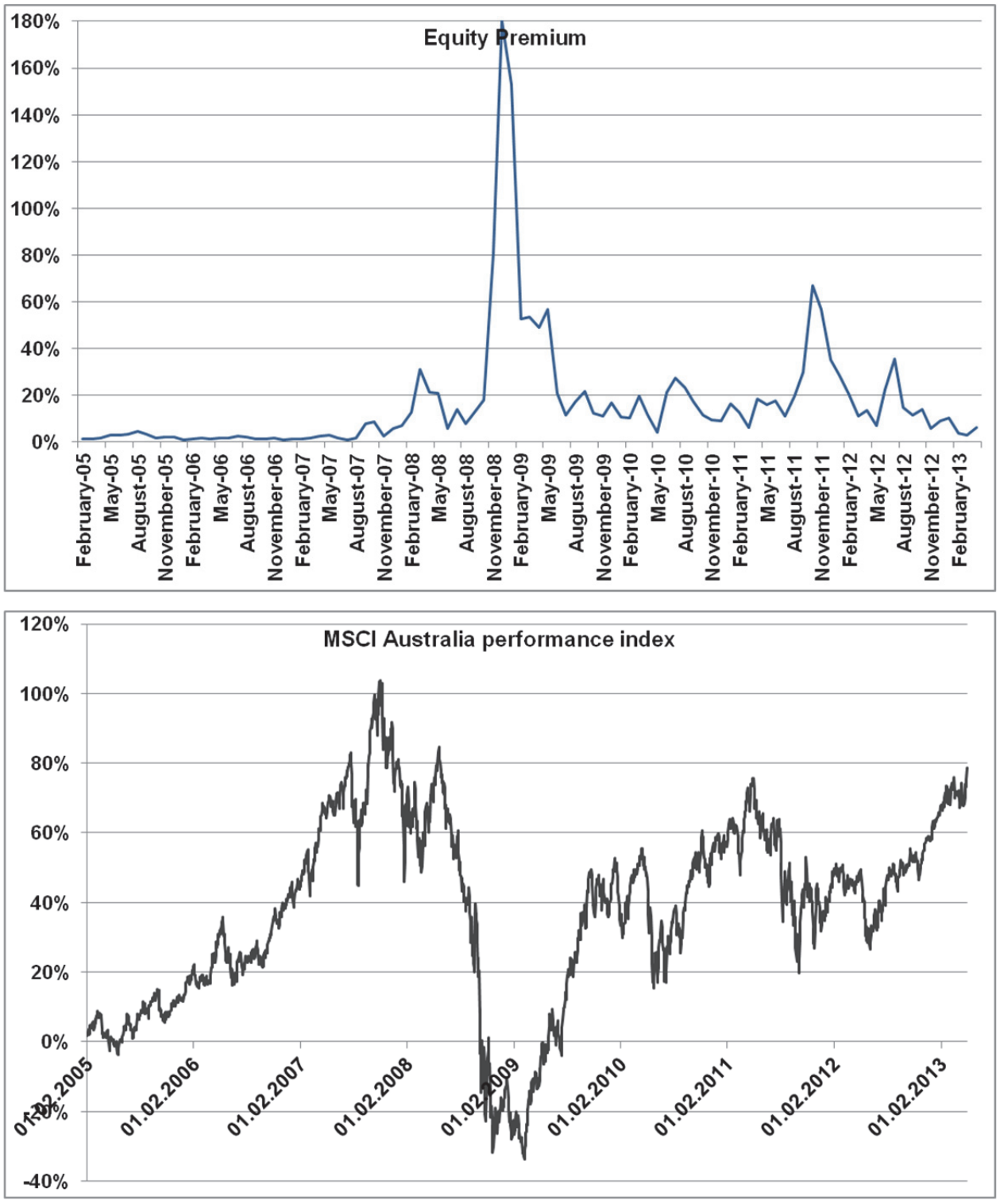
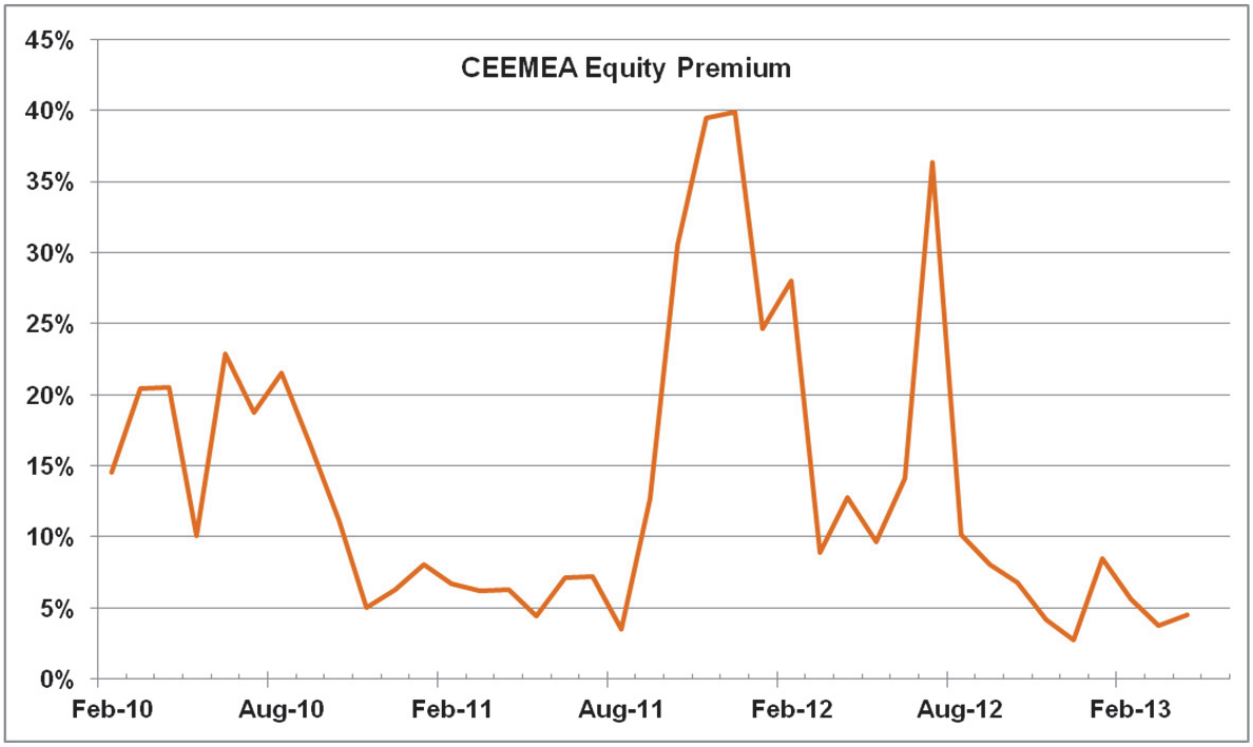
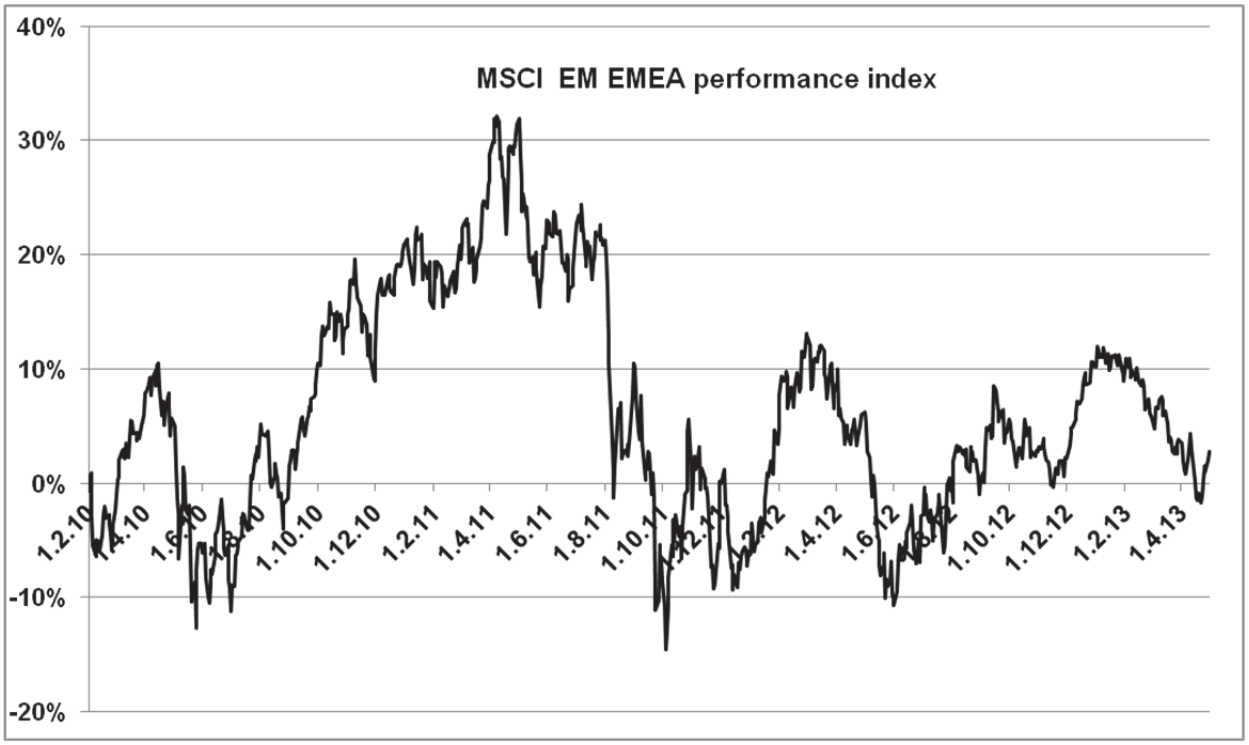
Appendix 2. Estimated equity premium and stock market performance for Australia. Equity premiums are monthly data on a yearly basis. MSCI Australia index performance means indexed daily MSCI values with 03.01.2005=100 in percent.

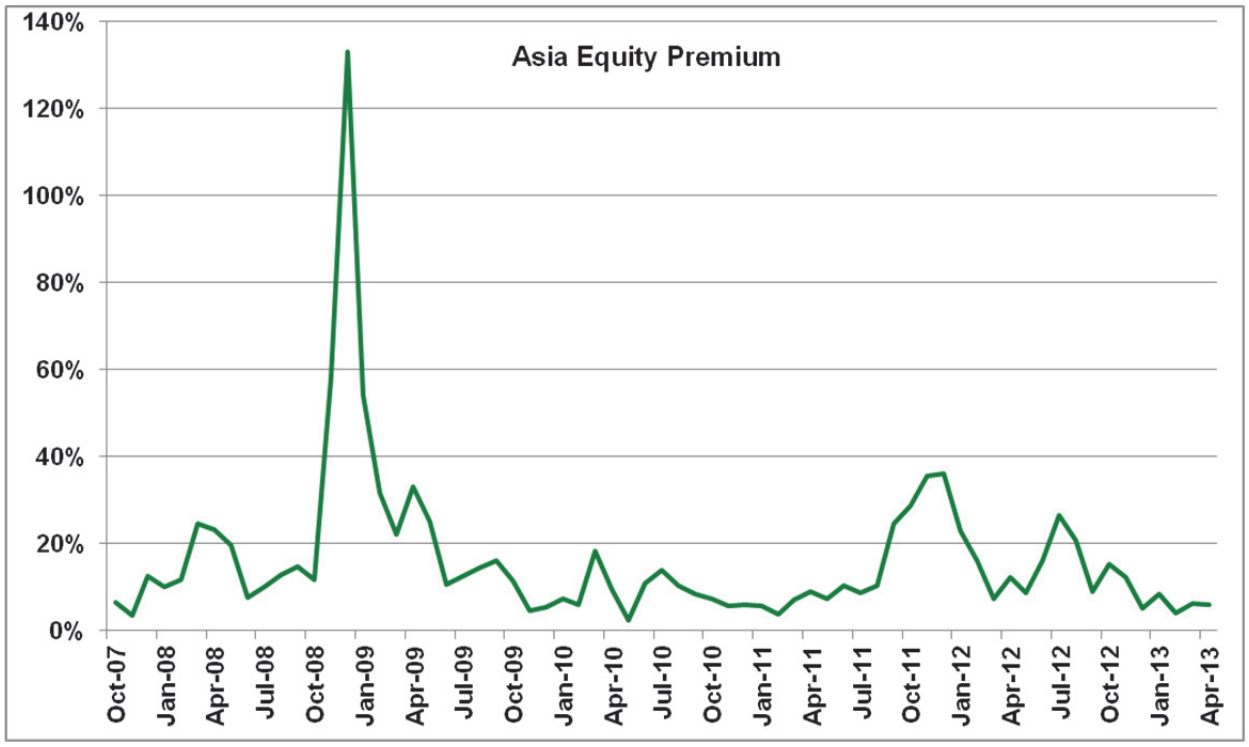


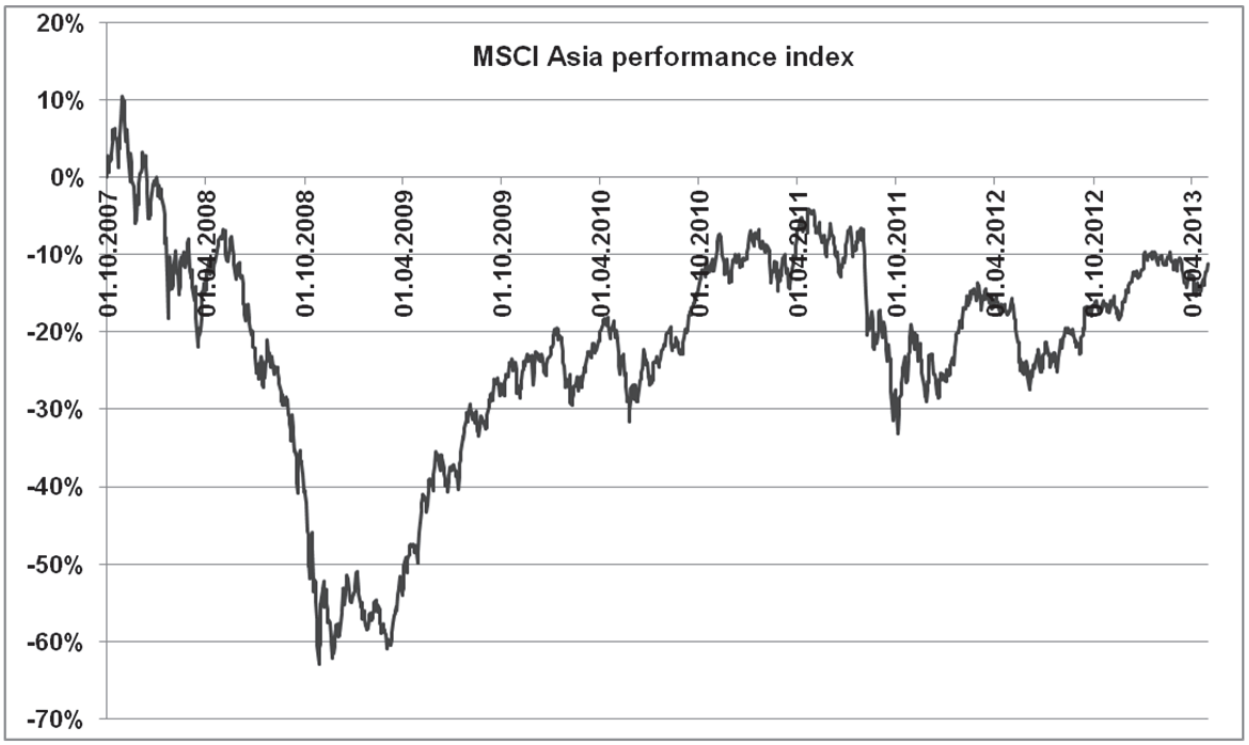
Appendix 3. Estimated equity premium (5-year CDS-based) and stock market performance for CEEMEA. Equity premiums are monthly data on a yearly basis. MSCI EM EMEA index performance means indexed daily MSCI values with 01.01.2010=100 in percent.





Appendix 4. Estimated equity premium and stock market performance for Asia excluding Japan. Equity premiums are monthly data on a yearly basis. MSCI Asia excluding Japan index performance means indexed daily MSCI values with 01.10.2007=100 in percent.





Do Workers' Remittances Induce Inflation? The Case of Vietnam, 1996–2012*

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Abstract. This paper seeks to examine the impact of remittances on inflation in Vietnam during 1996-2012. Using the vector autoregressive model (VAR), we show that remittance causes inflation indirectly through increasing money supply. We provide empirical evidence indicating that remittance inflows could have a significant impact on money supply with a one-lag quarter due to the failure of the State Bank of Vietnam in neutralizing the intervention effects on monetary base during this period. Secondly, money supply is found to accelerate inflation with a two-quarter lag in Vietnam. The paper, therefore, suggests a transmission mechanism of remittance to inflation in the context of a fixed exchange rate regime.

Аннотация. В статье анализируется влияние международных денежных переводов (ремиссий) на инфляцию во Вьетнаме в период 1996–2012 гг. С использованием вектора авторегрессии (VAR) авторы показывают, что ремиссии косвенно приводят к инфляции за счет увеличения денежной массы. Приведены эмпирические сведения о том, что приток ремиссий может оказать существенное влияние на денежную массу с задержкой на один квартал из-за провала Государственного банка Вьетнама в нейтрализации воздействия вмешательств на денежную базу в течение этого периода. Кроме этого, во Вьетнаме денежная масса, в свою очередь, оказывает влияние на инфляцию с задержкой на два квартала. Таким образом, в статье предложен механизм передачи от ремиссий к инфляции в контексте режима фиксированного обменного курса.

Key words: worker's remittance, inflation, fixed exchange rate regime, money supply, Vietnam.

1. INTRODUCTION

The paper aims to examine the effects of remittances on inflation in Vietnam during 1996–2012 by using the vector autoregressive model (VAR). In recent years, worker's remittance inflows into Vietnam have increased significantly and seemed to surpass other capital inflows such as foreign direct investment and foreign portfolio investment (Appendix Figure 1). They are expected to have positive effects on the economy such as economic growth, higher living standard, poverty reduction and hunger eradication. However, they seem to result in negative issues including high inflation pressure.

Our paper contributes in literature review in some new ways: firstly, the paper suggests transmission mechanism of worker's remittance in the fixed exchange rate regime that is implemented by most developing countries like Vietnam. Secondly, unlike previous studies focusing on microeconomic impact of remittance, this is the first research to examine effects of remittance on inflation in Vietnam, specifically large remittances flows leading to a high inflation. It, therefore, suggests policy recommendations to attract more remittance while reducing its negative impacts on the economy. Moreover, the estimated results were found to be appropriate for forecasting inflation in Vietnam in short-term.

There are three major findings. Firstly, remittance inflows could have a significant impact on money supply with a lag of one quarter due to the failure of the State Bank of Vietnam in neutralizing the intervention effects on monetary base during this period. Secondly, money supply is found to accelerate inflation with a two-quarter lag in Vietnam during 1996–2012. The paper, therefore, suggests a transmission

* Стимулируют ли инфляцию денежные переводы граждан, работающих за границей? (на примере Вьетнама 1996–2012 гг.).

mechanism of remittance to inflation in the context of a fixed exchange rate regime (e.g. remittances lead to a high level of money supply after one quarter, then it results in high inflation rate with a lag of two quarters). The paper also reveals empirical evidence that inflation expectations or inflationary mentality can be considered as an important explanation of inflation in Vietnam.

These findings contribute to literature on remittance's impacts on inflation under the pegged exchange rate regime. Moreover, it presents important policy implications for the authorities of developing countries who wish to attract more worker's remittance inflows like Vietnam. Accordingly, it is important that the country should shift its exchange rate regime from a fixed to a floating to lessen negative effects of remittance upon inflation.

The rest of paper is structured as follows: section 2 discusses literature review on impacts of worker's remittance on inflation. Section 3 presents the theoretical framework employed to estimate impacts of worker's remittance on inflation. Section 4 analyses determinants of inflation in Vietnam, focusing on remittance as an important factor causing inflation during 1996–2012. Section 5 presents a summary and conclusion. Finally, the Appendix provides summary statistics on the variables used in the empirical study, and presents the developments of capital flows including remittance in Vietnam during 1996–2012.

2. LITERATURE REVIEW

Remittance is one of capital flows that play very important role in economic development, especially for developing countries. From a microeconomic perspective, previous studies found empirical evidence that remittance inflows promote economic development by providing funds that recipients can spend on education, health care, business investment (Adams Jr., 2006; Yang and Martinez, 2006; McKenzie, 2006, Bracking and Sachikonye, 2006; Attzs, 2008). Regarding macroeconomic aspect, it can boost aggregate demand and thereby GDP as well as spur economic growth. Remittance, however, may also cause negative impacts such as high inflation, income inequality, and other social issues.

The impacts of remittances on inflation in the host country can be analyzed from three different aspects including domestic currency appreciation, large money supply, and balance of payments (Narayan *et al.,* 2011). The first could be explained based on the Salter (1959), Swan (1960), Corden (1960) and Dornbusch (1974) paradigm. This model could be considered as the theoretical underpinning to test empirically the incidence of capital inflows (e.g. FDI, remittances) on the real effective exchange rate (REER) as well as the price level in emerging economies. In other words, remittances flows will have spending effects, resulting in high domestic prices and domestic currency appreciation.

Another way to explain the relationship between remittances and inflation is using a micro-founded dynamic stochastic general equilibrium model suggested by Acosta *et al.* (2007). They argued that large remittance flows would lead to an increase in the household income, and then a decrease in the labor supply (people receiving remittances do not want to find a job). A lower labor supply will result in higher wage, contributing higher production costs. Both the real exchange rate and the ratio of tradable to nontradable output induce high spending and resource movement, and lead to an increase in inflation.

More importantly, impacts of an increase in remittances on inflation and nominal money supply will depend on the country's exchange rate regime. Reinhart and Rogoff (2004) argued that under a fixed exchange rate regime, the remittances temporarily increase the rate of inflation and the nominal money supply by moving resources from the tradable to nontradable sector. This result is consistent with findings of Amuedo-Dorantes and Pozo (2004), Bourdet and Falck (2006), Caceres and Saca (2006), Lopez *et al*. (2007), and Ball *et al*. (2009). In contrast, under a flexible regime, the remittances temporarily decrease the rate of inflation but do not have any impact on the nominal money supply (Ball *et al.*, 2009).

The different impacts of remittances on inflation under different exchange rate regimes can also be explained from the point of view of the balance of payments and international reserves accumulation, as follows. An increase in remittances leads to a rise in supply of foreign currency so that the domestic currency revaluates. If country follows a fixed exchange rate regime, the central bank should intervene by buying foreign currency in the foreign exchange market. Failure of central banks to sterilize fully the increase in international reserves will lead to an increase in the monetary base (Bugamelli and Paterno, 2009). Under the floating exchange rate regimes, central banks do not intervene so that monetary base and inflation may not be affected.

The remittances into Vietnam have increased manifold in recent years and are expected to have multitude of effects in the economy. It, therefore, is a very interesting topic that has drawn attention of policy makers as well as researchers. Studies on remittances into Vietnam focused mainly on their impacts on the economy such as remittances and house-

hold income (Pfau and Long, 2006; Nguyen Duc Thanh, 2007); remittances and economic growth (Khaled Sakr, 2006; Do Thi Duc Minh, 2007; Nguyen Minh Thao, 2009). This paper, therefore, could be the first research on impacts of remittances on inflation in Vietnam. Our findings will contribute to literature on empirical as well as suggest policy recommendations for Vietnam to reduce negative effects of remittances on the economy.

3. THEORETICAL FRAMEWORK

The impact of remittances on inflation in the country can use macroeconometric models for policy analysis. Before the 1980s, simultaneous equation system was used widely in forecasting and analyzing macroeconomic variables. The macroeconometric models had been criticized by Lucas, since the assumptions of invariant behavioral equations were shown to be inconsistent with dynamic maximizing behavior (Lucas, 1976)

Sims (1980) changes the focus of the society of econometricians. He argued that all macroeconomic variables are endogenous in essence — they are interrelated. Money supply, for example, is controlled by the Central Bank, but money-related decisions made by the Bank are based on the state of the economy, which consists of other macroeconomic variables including inflation, unemployment and so on. Therefore, he proposed a symmetric model in which all variables play an equal role, and all are endogenous — the vector autoregressive model (VAR). The VAR models may not satisfy Lucas's criteria for policy intervention but are useful to find the impact of remittances on inflation.

In general, the unrestricted VARs are on reduced form, and are therefore uninterruptible without "reference" to theoretical economic structures. Suppose that Y_t is a (nx1) vector of macroeconomic variable whose dynamic behavior is governed by a finite structural model.

$$B_0 Y_t = \gamma + B_1 Y_{t-1} + B_2 Y_{t-2} + \ldots + B_p Y_{t-p} + u_t \quad (1)$$

where γ is a constant, B_i is a (nxn) matrix of coefficient, and u_t is a (nx1) vector of white noise structural disturbances, with covariance matrix Σ. A reduced form of Y_t can be written as:

$$Y_t = \delta + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \ldots + \alpha_p Y_{t-p} + e_t \quad (2a)$$

or

$$\alpha(L) Z_t = \delta + e_t \quad (2b)$$

where $\delta = B_0^{-1}\gamma$, $\alpha_i = B_0^{-1} B_i$, and $e_t = B_0^{-1} u_t$ is white noise process, with nonsingular covariance matrix Ω. $\alpha(L) = I - \alpha_1 L - \alpha_2 L^2 \ldots \alpha_p L^p$. From the reduced form to the structural model, a set of identifying restrictions must be imposed. It is common to assume that the covariance matrix for u_t (Σ) is diagonal, while B_0 has unity on its main diagonal but elsewhere is unrestricted. This implies that each number of Y_t is assigned its own structural equation, which ensures that the shocks can be given an economic interpretation.

The α_is and Ω can be estimated by applying OLS to the reduced form (2). However, if the B_is are unrestricted, we cannot estimate B_0 as the α_is contain pn^2 known elements and there are $(p+1)\, n^2$ unknown elements in the B_is. Instead one solves for B_0 from:

$$\Omega = \mathrm{cov}(e_t) = \mathrm{cov}(B_o^{-1} u_t) = B_o^{-1} \sum (B_o^{-1})' \quad (3)$$

There are n (n+1) /2 distinct covariances in Ω. The assumption is that Σ is diagonal and contains n elements. It means that n (n-1) /2 restrictions should be needed to identify the system.

Assuming Y_t is a covariance stationary vector, (2b) can be written as:

$$Y_t = \phi(L)\, e_t \quad (4)$$

where $\phi(L) = \alpha(L)^{-1}$ and $\phi_0 = I$. (4) is not identified. To identify the system, we choose any nonsingular matrix P, such that the positive definite symmetric matrix $\Omega = PP'$. Rewriting (4) gives:

$$Y_t = \sum_{i=0}^{\infty} \phi_i P P^{-1} e_{t-i} = \sum_{i=0}^{\infty} C_i \varepsilon_{t-i} \quad (5)$$

where $C_i = \phi_i P$ and $\varepsilon_t = P^{-1} e_t$.

Table 1. ADF Unit root test for three variables in VAR model.

Variables	Critical values			ADF statistics	Decision
	1%	5%	10%		
gCPI	-3.5600	-2.9176	-2.5966	−2.9834**	Reject Ho
gM2	-3.5420	-2.9100	-2.5926	-6.1084***	Reject Ho
gRE	-3.5440	-2.9108	-2.5930	-7.7660***	Reject Ho

Note: ***, **, * indicates that the statistic is significant at the 1 percent, 5 and 10 percent level of significance respectively.

Table 2. VAR lag order selection criteria.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	208.2835	NA	2.14e-07	-6.842784	**−6.738067***	-6.801823
1	224.2560	29.81536	1.70e-07	-7.075201	-6.656332	-6.911358
2	239.3123	26.59941	1.39e-07	-7.277077	-6.544056	**−6.990352***
3	242.2111	4.831290	1.72e-07	-7.073703	-6.026530	-6.664096
4	257.8514	**24.50311***	**1.39e-07***	**−7.295045***	-5.933721	-6.762557
5	263.4774	8.251566	1.59e-07	-7.182581	-5.507105	-6.527210

Table 3. Stability test.

Root	Modulus
0.637734−0.561589i	0.849757
0.637734 + 0.561589i	0.849757
0.084072−0.779227i	0.783749
0.084072 + 0.779227i	0.783749
0.742837	0.742837
−0.312148−0.584861i	0.662947
−0.312148 + 0.584861i	0.662947
−0.446118−0.365315i	0.576608
−0.446118 + 0.365315i	0.576608
−0.485741	0.485741
0.226392−0.423565i	0.480272
0.226392 + 0.423565i	0.480272
No root lies outside the unit circle.	
VAR satisfies the stability condition.	

One of applied VAR model is to establish the impulse response function. In terms of notation above, the matrix C contains the effect of a unit increase each of the variable's innovations at time t on all variable in Y at time t+s: $C_s = \frac{\partial Y_{t+s}}{\partial \varepsilon_t^{'}}$

The VAR model specified here focuses on three variables: inflation (CPI), money supply and worker's remittances. These variables are minimum of variables that are necessary to identify the structural disturbances.

We define Y_t as a vector of stationary macroeconomic variables $Y_t = (gcpi_t, gm2_t, gre_t)$ where $gcpi_t$, is the CPI growth rate, gm2 is the growth rate of money supply and gre_t is the growth rate of worker's remittances (RE). A reduced form of Y_t can be modeled as:

$$gcpi_t = \alpha_1 + \sum_{j=1}^{p} \beta_{1j}^{1} gcpi_{t-j} + \sum_{j=1}^{p} \beta_{1j}^{2} gm2_{t-j} + \sum_{j=1}^{p} \beta_{1j}^{3} gre_{t-j} + e_{1t}$$

$$gm2_t = \alpha_2 + \sum_{j=1}^{p} \beta_{2j}^{1} gcpi_{t-j} + \sum_{j=1}^{p} \beta_{2j}^{2} gm2_{t-j} + \sum_{j=1}^{p} \beta_{2j}^{3} gre_{t-j} + e_{2t}$$

$$gre_t = \alpha_3 + \sum_{j=1}^{p} \beta_{3j}^{1} gcpi_{t-j} + \sum_{j=1}^{p} \beta_{3j}^{2} gm2_{t-j} + \sum_{j=1}^{p} \beta_{3j}^{3} gre_{t-j} + e_{3t}$$

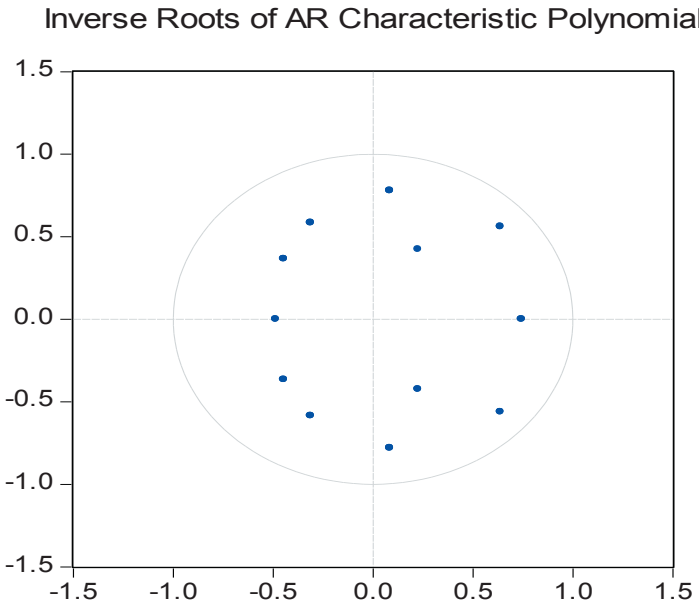

Figure 1. Stability test — Inverse roots of AR characteristics polynomial.

To go from the reduced form to the structural model, a set of identifying restrictions must be imposed. As all variables defined in Y_t are stationary, Y_t is a covariance stationary vector process.

4. ASSESSING IMPACTS OF REMITTANCE ON INFLATION IN VIETNAM DURING 1996–2012

4.1. DATA DESCRIPTION

In order to analyse impacts of remittance on inflation, we use vector autoregressive (VAR) model suggested in Ball *et al.* (2009) for three variables[1]. They are CPI (Consumer Price Index), M2 (Money supply), and RE (worker's remittances). The main sources of data come from the General Statistics Office (GSO) and International Financial Statistics (IMF) for period of 1996Q1–2012Q3. Data are collected on quarterly basis and seasonally adjusted by census X12. They are taken in the form of growth. Statistics for variables is summarized in Appendix table 1.

4.2. SELECTING AN APPROPRIATE MODEL

4.2.1. Unit root tests

In order to examine impacts of remittances on inflation in Vietnam by employing VAR model, we should do ADF unit root test. As shown in Table 1, all variables are taken in the form of growth, and are found to be stationary at 5 percent level of significance. They are I (0).

4.2.2. Selecting lag length of model

Lag length of the model is 4 periods, which is selected based on five criteria including LR, FPE (Final prediction error), AIC (Akaike information criterion), SC (Schwarz information criterion), HQ (Hannan-Quinn information criterion) (Table 2).

4.2.3. Diagnosis tests

In order to check the appropriateness of the estimated VAR model, we estimate AR roots or inverse roots of the characteristic AR polynomial. Table 3 and Fugure 1 show that the estimated VAR is stable because all roots have modulus less than one and lie inside the unit circle.

Moreover, we did the Portmanteau Tests for autocorrelations. Portmanteau Test computes the multivariate Box-Pierce/Ljung-Box Q-statistics for residual serial correlation up to the specified order (Table 4). We found that with different lags, p-values of Q-statistics are greater than 5 percent. We accept the null hypothesis of no serial correlation up to lag 5.

In order to test for a range of specifications of heteroscedasticity in the residuals of VAR equation, we employ White Test. Results of White's Heteroscedasticity Test argued that we accepted null hypothesis of homoscedasticity at one percent level of significance (Table 5).

[1] Unlike model suggested by Ball *et al.* (2009), exchange rate is eliminated from our model because Vietnam followed the fixed exchange rate regime during the period (Takagi and Pham, 2011). Moreover, exchange rate channel was not effective in the transmission mechanism of monetary policy in the case of Vietnam (Pham, 2013).

Table 4. VAR residual serial correlation LM tests.

VAR Residual Serial Correlation LM Tests		
Null Hypothesis: no serial correlation at lag order h		
Date: 03/22/13 Time: 17:28		
Sample: 1996Q2 2011Q3		
Included observations: 58		
Lags	LM-Stat	Prob
1	9.319912	0.4083
2	4.263225	0.8932
3	10.86021	0.2854
4	16.62412	0.0549
5	5.323031	0.8053

Table 5. VAR residual heteroscedasticity tests.

VAR Residual Heteroscedasticity Tests: No Cross Terms (only levels and squares)		
Joint test:		
Chi-sq	Df	Prob.
147.1166	160	0.7590

4.3. ESTIMATING THE MODEL

The above residual tests showed that VAR model for three variables (gcpi, gm2, and gre) are good for estimating impacts of worker's remittance on inflation as well as forecasting inflation rate in short-term. After carrying out lag exclusion tests for each lag in the VAR model, we obtained the appropriate system of equations as follows:

$$\underset{se}{gcpi(t)} = \underset{(0.135)}{0.853}gcpi_{t-1} - \underset{(0.05)}{0.02}gm2_{t-1} - \underset{(0.136)}{0.425}gcpi_{t-2} + \underset{(0.041)}{0.071}gm2_{t-2} - \underset{(0.108)}{0.116}gcpi_{t-4}$$

$$\underset{se}{gm2(t)} = 0.029 - \underset{(0.224)}{0.715}gcpi_{t-1} + \underset{(0.013)}{0.023}gre_{t-1} + \underset{(\mathbf{0}..285)}{0.774}gcpi_{t-3} - \underset{(0.301)}{0.442}gcpi_{t-4} + \underset{(0.095)}{0.232}gm_{t-4} \quad (5)$$

$$\underset{se}{gre(t)} = -\underset{(1.75)}{2.099}gcpi_{t-1} - \underset{(0.114)}{0.246}gre_{t-1} - \underset{(0.65)}{0.936}gm2_{t-2} - \underset{(0.118)}{0.276}gr\,e_{t-2} + \underset{(0.629)}{3.018}gm2_{t-4}$$

Based on system of equations (5) derived from the VAR model of estimating impacts of worker's remittance in Vietnam for period 1996–2012, there are some main findings as follows:

First, one percent increase in worker remittances leads to 0.023 percent significant increase in money supply (M2) after one quarter in the case of Vietnam during 1996–2012. Moreover, the impulse response function derived from the VAR model provides similar finding (Appendix Figure 3). This finding is consistent with those of Amuedo-Dorantes and Pozo (2004), Bourdet and Falck (2006), Lopez, Molina and Bussolo (2007), Ball *et al*. (2009).

In case of Vietnam, this phenomenon could be a result the failure of the State Bank of Vietnam to neutralize the intervention effects on monetary base during this period. For example, after joining the WTO in 2007, Vietnam experienced appreciation pressure amid buoyant capital inflows (e.g. foreign direct investments, foreign portfolio investment, and remittances) (Appendix, Figure 1). The SBV intervened in the inter-bank market to buy more than estimated US$9 billion during 2007 to ease appreciation pressure on the Vietnamese dong[2], with the result that the balance of foreign exchange reserves reached a record US$23.5 billion at the end of the year. At the same time, it attempted to sterilize the impact of intervention by selling Treasury bonds, and by increasing reserve requirements on dong deposits (from 5 to 10, and further to 11 percent) as well as on foreign currency deposits (from 8 to 10, and further to 11 percent). In March 2008, the central bank also sold 20300 billion dong in one-year "compulsory" Treasury bills (i.e., government bills commercial banks are "required" to purchase)[3] to 41 commercial banks at the coupon rate of 7.8 percent. Despite these efforts, money

[2] The Vietnam's *de facto* exchange rate regime was fixed or pegged during 1990–2010 according to the IMF report and Takagi and Pham (2011).
[3] 41 commercial banks are required to purchase these bills at a coupon rate below the prevailing market rate.

Table 6. Forecast inflation in Vietnam, 2011Q4–2012Q2.

gCPI				
Time	forecast	lower CI	upper CI	+/-
2011 Q4	−0.0164	−0.0493	0.0166	0.0329
2012 Q1	−0.0191	−0.0620	0.0237	0.0429
2012 Q2	−0.0156	−0.0595	0.0283	0.0439
gM2				
Time	forecast	lower CI	upperCI	+/-
2011 Q4	0.0562	−0.0125	0.1250	0.0688
2012 Q1	0.0573	−0.0145	0.1291	0.0718
2012 Q2	0.0535	−0.0205	0.1274	0.0740
gre				
Time	forecast	lower CI	upper CI	+/-
2011 Q4	0.1354	−0.4462	0.7170	0.5816
2012 Q1	−0.2943	−0.9002	0.3117	0.6060
2012 Q2	0.0949	−0.5303	0.7202	0.6252

Table 7. Real and forecast inflation in Vietnam.

	CPI (Real)	**CPI (Forecast)**	**Error**	**Error square**
2011 Q4	116.44	120.412312	0.039723	0.001577926
2012 Q1	114.15	118.1124368	0.039624	0.001570091
	Square root of sum of error square			0.0561

supply (M2) increased by 47.2 percent compared with 2006 (Takagi and Pham, 2011).

Secondly, equations (5) reveal empirical evidence that money supply has significant impact on inflation in Vietnam with a lag of two quarters. For example, one percent increase in money supply will result in 0.071 percent significant increase in inflation after two periods. In other words, an increase in money supply leads to a high inflation rate in spite of lagged influences. This finding is consistent with conventional monetary theory as well as findings of Chu Khanh Lan (2012), To Ngoc Hung (2012).

Thirdly, worker's remittance had indirect effect on inflation rate via money supply in the case of Vietnam. According to equation system (5), remittance has directly positive impact on money supply with lag of one period, and then money supply will lead to inflation in Vietnam after two quarters. It, therefore, could be considered as the transmission mechanism of worker's remittance to inflation in Vietnam for period of 1996–2012. The transmission resulted from the fact that Vietnam followed the fixed exchange rate regime in order to stabilize macroeconomic environment.

Fourthly, this VAR model also provides empirical evidence that inflation expectations can be considered as important explanation of inflation in Vietnam in the sense that one percent increase in inflation rate at time t will lead to an increase of 0.853% in inflation at time (t+1). This finding is consistent with those of Nguyen Thi Kim Thanh (2008), Chu Khanh Lan (2012), To Ngoc Hung (2012). The finding seems to reflect inflationary mentality in Vietnam during this period. The term "inflationary mentality" could be explained as follows. There is a fact that if inflation increased significantly, residents expected commodity prices to continue to increase in future. Therefore, suppliers tend to quote a new price for their commodities higher than usual. This phenomenon could result from an unsound monetary policy and depreciation of the Vietnamese dong during 1996–2012.

4.4. FORECASTING INFLATION RATE IN VIETNAM

One of advantages of the VAR model is that it could be employed to analyze and forecast macroeconomic variables. The above diagnosis checking tests argued that the estimated model is a good one. It, therefore, could be used to forecast inflation rate in Vietnam in short-term.

In order to forecast inflation in Vietnam, we employ system of equations (5) to estimate inflation for period 2011Q4–2012Q2 (Table 6). Then, we

take gaps (errors) between real CPI and forecast CPI at the same time. As we can see in Table 7, errors are not greater than 4 percent, and square root of sum of error square is 5.61 percent. Therefore, the model for examination of impacts of remittance on inflation could be good for forecasting inflation in short-term.

5. CONCLUDING REMARKS

The paper examines the effects of worker's remittance inflows on inflation in Vietnam during 1996–2012. There are three major findings. Firstly, remittance inflows could have a significant impact on money supply with a lag of one quarter due to the failure of the State Bank of Vietnam in neutralizing the intervention effects on monetary base during this period. Secondly, money supply is found to accelerate inflation with two-quarter lag in Vietnam during 1996–2010. The paper, therefore, suggests a transmission mechanism of remittance to inflation in the context of a fixed exchange rate regime (specifically, remittances lead to a high level of money supply, resulting in high inflation rate).

These findings contribute to literature on remittance's impacts on inflation under the pegged regime. Moreover, they present important policy implications for the authorities of developing countries who wish to attract more remittance like Vietnam. Accordingly, it is important that the country should shift its exchange rate regime from a fixed to a floating to lessen negative effects of remittance upon inflation.

Another important finding is that inflation expectations can be considered as important explanation of inflation in Vietnam in the sense that an increase in inflation rate at time t will lead to an increase of inflation at time (t+1). This finding reflects inflationary mentality in Vietnam during this period. It suggests policy implications for monetary authorities of developing countries, which suffer high inflation like Vietnam. Accordingly, the monetary authorities should eliminate inflationary mentality by following a sound monetary policy in order to enhance residents' belief in value of domestic currency.

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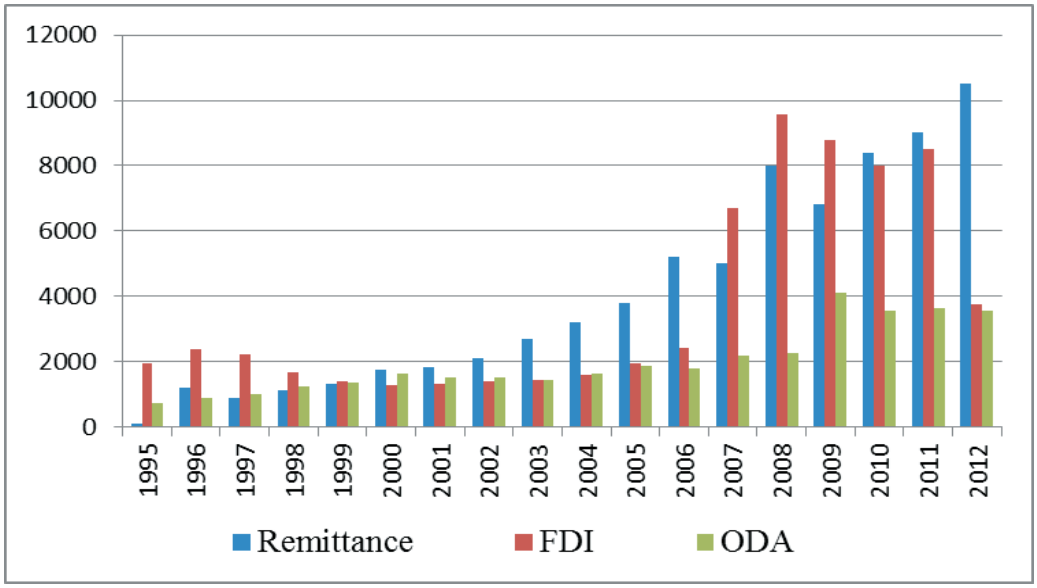
Appendix

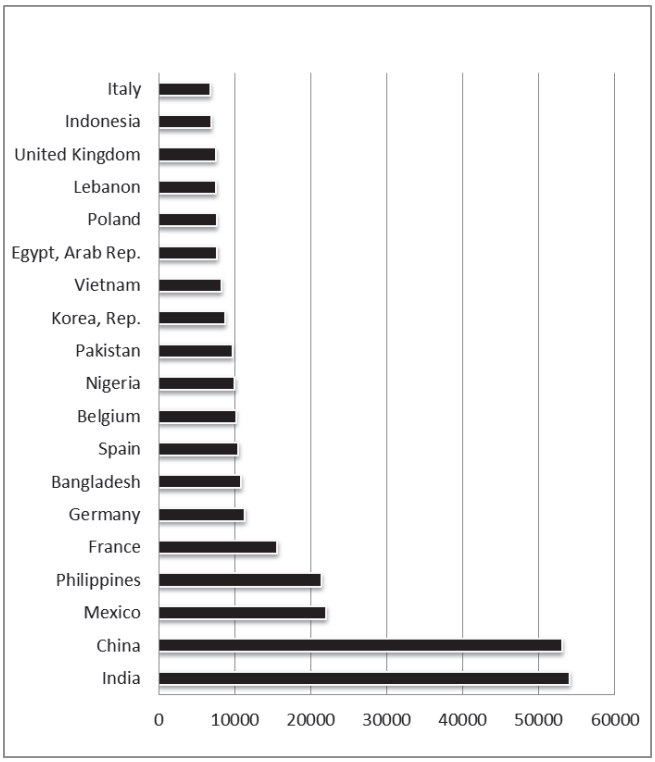
Appendix Table 1. Summary Statistics for Three Variables in the VAR Model.

	GCPI	GM2	GER
Mean	–4.20E-05	0.067701	0.009872
Median	–0.00096	0.059912	0.00241
Maximum	0.062065	0.355664	0.093545
Minimum	–0.07207	–)0.00366	–0.00956
Std. Dev.	0.027214	0.048191	0.019001
Skewness	–0.39852	3.313459	2.516102
Kurtosis	4.049143	20.41046	9.255461
Observations	66	66	66



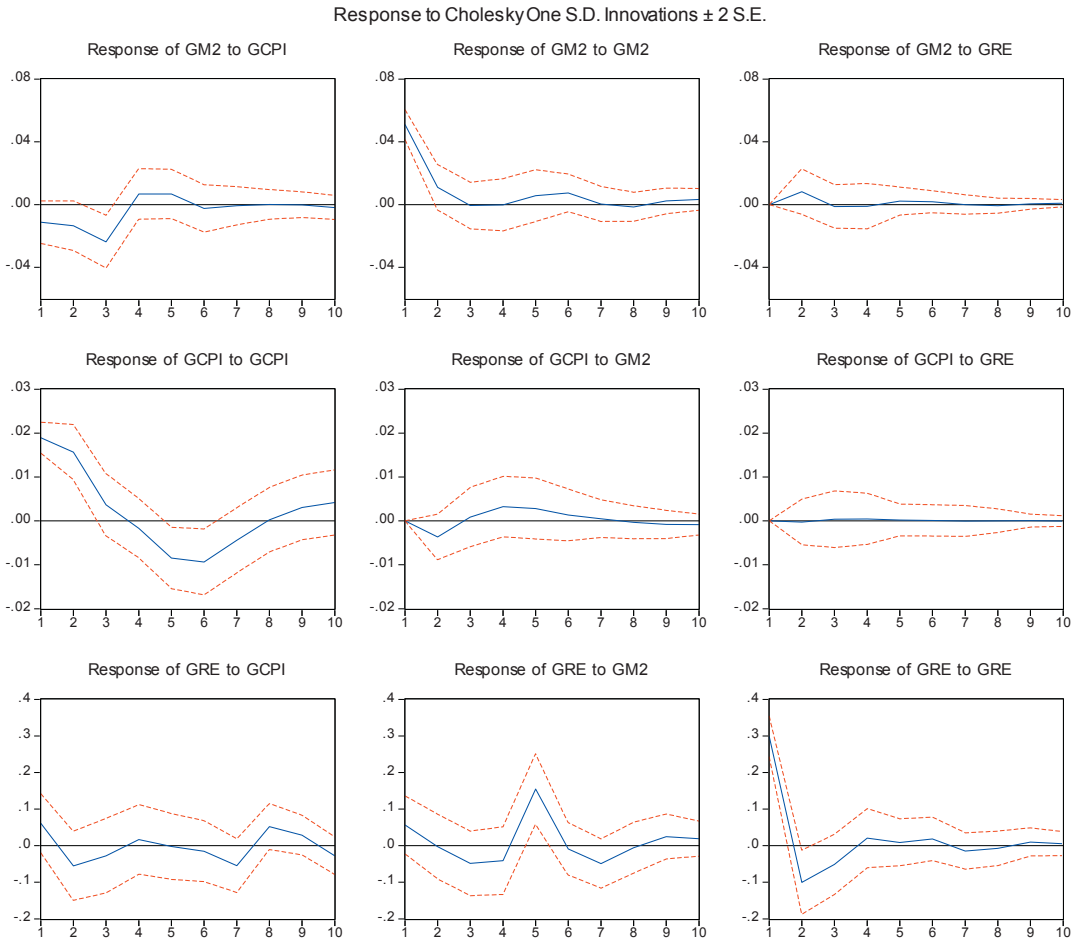
Source: Ministry of Planning and Investment, the State Bank of Vietnam.

Appendix Figure 1. Developments of FDI, ODA and Worker's Remittance Inflows in Vietnam, 1995–2012 (in millions of USD).



Source: Database of World Bank

Appendix Figure 2. Top 20 countries receiving worker's remittances in 2012 (in millions of USD).



Appendix Figure 3. Response of GM2, GCPI, and GRE to Structural One Standard Deviation Innovations to GM2, GCPI, and GRE.

Integrated Performance Management — Strategy, Risk and Sustainability Management*

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Abstract. This article gives an overview about an integrated approach to Performance Management, meaning strategy formulation and implementation. A step-wise approach is illustrated to arrive at strategic goals and to implement them by defining key performance indicators, actions and responsibilities. Modern approaches to trend analysis are introduced in order to make more predictable statements. Risk management as the other side of strategy implementation is suggested to get integrated into the process of performance management. Finally, besides economic factors, sustainability aspects are integrated into performance management. Social and ecological assets are not only altruistic steps but can lead to financial benefits if appropriately integrated. The described results are based upon various research projects of FHS St.Gallen, University of Applied Sciences.

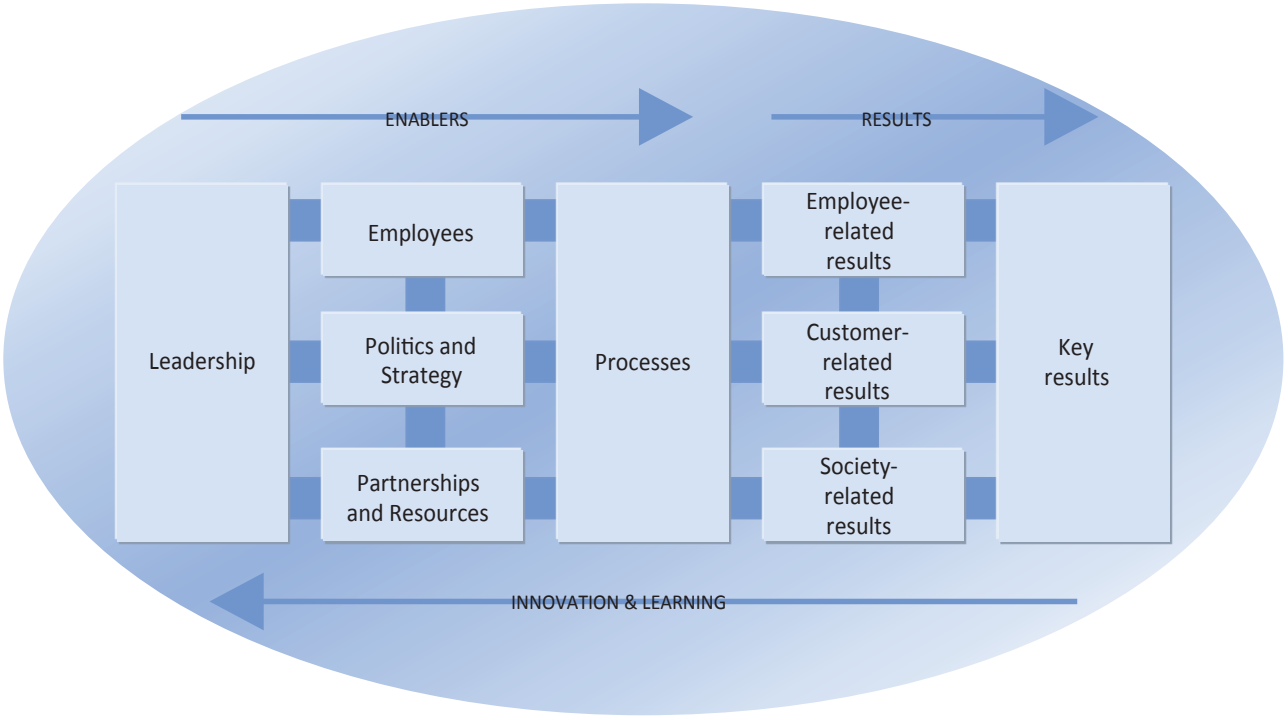
Аннотация. В данной статье дается общее представление о комплексном подходе к управлению эффективностью, в частности к разработке и осуществлению стратегии. Показан поэтапный подход к достижению стратегических целей и осуществлению их путем определения ключевых показателей эффективности, действий и обязанностей. Вводятся современные подходы к анализу тенденций для повышения предсказуемости результатов. Предлагается интегрировать управление рисками, препятствующими достижению стратегических целей, в общий процесс управления эффективностью. Наконец, помимо экономических факторов, в управление эффективностью также интегрируются аспекты устойчивого развития. Создание социальных и экологических активов преследует не только альтруистические цели, но может привести и к финансовой выгоде, если эти активы интегрированы надлежащим образом. Описанные результаты основаны на различных исследовательских проектах Университета прикладных наук Санкт-Галлена (Швейцария).

Key words: performance management, strategy formulation, strategy implementation, risk management, data analytics, sustainability management.

HISTORICAL OUTLINE

The term "Performance Management" is used in many different contexts and disciplines. One common definition is the "implementation of strategic goals into operative plans, the formulation and implementation of operative control and leadership impulses as well as the monitoring of the strategic alignment of the organization" (Merz, 2008). The underlying concept — managing performance — is as old as there have been organizations. However its direct roots go back to the 1970s. The so-called "decision support systems" were software components which focused on individual functional areas. The "Executive Information Systems" of the 1980s had a look at the whole company and were basically an enterprise-wide information system. In 1989 the Gartner Group created the name "Business Intelligence"; the goal of this approach was to improve decision making based on substantial information. In the mid-1980s the term "Performance Management" was first suggested in the US as an aggregated term to describe control and improvement approaches. Finally, in 2001 the Gartner Group created the term "Corporate Performance Management" to include the necessary processes, methods, key performance indicators and systems in order to improve performance (Hannig, 2008). Especially the last two decades came up with numerous concepts which can be categorized as Perfor-

* Комплексное управление эффективностью: управление стратегией, рисками, устойчивостью.



Graph 1. EFQM–Model (European Foundation for Quality Management, www.efqm.org).

mance Management approaches. The following chapters briefly describe the most important ones among them.

APPROACHES TO PERFORMANCE MANAGEMENT

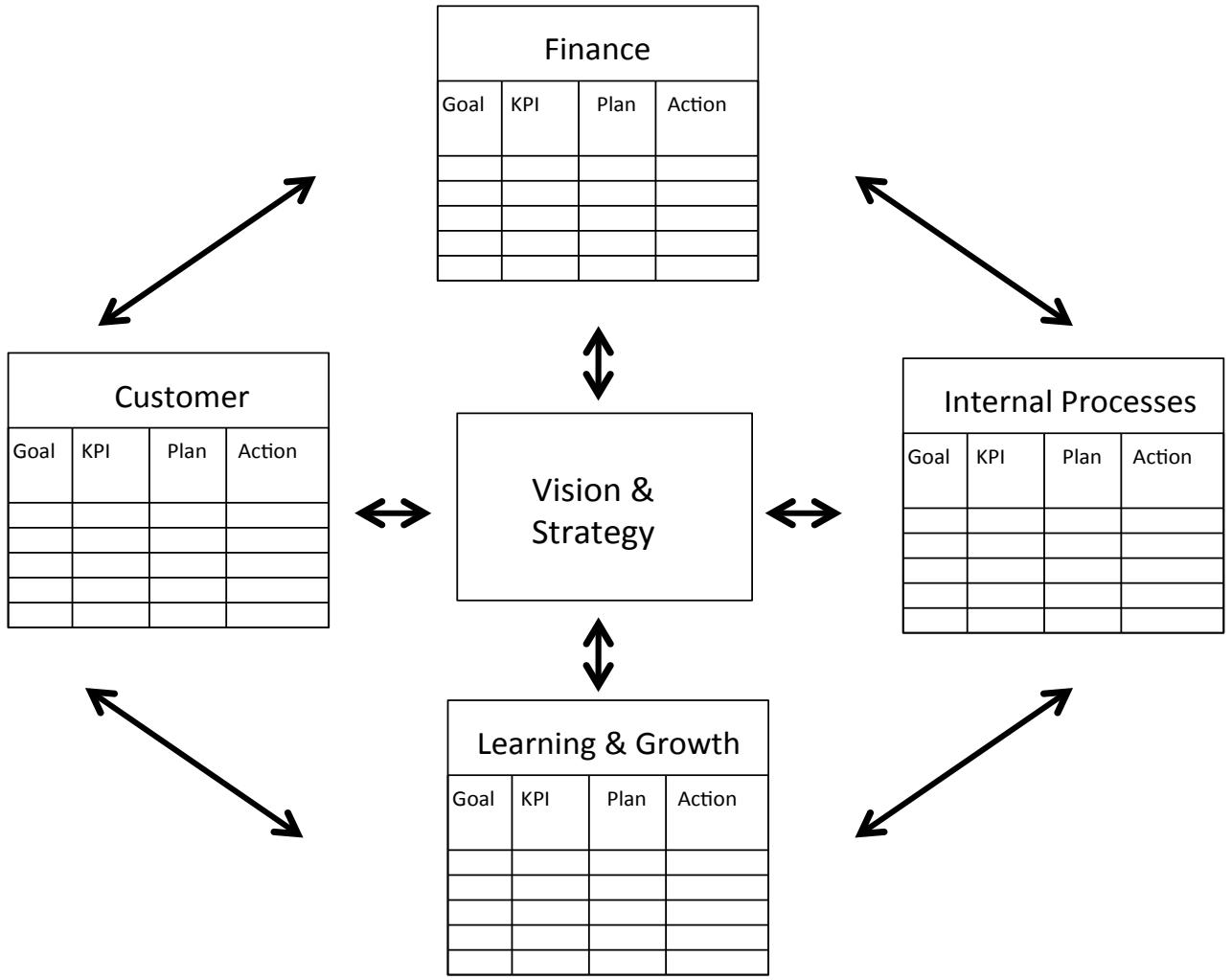
EFQM

The EFQM-model (European Foundation for Quality Management) is a systematic approach to look at the organization and its strategic environment. Graph 1 shows the different elements of this model. It categorizes its elements into enabler and results. The enablers are leadership, employees, politics and strategy as well as processes. The enablers lead to results which can be key results or results related to employees, customers, and society. There is a feedback loop from the results to the enablers which includes innovation and learning. Within each of its elements, the EFQM-model has a scoring system which makes a systematic auditing possible. The main advantage is that benchmarking becomes feasible; every year national and international quality awards are given to extraordinary companies based on the EFQM-model.

BALANCED SCORECARD

The Balanced Scorecard (BSC) is an approach to implement strategies of corporations. In 1992 it was developed by Robert Kaplan and David Norton (Kaplan and Norton, 1992); basically, it is a leadership and controlling instrument which aligns the organization according to its strategic goals. For that purpose, it divides the "world" into four so-called perspectives: Finance, Customers, Processes and Learning & Growth. The new thing at that time was that the Balanced Scorecard set the focus on non-financial aspects of management. Within each of those perspectives, strategic goals are developed, actions and initiatives are defined, and key performance indicators (KPIs) are set in order to measure success or failure. The intention is to transform the general vision of a company into strategic goals and ultimately into concrete and precise actions. The word "balanced" means that there should be a balance between financial and non-financial goals. Another characteristic feature of a BSC is that there are cause-and-effect relationships between the goals and the KPIs. It turns out that the causes are usually in the non-financial areas, and the results are in the financial figures. The BSC can be defined at the top level of an organization or for different areas or functions within the corporation. The concept of cascading means that the goals for the top level can be broken down to departmental and even individual goals. This enables everyone within the organization to make contributions to the strategic goals of the company.

In 2004, the concept was modified, and the "Strategy Map" was developed (Kaplan and Norton, 2004). The four perspectives still remain the same. The main



Graph 2. The classical Balanced Scorecard (Kaplan and Norton, 1992).

difference is that a time-related dynamic has been included. The strategy map differentiates between leading and lagging indicators and shows where the levers and where the results are.

INTELLECTUAL CAPITAL

The concept of "Intellectual Capital" was developed by Eric Sveiby in Sweden in 1997 (Sveiby, 1997). It is a very similar approach like the BSC. However, it splits the Learning & Growth perspective in two — one for innovation and development, and one for human capital. Thereby, this concept places a specific emphasis on employees and people in general. Another point to mention is external structure; with this, Sveiby describes the relationship and connections to the different stakeholders like customers, suppliers, political institutions etc.

PERFORMANCE PRISM

The Performance Prism was developed in England by Kennerley and Neely (Kennerley and Neely, 2002). It categorizes into the dimensions strategies, processes, capabilities, and stakeholders. The main difference to the other approaches is the reciprocity of the relationship with the stakeholders. The company has to satisfy its stakeholders, but also the stakeholders have to make contributions to the company, e.g. shareholders have to follow a reasonable dividend policy, suppliers have to deliver on-time, politics has to provide the necessary laws and certificates, etc.

STRATEGY FORMULATION AS A PREREQUISITE FOR PERFORMANCE MANAGEMENT

The above described approaches of Performance Management focus on implementing strategic goals and monitoring their success based on KPIs. However, in a step before, strategic goals have to be formulated. A goal is a future to-be situation, defined by the company. The actions and initiatives are means to reach those goals. The formulation of the strategic goals is the most important step before Performance Management can come into action. There

are different approaches how to develop strategic goals. Most of them can be categorized either as resource- or market-based. The resource-based view starts within the corporation and its core competences, and takes them "inside-out". The concept of the core competencies was introduced by Prahalad and Hamel in 1990 (Prahalad and Hamel, 1990). According to this approach, a company has to possess or create competitive advantages with technologies, processes, products or any other core competences in order to be successful on the market. The other view is the market, i.e. the relevant market has to be analyzed with regard to its competitiveness. One of the most prominent models is the "Five Forces" model by Michael Porter (Porter, 1980). By analyzing the power of customers and suppliers and by evaluating substitute products/services, as well as potential and already existing competitors in the market, one can determine what the market looks like and what it needs. The following chapters describe a step-by-step approach which combines market and resource view and has been developed in several research projects of FHS St.Gallen, University of Applied Sciences, Switzerland. The different steps are illustrated with the case study Feinkost Käfer (a fine food store), one of the project partners.

FEINKOST KÄFER

Feinkost Käfer in Munich, Germany, is one of the top addresses in Europe for exclusive party service, high quality retail store and excellent gastronomy. The fine food shop in Munich is one of the leading food stores in Europe. It has about 8000 articles, and more than 120 employees. The main strengths of the shop are the large variety of products and the individual service through specially trained employees. The main challenges in this business are to manage this large variety and complexity, as well as the necessity for a high service level (Käfer, Lux and Philipp, 2012). Since Käfer is managing this challenge currently quite well, it is in a good competitive position.

STRATEGY FORMULATION AT FEINKOST KÄFER

During strategy formulation, the important long-term goals of a company are defined. Identifying and using opportunities is of particular importance here. Strategy formulation can be conducted in six steps.

1. Definition of mission, vision, and values: Feinkost Käfer's mission statement is "To be the fine food shop in Europe, where customers want to buy the most unique products of highest quality with the most friendly and best service personnel". Based on that mission, already two strategic goals can be defined: "Sustainable implementation of five core Käfer values: *adoring, high-quality, unique, surprising,* and *emotional*", "Implementation of the quality manifest".

2. Identification of trends: In this step, the trends, which are relevant for the industry and the individual company, have to be identified. The trends are typically located outside of the organization. Commonly they can be economical, ecological, social, legal, and technological in nature. Usually, trend analysis is done in a brainstorming process or with a desk and document research. In a research project, an empirical survey was conducted with the goal to identify potential opportunities. The results helped companies in identifying trends. A new approach is data analytics. Massive amounts of data are collected mainly in the internet ("Big Data") and analyzed in order to identify certain patterns which might indicate a future trend. As a matter of course, there is no certainty but always a likelihood that those trends come true, but it helps in judging. An example of trends in the fine food market is the trend towards bio-food and regional products.

3. Market segmentation: A company has to define the most promising market segments. A market segment is a combination of products/services, customers/customer groups, regions, and market channels. In this context a company defines in which market segment it will be doing business and where, according to its management, are the largest opportunities. For Feinkost Käfer, the target customer is between 30 and 50 years old, mainly end-consumers, who are coming not only from Munich, but from all over the world, mainly from Europe.

4. Competition analysis: According to the "Five Forces" model the relative power of customers, suppliers, and competitors are evaluated. For Feinkost Käfer the result was that the individual customers and suppliers did not have a large negotiating power. Additionally, no other comparable fine food shop could be identified.

5. Strengths-Weaknesses-Opportunities-Threats (SWOT-analysis): In the first part, the strengths and weaknesses of an organization have to be identified. Those are mainly internal factors leading to success or failure. The main strengths for Feinkost Käfer were its brand, tradition, the high service quality and the high-end assortment of products. Missing communication among the different departments and lack of qualified labor force were identified as the most important weaknesses. In the second part, the

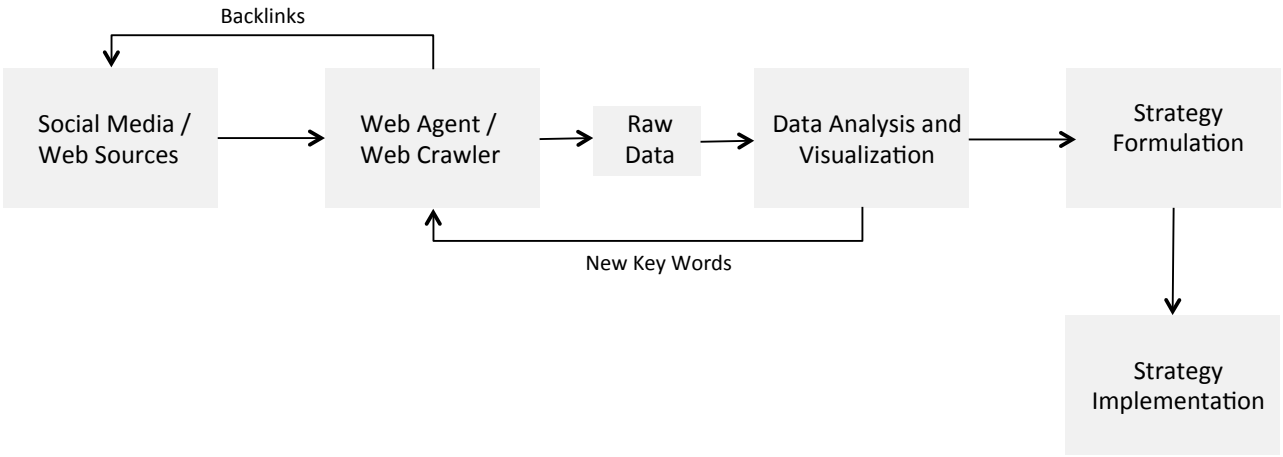
Strategic Goal	Responsible	Key Performance Indicator	Balanced Scorecard Perspective	Actions
Long-term value orientation	Mr. Meier	Return on Sales	Finance	Monitoring, Reporting (mainly weekly jours fixes with accounting, bi-weekly reports to general management, quarterly adaptation of forecast)
	Mr. Meier	Sales Increase	Finance	
Becoming most innovative fine food shop in Europe	Mr. Smith	Number of innovative and unique offerings in Bavaria	Customer	Inventory of existing innovative products
	Mr. Smith	Number of new and unique products in the assortment	Customer	Expand and optimize existing food scout system
				Further development of internal food scout activities
				Innovation cirlcle (employees from different departments)
Long-term implementation of the five core values	Mr. Meier	Tranfer rate of th values	Learning & Growth	Development of training and workshops
				Conducting training and workshops
				Design and conducting en employee survey

Graph 3. Strategy of Feinkost Käfer (extract).

opportunities and threats are identified. Those are mainly external factors. Trends which potentially have a positive impact on the organization are called opportunities; trends which have a negative influence are called threats. The main opportunities at Feinkost Käfer were the implementation of a central purchasing department for the Käfer group and the cost consciousness of the management and team leaders. Potential threats are loss of reputation and food scandals.

6. Formulation of strategic goals: Based on the SWOT-analysis, the strategic goals are developed. Especially when strength matches with an opportunity, strategic goals can be formulated. If a weakness meets a threat, goals which try to prevent damage from the company can be developed. At Feinkost Käfer, 12 strategic goals have been developed. Three of them are described below.

- From a financial perspective, the goal is to achieve a long-term value orientation. This is measured with the KPIs sales growth and return on sales. Real actions to achieve this goal do not exist at the financial level. The defined KPIs are meant to monitor this goal;
- Feinkost Käfer wants to become the most innovative fine food shop in Europe with unique products — from their customers' viewpoint. Only this way, Käfer can retain loyal customers and acquire new ones. The according KPIs are the number of innovations and the number of new and unique products in the assortment. For that purpose, the already existing food scout system (world-wide food tester) is supposed to be expanded; in addition, innovation circles at all levels of the organization will be established;
- Feinkost Käfer stands for five values: *high-quality, emotional, unique, surprising,* and *adorable*. The goal is to implement those values within the organization. The defined KPI is the transfer rate, i.e. the number of internalized values — meas-



Graph 4. Procedure of trend analysis with fuzzy cognitive maps.

ured by an anonymous survey. This is supposed to be supported by workshops and trainings.

The general rule is that there should not be too many strategic goals in order to focus on the essential; however, there should also not be too few goals in order to have a balance between financial and non-financial goals. The recommendation here is to have between five and ten goals.

BIG DATA AS A SOURCE FOR TREND ANALYSIS

One key element in strategy formulation is the trend analysis. Since mostly this is done on a brainstorming basis, the likelihood of forgetting important aspects is fairly high. A new and innovative approach is to use the massive amount of unstructured data in the internet for trend analysis. This is currently being tested in a research project which is conducted by the author of this article. In order to do this, certain strategically relevant key words as well as data sources (social media, blogs etc.) have to be gathered and entered into a web agent (web crawler). This web crawler extracts relevant information out of the pre-defined sources and stores the relationships between the pieces of information with the help of ontologies. Those relationships are analyzed by using fuzzy logic and are visualized with so-called fuzzy cognitive maps. They show the relationships among the pre-defined key words and indicate new key words which have been mentioned in the relevant context on the internet. Those new key words then might be indicators for new trends. Since this process is ongoing, new data from the internet are constantly flowing into the database; one can monitor the development of the key words and their frequencies. If the presence of certain terms is constantly increasing over time, a trend is likely to appear.

INTEGRATED PERFORMANCE MANAGEMENT

The classical approach to Performance Management is to implement the strategic goals, initiate actions, and monitor the goal achievement with appropriate KPIs. The Integrated Performance Management includes elements of strategic risk management and aspects of sustainability in this process.

CLASSICAL PERFORMANCE MANAGEMENT

"What gets measured, gets done". This expression by Peter Drucker means that strategic goals have to be operationalized, the strategy has to be implemented. For that purpose, the following steps have to be conducted:

1. Selecting the relevant KPIs: There are many KPIs around, the art is to find the right ones. For that purpose, it is important to find out the value driver behind the strategic goal. For example, if the goal is to become the most innovative fine food shop in Europe, the relevant value driver is innovation. That means, KPIs have to be selected which measure innovation. For defining the KPI, the relevant perspective has to be defined. If innovation is meant to be from a process perspective, then the number of innovative products might be an appropriate KPI. If the value driver is meant to express the view of the customer, the appropriate KPI is rather something like number of perceived innovations (by the customer).
2. Defining the KPIs: Once the KPIs are selected, they have to be closely defined. This definition has to be very exact, so that people know what needs to be included in the calculation of the KPI value. If a KPI is called number of innovative products, then it needs to

be defined what an innovative product is and for what period this KPI is measured, e.g. per year. It is also very important to define who is responsible for the KPI and the strategic goal behind it. Precise names are more suitable than teams or departments because names are more binding. Finally, the plan and actual values of the KPIs have to be collected or calculated. If the KPIs are new, it can be that actual values are not yet available. When selecting and defining KPIs, this should be done under cost-benefit considerations. If the necessary data for a KPI are too difficult to get, it might not be worth including it. The frequency, with which the values are collected, is also important. For financial figures, monthly values might be appropriate; for customer- and employee-related KPIs, annual values might be sufficient.

3. Defining actions and initiatives: In order to reach the strategic goals and the plan values of the defined KPIs, actions have to be taken. They have to be defined for each goal. For each action, responsibilities have to be assigned. Here, the same applies as above, precise names are better than groups of people.

4. Defining the time line: For the strategic goals and for the actions it has to be fixed when the goals should be achieved and the actions be taken.

When those steps are completed, the results can be documented and shown in a dashboard (see Graph 4). It is important that the planned goals and KPIs are reviewed on a constant basis.

RISK MANAGEMENT AND COST DRIVERS

Risk management can be defined as the "totality of all organizational regulations and actions to identify and manage the risks which are inherent in corporate operations" (Diederichs, Form and Reichmann, 2004). The core elements of risk management are:

- Risk Analysis: Identification and valuation;
- Planning and controlling: Managing risks by avoidance, acceptance, sharing, or shifting (e.g. to an insurance company);
- Monitoring: Reporting and indicators (KRIs).

Risks as well as opportunities have to be managed. That is why it makes sense to combine strategy implementation (performance management) and risk management. In order to do that, the above-developed strategy map is extended by risks and risk indicators in order to build a risk scorecard. By following such an approach, both sides of the coin — opportunities and threats — are equally considered. In practical business life, those two sides are frequently separated. Different departments deal with them. It would generate substantial synergies to combine them to one approach. The following steps are necessary to develop such a combined approach (Lux and Löhrer, 2012).

1. Assigning the relevant risks to the strategic goals: For each of the defined strategic goals the relevant strategic risks are identified and assigned. This can be done in a brainstorming process or with the help of risk catalogues.

2. In order to keep the focus, only the most important risks should be considered. Therefore, the identified risks need to be evaluated. Commonly, risks are evaluated on the basis of the criteria "extent of damage" and "likelihood". Additionally, the dimensions "controllability of the risk" and "degree of surprise" can be added. Those risks which are considered most important will be adopted into the risk scorecard.

3. Identifying the most important risks which are not associated with a strategic goal: Independent from the strategic goals, there might be strategic risks which should also be considered. They are added without an assignment to the strategic goals.

4. Identifying and defining key risk indicators (KRI): In order to measure the risks, indicators need to be defined if it makes sense. Sometimes it might not make sense. For example, in order to measure the exchange rate risk, the exchange rate or the change in exchange rate might be a good indicator. The risk of political changes is much more difficult to grasp. In such a case, it might be more appropriate not to define a KRI but to estimate the financial consequences of the risk on the strategic goal or the business result in total (see step 6).

5. Identifying plan and actual values of the KRI.

6. Estimating the financial consequences of the risk on the strategic goal or the KPI: This consequence can be a percentage or an absolute value.

7. Estimating the likelihood that the KRI has the consequence on the KPI.

8. Assigning a weight to the risk: If the risk has consequences on several strategic goals or KPIs, weights have to be assigned. If, for example, the risk "economic development" has a potential damage of 1 million and has consequences on the sales and the profit, these consequences have to be split, e.g. sales decrease 800.000 and profit decrease 200.000.

9. Calculating the consequences: Through multiplying extent of damage, likelihood and weight the consequences of the risk can be quantified.

10. Determining the tolerance levels of the KPI: Percentage or absolute value.

11. Defining actions: If the tolerance levels are exceeded, actions have to be defined in order to reduce the consequences of the risks.

12. Estimating the consequences of the risks on the financial result: The calculated consequences

Strategic Goal	Key Performance Indicator	Plan Value	Actual Value	Risk (goal–related)	Key Risk Indicator (KRI)	Plan Value (KRI)	Actual Value (KRI)	Estimated impact of risk on KPI	Likelihood	Weight	Tolerance Level	Actual impact on KPI	Actions	Impact on financial result	Impact in CHF
Reduction of quality costs	Scrap rate	1%	4%	Additional administrative tasks	Increasing administrative costs	0%	5%	–8%	30%	100%	–5%	–2,40%	no actions	Administration costs	–154
	Number of cost–related improvement suggestions	5	0												
Build up image of a Swiss supplier of high quality products	Customer satifaction index	95%	85–95%	High costs with uncertain outcome	Increase in marekting costs	10%	20%	–30%	20%	100%	–10%	–6,00%	no actions	Sales and marketing	–114
Strengthening the distribution channels	Distributor rate	40%	10%	No direct control over distributors											
	Number of contacts to trading companies and retailers	200	100	Distributors cooperate with competitors	Percentage of distributors cooperating with competitors	50%	80%	–5%	40%	100%	–4%	–2,00%	Increase direct marketing for distributors	Net sales	–3 960
				Risk (not goal–related)	**Key Risk Indicator (KRI)**	**Plan Value (KRI)**	**Actual Value (KRI)**	**Estimated impact of risk on KPI**	**Likelihood**		**Tolerance Level**		**Actions**	**Impact on financial result**	**Impact in CHF**
				Increasing raw material prices	Price index raw materials	105%	110%	–5%	50%		–5%	–2,500%	no actions	Cost of goods	–2 427
				Increasing pressure through competitors	Number of direct co`mpetitors	5	8	–5%	40%		–10%	–2,000%	no actions	Net sales	–3 960
				Increasing costs through environmental protection laws	Number of relevant environmental protection laws	10	15	–3%	20%		–3%	–0,600%	no actions	Cost of goods	–583
				Difficulty to attract qualified employees	Average time for recruiting	60	100	–15%	40%		–5%	–6,000%	Increase coopeation with universities	Profit	–329
				Employee fluctuation through culture change	Fluctuation rate	2%	5%	–10%	30%		–5%	–3,000%	no actions	Profit	–164
Total															**–11 691**

Graph 5. Example of a risk scorecard.

Strategic Goal	**Respon-sible**	**Actions/ Initiatives**	**Key Performance Indicator**	**Traffic light (red/yellow/ green)**	**Risk (goal-related)**	**Key Risk Indicator (KRI)**	**Actions**
Reduction of quality costs	Mr. Meier	Introduce automatic quality control	Scrap rate		Additional administrative tasks	Increasing administrative costs	no actions
			Number of cost-related improvement suggestions				
Build up image of a Swiss supplier of high quality products	Mr. Smith	Marketing campaign	Customer satifaction index		High costs with uncertain outcome	Increase in marekting costs	no actions
		New branding concept					
Strengthening the distribution channels	Ms. Jones	Meetings with distributors	Distributor rate		No direct control over distributors		
			Number of contacts to trading companies and retailers		Distributors cooperate with competitors	Percentage of distributors cooperating with competitors	Increase direct marketing for distributors
					Risk (not goal-related)	**Key Risk Indicator** (KRI)	**Actions**
					Increasing raw material prices	Price index raw materials	no actions
					Increasing pressure through competitors	Number of direct competitors	no actions
					Increasing costs through environmental protection laws	Number of relevant environmental protection laws	no actions
					Difficulty to attract qualified employees	Average time for recruiting	Increase cooperation with universities
					Employee fluctuation through culture change	Fluctuation rate	no actions

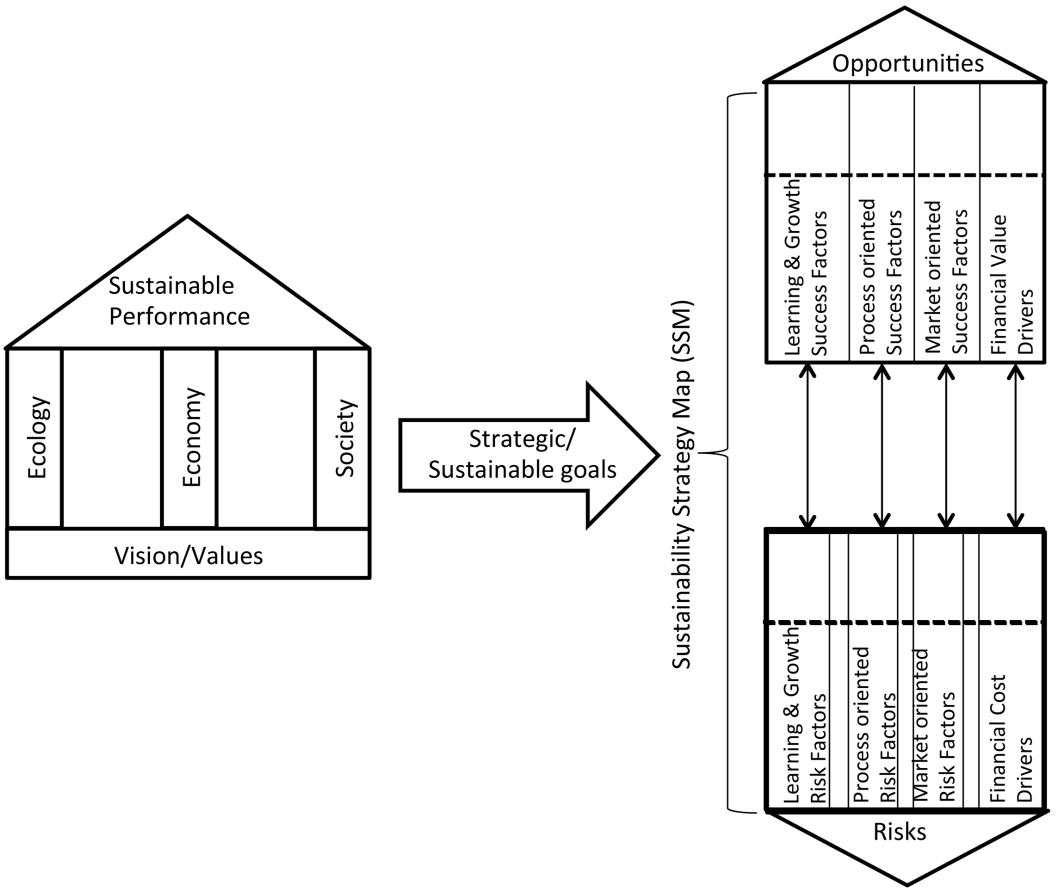
Graph 6. Cockpit view of strategic goals and risks.

(step 9) are reviewed with consideration of the actions planning in step 11.

The following example illustrates this procedure: We assume that one of the strategic goals of a Swiss company is "Sales increase in the Euro zone". This is measured by the annual sales increase in Swiss francs. The value of this KPI is currently 10%. There are two potential risks: Exchange rate and economic situation. The former one is measured by the exchange rate, the latter one by the domestic demand in the respective Euro countries. Those are the KRIs. It is estimated that the Swiss franc will gain further 5 cents (compared to the Euro), and the domestic demand will decrease by 20%. The former risk will decrease export sales by 5%, the latter one by 20%.

The likelihood that the exchange rate actually changes is 60%, the domestic demand will make the expected change with a likelihood of 50%. Under those assumptions the consequence on the KPI "sales increase" would be as follows:

$$0{,}6 \times (-5\%) + 0{,}5 \times (-20\%) = -13\%$$



Graph 7. Integration of sustainability into Performance Management.

Instead of the expected sales increase of 10% it seems that there will be a sales decrease by 3%. Assuming the tolerance level is set to 5%, actions would have to be taken in order to reduce the risk. Examples of such actions would be setting up production sites in the Euro zone or purchasing raw materials in the Euro zone. Actions in order to increase the domestic demand are not under the discretion of an individual company; those are macro-economic frame conditions.

Now it is fairly easy to estimate the impact on the financial result. Assuming that in the above-mentioned example the sales is 1 million Swiss francs, a 3% decrease in sales would lead to sales of CHF 970.000. By increasing the purchase volume in Germany this could possibly be increased by 20.000 to 990.000. Ultimately, this would result in a sales decrease of CHF 10.000.

Graph 5 shows a fictitious risk scorecard. Certain risks are associated with strategic goals, others are independent. Graph 6 shows a cockpit view of strategic goals and risks.

SUSTAINABILITY – SOCIAL AND ECOLOGICAL POWER

Sustainability is an important topic in the private and public sector. Scarce resources, climate change, and social grievances require a change in thinking. People have to live in such a way that they can satisfy their needs without limiting those of future generations (Hauff, Brundtland Commission, 1987). A sustainable development cannot be achieved without corporations (Ehnert, 2012). According to a survey conducted by FHS St.Gallen, 82% of the Swiss companies consider sustainability important (Kugler and Olbert-Bock, 2012). Depending on the industry, it is seen as an important feature, which is required by the customer. Lack of sustainability aspects can have negative consequences on the competitive position of a company because the topic is increasingly on the agenda of stakeholders like customers, investors, business partners and non-governmental organizations (NGOs) (Kugler and Olbert-Bock, 2011).

Prerequisite for sustainable success and performance is a balanced consideration of the elements of the so-called "Triple Bottom Line": Ecology, Social, Economy (Elkington, 1997). This model has been modified several times, namely by including effectiveness and efficiency aspects. However, this model is still dominated by the economic perspective. The main questions in this context are (Schaltegger *et al.*, 2007, p. 4ff.):

• How can a company reduce the amount of environmental pollution caused by its activities (ecological effectiveness)?

• How can socially undesirable effects, caused by company's activities, be reduced (social effectiveness)?

• How can environmental protection and social engagement be realized in a possibly profitable and value-creating way (economic efficiency)?

• How can those three challenges be balanced and integrated into the traditional, economically oriented management (integration challenge)?

As described above, strategic goals are long-term to-be situations of an organization. Profit-oriented corporations in particular have mainly economic and financial goals. Sustainable strategies according to the "triple bottom line", however, are characterized by the fact that they not only contain financial aspects but also relevant ecological and social aspects. Firstly, the content of those aspects has to be defined. Secondly, the extent to which sustainable goals are taken into consideration — as sub-goals with regard to economic goals, or at an equal level (Kugler and Olbert-Bock, 2011). In order to distinguish themselves from merely being long-term, sustainable goals have to consider explicitly ecological and social aspects of business. Examples of sustainable goals at Migros Corporation, the largest retailer in Switzerland, are the following:

• Improvement of chocolate brand as a socially and environmentally responsible brand;

• Finding an equilibrium between economic, ecologic, and social requirements;

• Achieving a long-term, sustainable growth.

The process to develop sustainable goals is the same as for developing strategic goals. Therefore, it makes sense to integrate them into one approach. Graph 7 shows how this can be done.

Based on the triple bottom line, strategic and sustainable goals are developed and formulated. Together with the appropriate KPIs and KRIs they are part of the Sustainability Scorecard which contains traditional economic elements and sustainable aspects. Given the fact that the classical Performance Management also includes non-financial figures and aspects, there will usually be an overlap.

CONCLUSION

The above-described model integrates different aspects of Performance Management in order to reduce complexity and make use of synergies. However, since so many different aspects are contained, it is important to reduce it to a minimum, otherwise it cannot be handled by managers. Future research has to further validate this model and show the financial impacts on the bottom line.

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Carbon Dioxide Emissions from Indian Manufacturing Industries: Role of Energy and Technology Intensity*

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Abstract. Industrial energy efficiency has emerged as one of the key issues in India. The increasing demand for energy that leads to growing challenge of climate change has led to major issues. This paper is an attempt to compute Carbon Dioxide (CO_2) emission from fossil fuel consumption for firms in Indian manufacturing sector from 2000 to 2011 by adopting the IPCC Reference Approach. The contribution of this paper lies in estimating CO_2 emission at the firm level and analyzing the factors that explain inter-firm variation in CO_2 emission. The results indicate that there are differences in firm-level emission intensity and they, in turn, are systematically related to identifiable firm specific characteristics. This study found size, age, energy intensity and technology intensity as the major determinants of CO_2 emission of Indian manufacturing firms. In addition, capital and labour intensity of the firms are also related to the firms' CO_2 emission intensity. We conclude the short run policy implications should be aimed at encouraging firms to invest more in R&D and technology sourcing, and at long run firms should be able to adapt cleaner energy to reduce CO_2 emission from the fuel consumption.

Аннотация. Вопрос энергоэффективности промышленности Индии в последнее время приобрел ключевое значение. Увеличение спроса на энергию, которое вызывает растущую проблему изменения климата, привело к серьезным последствиям. Эта статья является попыткой оценить выбросы углекислого газа (CO_2) в индийской обрабатывающей промышленности с 2000 по 2011 год на основе методики МГЭИК. Результаты данного исследования свидетельствуют, что существуют различия в интенсивности выбросов на уровне предприятий, которые, в свою очередь, находятся в зависимости от идентифицируемых специфических характеристик предприятий. Исследование показало, что к числу основных факторов, определяющих выбросы CO_2 индийских предприятий, относятся размер, время использования, энергоемкость и интенсивность технологий. Кроме того, объем капитала и интенсивность труда также связаны с интенсивностью выбросов CO_2. Мы пришли к выводу, что в краткосрочной перспективе политика должна быть направлена на поощрение фирм инвестировать больше в НИОКР, а в долгосрочной перспективе компании должны переходить на более чистые энергетические технологии для снижения выбросов CO_2 от потребления топлива.

Key words: CO_2 emission, technology intensity, firm heterogeneity, panel data, Indian manufacturing.

1. INTRODUCTION

Political efforts to address the concerns of climate change have developed greatly in the last twenty years. In 1992, at the Rio Summit, the United Nations Framework Convention on Climate Change (UNFCCC) was established. Then, in 1997, despite its flaws, the Kyoto Protocol set targets to curb greenhouse gas emissions on a number of industrialized countries emissions between 2008 and 2012. While natural scientists identified the relationship between greenhouse gas concentrations and climate change and highlighted many of the threats, social scientists, particularly economists, played a crucial role in developing strategies for mitigating climate change (Nordhaus, 1991; Cline, 1992; IPCC, 2007). Economists have been influential in arguing that the cost of mitigation may not be as great as many

* Зависимость уровня выбросов углекислого газа в индийской обрабатывающей промышленности от энергетических технологий.

expected (Porter, 1991; Fischer & Newell, 2008) and there may be substantial benefits (Stern, 2004; Sterner & Persson, 2008). They also proposed mechanisms for trading responsibilities and credits related to greenhouse gas (GHG) emission reductions, which have been central tools to agreement on targets related to Kyoto Protocol (Atkinson & Tietenberg, 1991; Stavins, 1995). At a national level, many governments have introduced taxes to discourage the consumption of high-carbon energy sources (Pearce, 1991; Newbery, 1992; Oates, 1995; Parry and Small, 2005; Nordhaus, 2007; Sterner, 2007). In other words, economists have become highly influential in the global efforts to achieve climate stability.

In a parallel line at macroeconomic perspective there is no consensus on the effect of international trade on the environment; and in particular on the effect of trade on global emissions. Neither theoretical nor empirical literature provides a clear-cut answer to the link between trade and CO_2 emissions. Literature survey emphasizes on limited studies in explaining patterns of emission for industry or firm level. However, studies in eco-innovation are given much importance. Studies in eco-innovation can be broadly divided into two categories:

1) The first mainstream research deals with the drivers of eco-innovation strategies. The seminal work by Jaffe and Palmer (1997) studies environmental innovation (R&D and patents) at industry level, followed by Brunnermeier and Cohen (2003), employs panel data on manufacturing industries to provide new evidences on the determinants of environmental innovation measured by number of patents. Rennings *et al*. (2003) exploit OECD survey data in order to investigate whether environmental auditing schemes and pollution abatement innovation are correlated. Mazzanti and Zoboli (2008) present evidence for manufacturing sector at a district level, focusing on an extended set of drivers (environmental R&D, policy induced costs, industrial relations, and other innovations). Frondel *et al*. (2004) use an OECD survey data on manufacturing firms and focus on internal firm-based strategies, external policy variables and test the drivers for end-of-pipe measures or integrated cleaner production processes.

2) The second stream of research is focused on environmental innovation and employment effects. The main contributions in this stream include Rennings & Zwick (2001) and Pfeiffer & Rennings (1999).

In economic literature, it is also argued that innovation through technological advancement makes firm/industries competitive and productive. In such reviews, arguments are also attempting to link the complementarity of energy to capital, where energy is considered as an instrument to capture the technological indicator. This line of study follows productivity framework and necessarily tries to estimate the relationship of energy and non-energy inputs. Gap in literature lies in analyzing the patterns of firm level emission, and relate to firm characteristics. This study attempts to fill this gap and computes firm level CO_2 emission. Given the absence of theoretical and empirical reviews in this line of thought, we employ the structure-conduct-performance paradigm in analyzing the inter-firm differences in CO_2 emission. This paper assumes the choice of primary source of energy as one of the eco-innovation strategies of firms, and we would like to arrive at the inter-firm differences in the determinants of the negative externalities, specifically the CO_2 emissions from the choice of fossil fuel consumption. The remainder of the paper is as follows. Section 2 discusses the review of literature; section 3 describes the estimation of CO_2 emission; section 4 describes the econometric model and variable construction. Section 5 presents the descriptive analysis of the sample. Section 6 presents the empirical results, and section 7 concludes with policy implication.

2. REVIEW OF LITERATURE

This section of the paper attempts to look at the mainstream research similar to the objectives of this work. To start with eco-innovation, the study carried out by Rennings and Zwick (2001) is based on a sample of eco-innovative firms for five European Union (EU) countries in manufacturing and service sectors. The result of the study indicates that in most of the firms employment does not change as a consequence of eco-innovations. The econometric results show that, apart from some product innovations, eco-innovation typologies do not influence the level of employment, though as expected, according to their evidence environmentally oriented innovations seem to lead to a skill-based effect. Also end-of-pipe innovations are related to a higher probability of job losses, while innovations in recycling have a positive effect on employment. Employment effects may thus be unevenly distributed with strong negative effects from environmental strategies/policies on low skills intensive industries and potentially positive effects on other industries. It could also be argued that product and process eco-innovation strategies may bring about (potentially negative) net effects on employment, attributable to a destruction of the low skilled labour force and a creation of high skilled positions (R&D).

There is a complementary stream of literature that has focused on the various static and dynamic relationships between eco-innovation, environmental performances and firm performances. Konar and Cohen (2001) investigated the effect on firms' market performance of tangible and intangible assets, including two environmental performance-related elements as explanatory factors. Cohen *et al*. (1997) also analyzed the relation-

ship between environmental and financial performances. Overall, authors found that investing in a *green portfolio* did not incur a penalty and even produced positive returns. Gray and Shadbegian (1993) used total factor productivity and growth rates of firms over 1979-1990 as performance indicators to test the impact of environmental regulations and pollution abatement expenditures. They found that 1$ more expenditure on abatement is associated with more than 1$ worth of productivity losses. Analysis on variations over time or growth rates, the relationship between abatement costs and productivity was found insignificant. Greenstone (2001) estimated the effects of environmental regulations, using data from 175 million observations of firms in 1967-87, US censuses of manufacturers. According to the study environmental regulations negatively affect growth in employment, output and capital shipments.

The EU-based study by Ziegler *et al*. (2008) focused on the effects of environmental strategies on the stock performances of corporations using standard cross section/ panel approaches and event studies that analyze whether there are exogenous unexpected policy effects on the short-term performance of environmentally minded firms. This study was criticized for their intrinsic very short-term focus. Based on official datasets they conclude that the evidence focusing on stock market performance is limited since the majority of firms especially in Italy are of medium or small size and do not appear in stock market data. Innovation dynamics are close to productivity trends, which in the end are the main engines of firm performance. Doonan *et al*. (2005) examined the role of communities to create incentives for local industrial facilities to reduce pollution. They found that firms face both internal and external pressures to improve their environmental performance. Using primary data collected for 750 Canadian pulp and paper industries during 1992, they found that the government policies are much of a barrier for the industries. However, financial and consumer markets are not most important barriers. They found that education status of employee is one of the important determinants of environmental performance. The regulatory intervention is also found as the major determinant of environmental performance of the pulp and paper industries. In case of the Indian manufacturing industries firm level energy intensity and their determinants have been studied majorly by Goldar (2011) and Sahu & Narayanan (2011). Both the studies use Indian manufacturing data from CMIE PROWESS online database and follow structure-conduct-performance theory of the firm and analyzed the determinants of energy intensity at firm level. In both of the studies energy intensity is considered as a proxy for energy efficiency of firm. However, what is relevant to our study is the main hypothesis that increasing environmental efficiency by environmental innovations strengthens competitiveness and the firm heterogeneity. The above discussion on the existing review of literature concludes that environmental performance has direct or indirect relationship with the firm performance, in terms of employment or in terms of productivity growth. However, none of them have linked the negative externality such as CO_2 emission as a byproduct of the firm to firm heterogeneity. Hence, the motive of the paper is to focus on emission (CO_2) intensity with the firm heterogeneity.

3. THE CONCEPTUAL FRAMEWORK

One of the objectives of this work is to estimate the CO_2 emission at firm level. Further, we econometrically model the factors explaining determinants of inter-firm differences in the CO_2 emission. We begin explaining the construction of the firm level CO_2 emission for the sample of firms in Indian manufacturing industries. From figure 1, we can see that share of CO_2 emission of the manufacturing industries (at aggregate level) is higher as compared to other emissions (LEAP)[1]. From the figure we can also observe that industrial value added is increasing from 2000 to 2010 with fluctuations. The industrial value added is downward sloping till 2005, the share of CO_2 emission shows an increasing trend for the entire period. LEAP captures this data from the output point of view. Data at the aggregate level is available, but firm level emission information is not reported. One of the ways to capture the firm level emission is to compute the emission from the input use that is from the fossil fuel used by the firms. This is an indirect measure based on a scientific approach, closely related to the emission generated from firm according to the IPCC.

The estimation of emission from the fossil fuel consumption is based on the IPCC reference approach that refers as a top-down approach using aggregate information of fossil fuel consumed, to calculate the emissions of CO_2 from combustion. However, the study has few data limitations such as quality of coal used. This is not considered mainly because the calculation is carried out for the first time at firm level in Indian manufacturing firms using PROWESS data base. Data is collected from the Center for Monitoring Indian Economy database PROWESS 4.0. This data is a combination of the annual audited balance sheet (that gives information of the firm characteristics) and energy consumption at firm level. Therefore, firms that don't report energy consumption are dropped from the active data sheet. Also, since we are adopting the IPCC reference approach, we have considered only fossil fuels consumed by the firms.

[1] The Long-range Energy Alternatives Planning system (LEAP) is a widely-used software tool for energy policy analysis and climate change mitigation assessment developed at the *Stockholm Environment Institute (SEI)*.

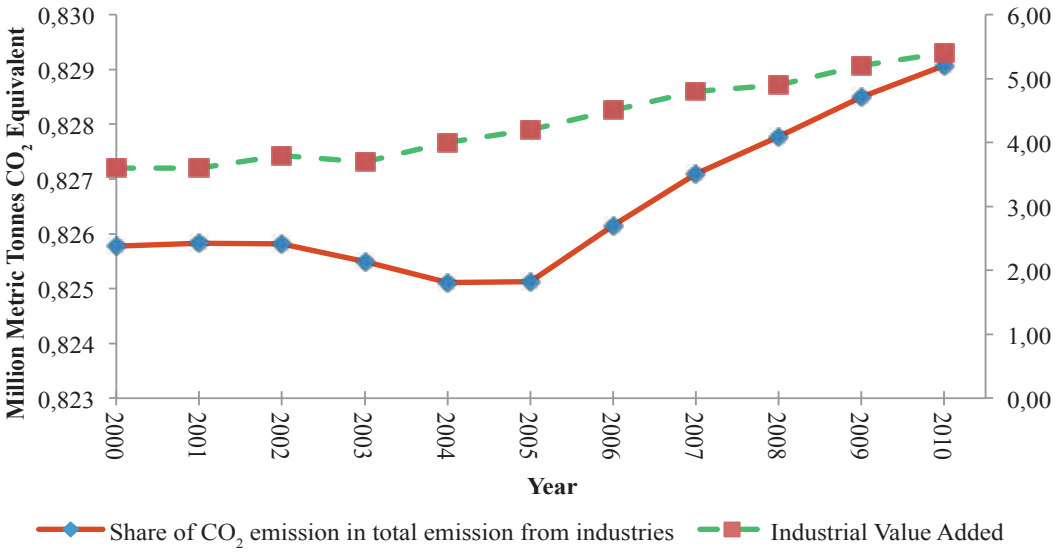

Figure 1. Share of CO_2 emission and industrial value added in Indian manufacturing industries
Source: Author's estimate from LEAP Data Base, www.energycommunity.org/LEAP.

The IPCC reference approach of estimating emissions from fossil fuels is as follows:

$$CO_2 = \sum_{i=n}\left[\left(\begin{pmatrix}(ac_f \times cf_f \times cc_f)\times \\ \times 10^{-3} - ec_f\end{pmatrix}\times cof_f \times \frac{44}{12}\right)\right] \quad (1)$$

where, ac_f = apparent consumption fuel, cf_f = conversion factor for the fuel to energy units (TJ) on net caloric value basis, cc_f = carbon content (ton C/TJ i.e. to kg C/GJ), ec_f = excluded carbon defined as carbon in feed-stocks and non-energy use excluded from fuel combustion emissions (Gg C), cof_f = carbon oxidation factor defined as fraction of carbon oxidized (usually the value is 1, reflecting complete oxidation). Lower values used only to account for carbon retained indefinitely in soot, and (44/12) is the molecular weight ratio of CO_2 to carbon (C).

Further, following Chen *et al*. (2010) we construct the firm level emission from equation (1) as:

$$C_t = \sum_{i=1}^{3} C_{i,t} = \sum_{i=1}^{3} E_{i,t} \times NCV_i \times \ CEF_i \times COF_i \times (44/12) \quad (2)$$

Where, C_t = flow of carbon dioxide with unit of 10,000 tons, NCV_i = net calorific value provided by IEA energy statistics for India, 2011, CEF_i = carbon oxidization factor provided by 2006 National Greenhouse Gas Inventories in IPCC, COF_i is the carbon oxidization factor set to be 1 in this study. Therefore, based on equation (2) in manufacturing industries the calculated CO_2 emission coefficient for coal is 2.0483 (kg CO_2/ kg coal), for oil 3.272 (kg CO_2/ kg oil) and for natural gas 2.819 (kg CO_2/m^3 natural gas).

4. ESTIMATION METHOD AND VARIABLE CONSTRUCTION

Following Copeland and Taylor (1995) and assuming each firm produces two outputs: a manufactured good (*x*) and emission (*e*), the testable implication of the study follows a log linear relation of the following type:

$$\ln\frac{e}{x} = \left(\vec{fh}\right) \quad (3)$$

Where, $\ln\frac{e}{x}$ = Natural log of firm level emission intensity and $\vec{fh}$ is a vector representing firm characteristics. We use an unbalanced panel data for the estimation of equation (3). Following similar framework as in Goldar (2011) and Sahu & Narayanan (2011) for the Indian manufacturing industries, the general form of equation (3) is estimated with the following econometric specification:

$$\ln\frac{e}{x}_{it} = \alpha_{it} + \beta_1 ci_{it} + \beta_2 li_{it} + \beta_3 ei_{it} + \beta_2 s_{it} + \ \beta_2 s_{it}^2 + \beta_2 ag_{it} + \beta_2 ag_{it}^2 + \beta_2 t_{it} + \beta_2 rd_{it} + \beta_2 mne_{it} + \varepsilon_i + \mu_{it} \quad (4)$$

where ci: capital intensity, li: labour intensity, ei: energy intensity, s: firm size, s^2: square of firm size, ag: age of the firm, ag^2: square of age of firm, t: technology import intensity, rd: research and development intensity and mne: multinational affiliation.

Different empirical works that study reasons for energy (in)efficiencies pay attention to the market share or value added to the industry output and find the evidence that it can make a contribution to the explanation of inefficiencies as the factor of market power (Hrovatin and Urib, 2002). It is worth mentioning, that fossil energy resources are characterized by the considerable undesirable outcome (such as CO_2 emissions) and still their share in total energy generation is dominant, while the role of renewable energy sources is comparatively low, though extended recently. We have selected the following variables which influence the emission intensity of firms. Output is deflated net sales adjusted for change in inventory and purchase of finished goods. In PROWESS database the purchase of finished goods is defined as finished goods purchased from other manufacturers for resale. Hence, we subtracted purchase of finished goods from sales to arrive at the firms manufactured output. A positive increase in inventory is added to sales to arrive at output and a decrease subtracted.

Capital is measured as defined in Srivastava (1996) for the measurement of capital stock, which revalues the capital given at historical cost to a base year. Actual investment for the present period is estimated by taking the difference between Gross Fixed Asset (GFA) for current year and that of last year. The real investment value is expressed in the base price of 1993-1994=100. This enables us to use the perpetual inventory method to construct capital stock. In estimating the capital stock we first revalue the GFA at historical cost to a particular base year value. We have used GFA, after deflating it with the wholesale price index for machinery and machine tools, as plant and machinery accounts for 71 percent of the GFA (RBI Bulletin, 1990). Firms can gain a technological advancement not only through their own innovation but also through purchases of new capital or intermediate goods from other sectors. Capital intensity is measured in terms of deflated GFA as a proportion of output.

The PROWESS database provides information on wages and salaries of the firm and provides no information on the number of employees. Therefore, we need to use this information to arrive at the number of persons engaged in each firm. Number of persons engaged in a firm is arrived at by dividing the salaries and wages at the firm level by the average wage rate of the industry (at the three digit level) to which firm belongs. Hence, *Number of persons engaged per firm =Salaries and Wages/ Average Wage Rate*. To arrive at the average wage rate we make use of the Annual Survey of Industries (ASI) data on Total Emoluments as well as Total Persons Engaged for the relevant industry. And *Average Wage Rate = Total Emoluments/Total persons engaged*.

In most of the productivity studies of four factors of production, energy consumption is considered as one of the indicators for innovation. This implies that in cost minimization a firm can shift from one source to the other sources of energy. Hence, it will be of interest to check the relationship between energy efficiency and emission at the firm level. Size of the firm is the proxy for several effects as observed by Bernard and Jensen (2004). Size of firm is one of the components of firm heterogeneity. Because of scale economics bigger firms might use the efficient fuel and emit less. In the present study, firm's size is measured by the natural log of total sales. There could be a non-linear relationship between emission intensity and firm's size. Age of the firm is calculated as the deference between years of the study to year of the incorporation of the firm as reported in the PROWESS database.

Technology import intensity is defined as the expenses on import of capital goods and royalty and technical fees payments in foreign currency, to net sales of the firm. Higher the technology import it is assumed that firm might be emitting less as technology advancement of the firm might enable the firm to be energy efficient and emit less. R&D intensity is also one of the innovation strategies that might help firms in emitting less. Here, we define R&D intensity as the ratio of R&D expenditure to net sales. There is empirical evidence that foreign-owned firms tend to be more efficient in energy conservation (Faruq and Yi, 2010) and, at the same time, there is also evidence in Zelenyuk and Zheka (2006) that reveals a negative correlation between foreign ownership and firm's environmental efficiency level. We have created a dummy to capture the multinational affiliation (mne), where firm belonging to foreign affiliation takes a value 1 and the domestic firms takes a value of 0.

5. TRENDS AND PATTERNS OF CO_2 EMISSION: DESCRIPTIVE ANALYSIS

This section of the study depicts the descriptive analysis of the sample. We have estimated CO_2 emission based on equation (2), from the fossil fuel consumption of sample of firms in Indian manufacturing from 2000 to 2011. Figure 2 presents the aggregate mean annual CO_2 emission of the sample. From the figure we can observe that the aggregate CO_2 emissions of the sample of Indian manufacturing firms are fluctuating over the period with an increasing trend from 2005 to 2011.

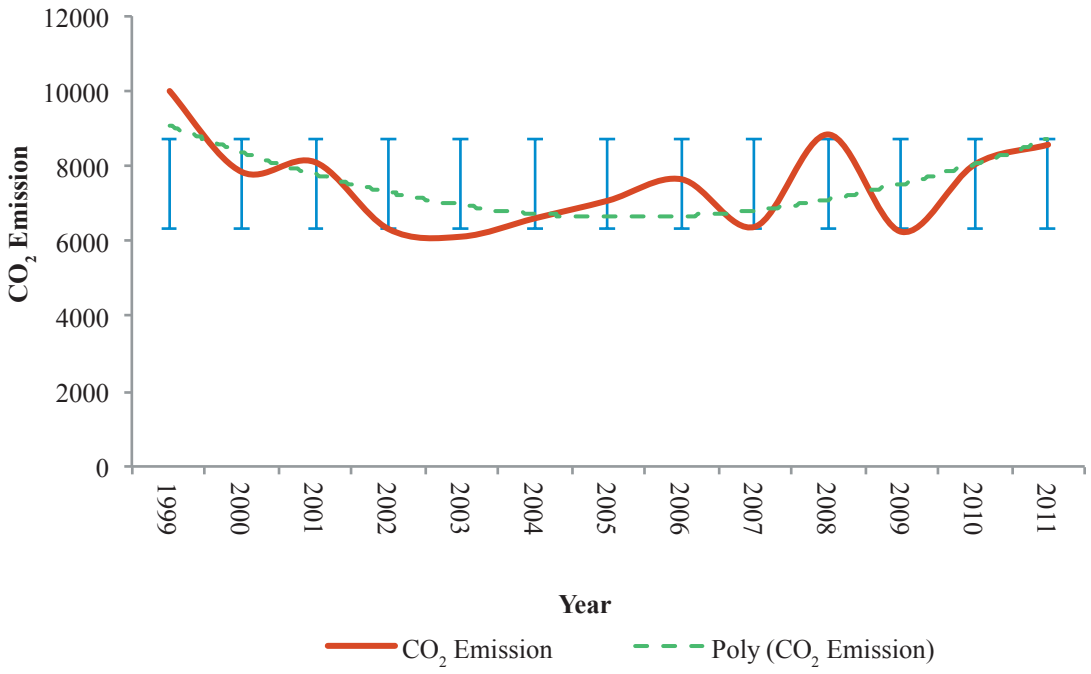

Figure 2. Average annual CO_2 emission (over study period)
Source: Author's estimates from PROWESS, Center for Monitoring Indian Economy.

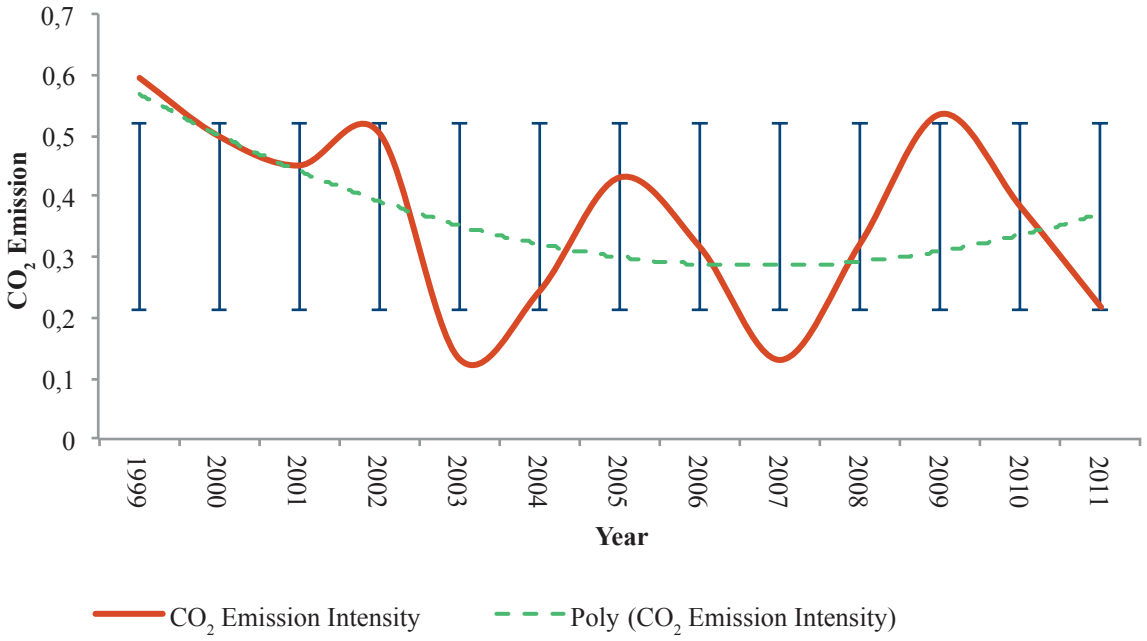

Figure 3. Average annual CO_2 emission intensity (over study period)
Source: Author's estimates from PROWESS, Center for Monitoring Indian Economy.

Emission intensity is considered as better measurement as compared to emission in absolute form as it is normalized with the output of the firm. Emission intensity is drawn in Figure 3. The standard deviation between the average emission and emission intensity, however, are different. We can observe that for emission intensity, the standard deviations across years are fluctuating as compared to the standard deviation of aggregate emission for the sample in Figure 2. If we compare between the distributions of both the series we can observe that emission of the sample are more stable as compared to emission intensity. However, the trend is quite similar for both the distributions. One of the interesting findings of this comparison is that the trend in average annual emission is flatter then the emission intensity over the years, which is due to the

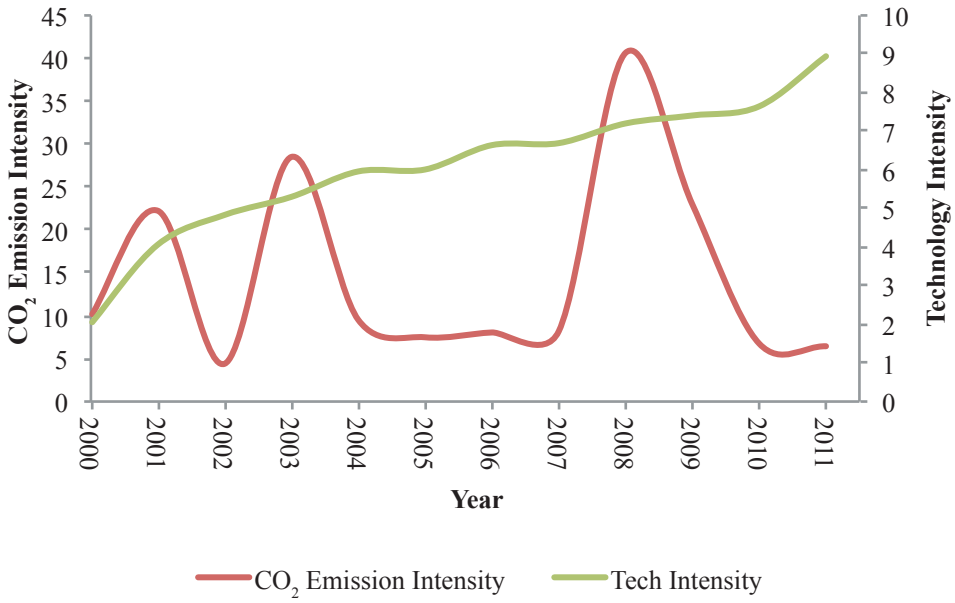

Figure 4. Comparison of CO_2 emission and technology intensity (over study period)
Source: Author's estimates from PROWESS, Center for Monitoring Indian Economy.

structure and production of the firms. Hence, when we normalize the emission with output we can get a different movement as compared to the absolute level of emission due to fossil fuel consumption.

From this discussion, we can assume that increase in emission of firms is related to the output, which is definitely related to the technology in use for the production process. To check this we plot technology intensity of firm with the emission intensity for the same period. Figure 4 presents this exercise. From this figure we can observe that from 2000 to 2008 the emission intensity is fluctuating while technology intensity was increasing. However, from 2009 even technology intensity continued to increase, emission intensity has started declining. For few years such as 2001, 2003 and 2008 emission intensity is higher and for the rest emission intensity has been less.

One of the indicators of firm heterogeneity is multinational affiliation of firms. In Figure 5 we have plotted technology import, R&D and the emission intensity of firms. As a result of technology import and investment on research & development a firm might lead to reduce emission. For a growing country such as India, we need to also look at the differences in emission for the multinational affiliated and the domestic firms. From Figure 5 we can see that foreign firms are higher technology intensive and higher R&D intensive. However, the domestic firms are emitting high. Emission intensity is not widely differenced, but domestic firms emit more than the foreign firms. Twelve years' data of the sample states that the CO_2 emission is higher for the domestic firms (0.32) as compared to the foreign firms (0.21).

Firms use different sources of fossil fuel as primary sources of energy hence, emissions from each of the energy type are supposed to be different. Therefore, we have attempted to see the difference in emission from different fossil fuel use. In addition we would also like to compare technology intensity with emission with different fossil fuel consumption. Figure 6 gives the comparison of energy, technology, R&D and emission intensity classified by different sources of primary energy consumption. From the figure we can see that energy intensity is higher for firms using coal and oil, however, firms using natural gas are energy-efficient. In case of technology intensity we can observe that firms using coal as primary source of energy are importing higher technology as compared to firms using natural gas and oil. However, oil-consuming firms are higher R&D intensive as compared to the other two classifications. Emission intensity is similar for firms using coal and oil, where coal-using firms are found higher emission intensive as compared to oil-using firms, but the firms using natural gas are least in emission intensity.

As literature suggests, the determinants of firm heterogeneity are size and age of the firm. We have classified the sample based on age and size distribution of firms and relate with firm level emission. Figure 7 presents group of firms classified based on size and age. In case of age of the firms we have created four classifications. The classification G-1 represents firms' age between 1-10 years old, G-2 represents 11-25, G-3 represents 26-50, and G-4 represents firms older than 51 years. Similarly, for size of the firms: G-1 represents 10^{th} percentile of the sample, G-2 represents 25^{th} percentile, G-3 represents 50^{th} percentile and G-4 represents high-

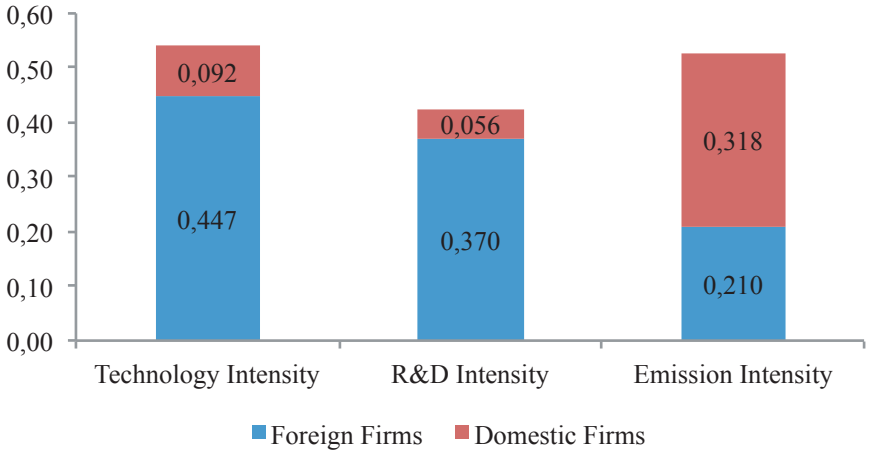

Figure 5. Emission, technology and R & D intensity of domestic and foreign firms (average over study period)
Source: Author's estimates from PROWESS, Center for Monitoring Indian Economy.

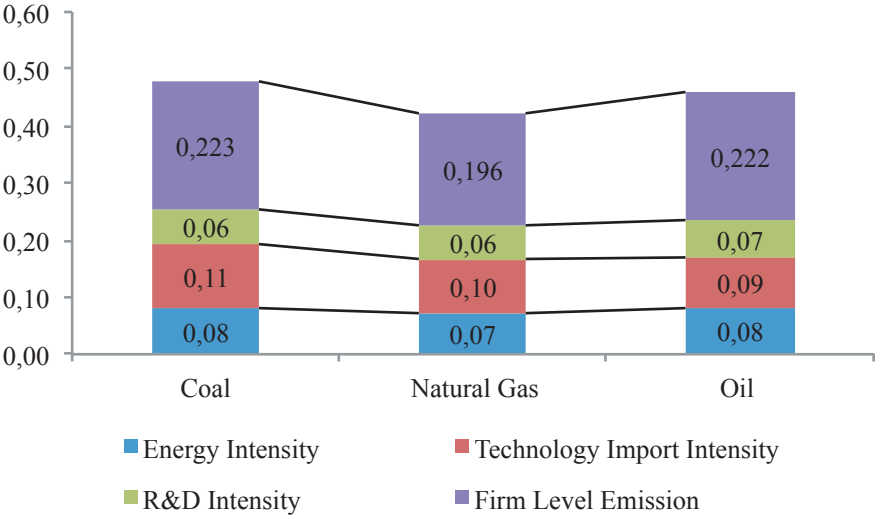

Figure 6. CO_2 emission, energy, technology and R & D intensity between three fuel sources (average over study period)
Source: Author's estimates from PROWESS, Center for Monitoring Indian Economy

er than the 50th percentile. Emission intensity of G-2 firms is the least as compared to the other classifications. Older firms are emitting the highest. For size of the firms, bigger firms are emitting higher compared to the smaller firms. The cross-tabulation might not give the concluding result between firm size and age of the firm to emission intensity; hence the econometric analysis will help us in determining the relation for policy formulation.

As of now we have analyzed the sample at aggregate level. However, as we know the sample consists of different types of firms at industrial classification. There are firms which use energy more and emit more. However, energy and emission intensity can be different based on the output level of such industrial classes. Hence, further the sample is classified in two digit industrial classification based on the NIC-2008 GoI classification. Indicators such as energy and emission intensity are further calculated for the set of these classifications. Table 1 and Figure 8 present the result. From the table and the figure we can observe that coke and refined petroleum industries are energy intensive in the set of 17 classes of two digit industries, whereas industries related to printing and reproduction are found to be energy efficient in the same classification.

Five energy intensive industries from the sample are (1) coke and refined petroleum, (2) paper and paper, (3) textiles, (4) wearing apparel and (5) fabricated metal products industries. In the similar classification five energy efficient industries are (1) printing and reproduction, (2) beverages, (3) food, (4) wood products and (5) computer and electronic industries. For the emission intensity we have also tried the similar classification and found that coke and refined petroleum industries are the emission intensive ones, and food industries are the least emitting industries for the sample. The

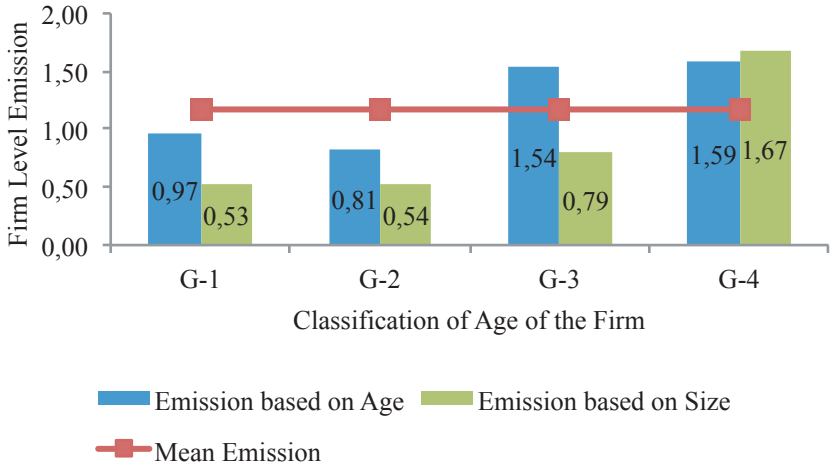

Figure 7. CO_2 emission for group of firms classified by age and size (average over study period)
Source: Author's estimates from PROWESS, Center for Monitoring Indian Economy.

Table 1. Comparison of energy intensity and CO_2 emission intensity across industries over study period

NIC	Industry Type	Energy Intensity	CO_2 Emission Intensity
18	Printing and reproduction	0.116	4.195
11	Beverages	14.381	6.443
10	Food	19.059	1.586
16	Wood products	29.519	21.002
90	Computer and electronic	32.557	6.754
12	Tobacco	44.398	8.051
15	Leather	46.320	33.301
60	Manufacture of basic metals	48.742	7.490
22	Rubber and plastics	56.561	40.630
20	Chemicals	60.122	4.399
50	Non-metallic mineral products	61.970	10.320
40	Pharmaceuticals, medicinal chemical	69.943	14.709
80	Fabricated metal products	86.847	9.532
14	Wearing apparel	109.536	8.174
13	Textiles	159.866	28.508
17	Paper	165.525	22.240
30	Coke and refined petroleum	252.124	55.362
	Full Sample	104.702	22.977

Source: PROWESS, Center for Monitoring Indian Economy.

top five emission intensive industries in the sample are (1) coke and refined petroleum, (2) rubber and plastics, (3) leather, (4) textiles and (5) paper industries. The top five emission efficient industries are (1) food, (2) printing and reproduction, (3) chemicals, (4) beverages and (5) computer and electronic industries.

A comparison of energy and emission intensity of the three digit classification of industries is presented in Figure 8. From the top five industries in case of efficient and intensive firms for energy and emission intensity it is not clear whether industries which are higher energy intensive also higher in emission intensity. Hence, we have attempted the Spearmans' rank correlation analysis for three digit industrial classification for energy, emission intensity and technology intensity of the industries. The technology intensity is classified in two major classifications: (1) technology import intensity and (2) research and development intensity. From the analysis of the rank correlation we conclude that energy and emission intensity are highly correlat-

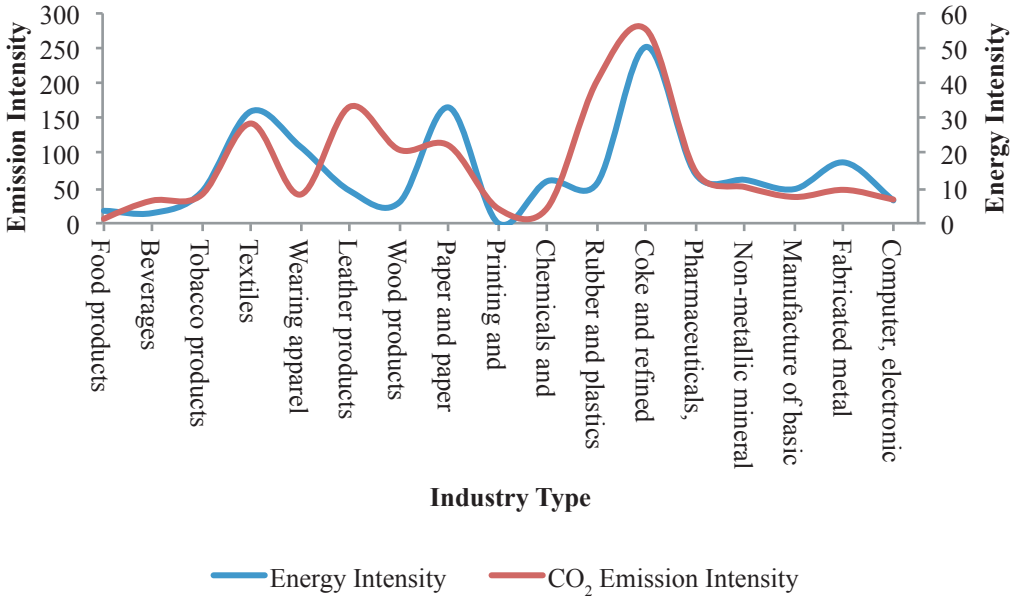

Figure 8. Comparison of energy intensity and CO_2 emission intensity across industries
Source: PROWESS, Center for Monitoring Indian Economy.

ed at 1% of statistical significance. The relationship is found to be positive hence, energy intensive firms are found to be higher emitting. In addition we can also observe from Table 2 that research and development intensity in negatively related and statistically significant to energy intensity of industries.

Above discussion has tried to link emission intensity with technology intensity and firm heterogeneity. We began from the macro point of view in relating industrial value added to CO_2 emission of industries. From the LEAP database we confirm that CO_2 emission is one of the major emissions from the industrial sector of the Indian manufacturing industries. However, this emission information is from the output generated of the firms as bad output. As data on CO_2 emission at firm level is not available we have constructed the emission at firm level from the IPCC reference case approach. Further, we also classified emission intensity to different firm characteristics, specifically MNE affiliation, firm size, age etc. Further, at three digit industrial classification we have computed the emission and energy intensity to find out the intensive and efficient industries in the sample. Also, this section tried to establish relationship of emission, energy intensity with technology intensity using rank correlation. However, the question of why firms differ in CO_2 emission was not established. The next section tries to attempt this question using an econometric approach at firm level.

Table 2. Rank correlation between various intensities.

	Energy Intensity	CO_2 Emission Intensity	Technology Import Intensity	R&D Intensity
Energy intensity	1.000			
CO_2 emission Intensity	0.633***	1.000		
Technology import intensity	-0.377	0.082	1.000	
R&D intensity	-0.499**	-0.226	0.193	1.000

Source: PROWESS, Center for Monitoring Indian Economy.

6. THE ECONOMETRIC RESULTS

The theoretical background of the estimated equation (4) is given earlier in section 3. However, before attempting equation (4) let us compute the correlation matrix for select variables. From the correlation coefficients (Table 3) it is seen that energy intensity is statistically significant and positively related to emission intensity, where size of the firm is negatively related and statistically significant to emission intensity. Capital intensity, age of the firm, technology import intensity and R&D intensity are also found to be positively related to firm level emission. Equation (4) is estimated first using pooled OLS and further using panel data econometrics that are fixed and random effects models. Based on the coefficients of Hausman statistics, the fixed effects estimates are selected over the random effects estimates. Methodologically, result of fixed effects is robust and efficient compared to the pooled OLS estimates. Hence, we have interpreted the results of the fixed effects model in Table 3. Equation (4) is a

Table 3. Correlation matrix

	Capital Intensity	Labour Intensity	Energy Intensity	Size of the firm	Age of the firm	Technology Import Intensity	R&D Intensity	Firm Level CO_2 Emission Intensity
Capital Intensity	1.000							
Labour Intensity	0.846	1.000						
Energy Intensity	0.004	−0.016	1.000					
Size of the firm	0.345	0.298	−0.235	1.000				
Age of the firm	0.104	0.138	0.020	0.172	1.000			
Technology Import Intensity	0.590	0.479	0.039	0.387	0.219	1.000		
R&D Intensity	0.092	0.155	0.107	0.127	0.040	0.109	1.000	
Firm Level CO_2 Emission Intensity	0.024	-0.015	0.582	-0.232	0.077	0.117	0.007	1.000

Source: PROWESS, Center for Monitoring Indian Economy.

semi log model and the definition of firm's size is also natural log of net sales, hence the econometric specification turns out to be a double log model. Hence, the coefficients of the model are hence elasticities. The detailed results of the pooled OLS and random effects are presented in Appendix Table A1, and the result of the fixed effects model is described in Table 4.

Two parameters are considered for technology intensity, namely technology import intensity and R&D intensity. We can observe from the result of the fixed effects estimates that technology import intensity is statistically significant at 1% and carries a negative sign with emission intensity implying that firms importing higher technologies are emitting less. Hence, higher the import of technologies of firms, lower the emission intensity of the firms. Because we have constructed emission from the input use of firms in terms of energy choice, the result indicates only one explanation of the relationship that is technology intensive firms mostly use cleaner source of energy such as natural gas. From the cross tabulation it is also clear that natural gas using firms are emitting less. Hence, higher technology intensive firms might be using natural gas in the energy mix instead of other two inputs. From the result it is clear that research and development intensity is statistically significant and negatively related to emission intensity. This means that firms investing more in research and development are emitting less. This result is also similar to the earlier discussions on the selection of energy choice of firm. Relationship of technology import and research & development intensity with emission intensity clearly states that they are negatively related, and firms depending more on technology import and investing more in R&D are emission efficient.

The result of technology intensity can also be discussed as firms import technology for upgrade of plant and machinery or develop the output process by using such technologies. In addition through higher R&D intensity firms learn from the technology imported and hence both parameters help the firm in achieving higher emission efficiency. Therefore, the role of technology intensity for firms is an important indicator in reducing emission. Linking these results with eco-innovation studies such as Konar and Cohen (2001) we can assume that technology import and the R&D investments are eco-innovation strategies of the firms in reducing emission intensity.

Since the sample consists of very small as well as very large firms, we have tried to establish non-linear relationship between firm's size and CO_2 emission intensity. The result indicates a positive and negative coefficient for size and size square variable. This implies that very large and very small firms are emitting less and the medium sized firms are emitting more. Similar exercise is also carried out for the age of the firms. We also found a nonlinear relationship for emission and age of firm indicating an inverted 'U' shaped relationship as the coefficients are statistically significant at 1% and carry positive and negative signs. That in turn indicates that both older and younger firms are emitting less, whereas medium-aged firms are emitting more. These results are akin to the literature on environmental Kuznets curve for both developed and developing countries. It means that as size and age of the firm increase, CO_2 emission also increases. However, with increasing innovation, technologies awareness and building capabilities of firms, emission level starts declining beyond a threshold point. In other words it may be easier for both older and younger firms as well as bigger and smaller firms to either adapt to or shift to cleaner energy sources compared to the medium-sized and aged firms to adapt or shift from the existing energy sources.

Further, capital intensity has a negative relation with emission intensity of the firm, and is highly

Table 4. Determinants of CO_2 emission intensity

Independent Variables	Coefficient	Standard Error	t value
Capital Intensity	−0.003	0.001	−2.200**
Labour Intensity	−0.005	0.003	−2.520***
Energy Intensity	1.293	0.164	4.870***
Firm Size	0.043	0.154	2.280***
Firm Size^2	−0.132	0.048	−2.730***
Firm Age	0.013	0.004	3.280***
Firm Age^2	−0.004	0.003	−2.010***
Technology Import Intensity	−0.539	0.274	−1.970**
R&D Intensity	−0.016	0.104	−2.160**
MNE Dummy	−0.042	0.168	−0.250
Constant	−1.305	0.141	−9.290
R^2 (overall)	0.289		
R^2 (within)	0.288		
R^2 (between)	0.294		
(u_i=0) F(2324, 621)	8.290***		
F(7,621)	20.65***		
Number of observations	2275		

Source: PROWESS, Center for Monitoring Indian Economy.

significant at 1%. This means firms with the larger capital are emitting less compared to firms with the smaller capital. If we compare the results of age and size of firm to emission we can see that older and bigger firms are emitting less and capital-intensive firms are also emitting less. Hence, we can now assume that older and bigger firms might be higher capital intensive firms. Hence, being capital intensive, older and larger emit less as compared to the less capital intensive firms. According to Narayanan (1998), accumulation of technological capabilities through learning by doing is facilitated by the skilled manpower employed in a firm. The calculation of the labour intensity is quite similar to Narayanan (1998), hence labour intensity can also refer as a proxy for skill manpower. The result of the labour intensity is statistically significant at 1% and negatively related to emission intensity. Therefore, labour intensive firms are emitting less as compared to the less labour intensive sample firms. Rennings and Zwick (2001) found that employment is not a major reason for eco-innovation of firms; in contrary we found that higher labour intensive firms are less emitting.

MNE affiliation of firms is not found to be statically significant, but looking at the descriptive statistics on the relationship of MNE, R&D and technology import intensity we can find that foreign firms are investing more in technology import and R&D compared to domestic firms. Even in case of the emission we can see that there is difference between the domestic and foreign firms. Therefore, we assume that the presence of foreign affiliation might be captured either in the technology import or in the research and development expenses of firms in the model. Further, energy intensity of firm is found to be positively related and statistically significant with the emission intensity. This implies energy intensive firms are also emission intensive. This result is akin to the rank correlation coefficient between energy and emission intensity. As the CO_2 emission is from the fossil fuel consumption this result is accepted.

7. SUMMARY AND POLICY IMPLICATIONS

The climate change, green house gases, and emissions are matters of increasing concern not only for developed countries but also for the developing as well as the underdeveloped countries. In addition, concerns have been also reinvigorated by the global and local environmental problems caused by the ever-increasing use of fossil fuels, and so it is clearly an enormous challenge to fuel economic growth in an environmentally sustainable way. India, being one of the largest and rapidly growing developing countries, needs a special focus on the issue of emission. Analysis of the emission from the industries of Indian economy should not only be at the aggregate level and national level. Specific interest must be given to the sub-sectors as well. This work is an attempt to compute CO_2 emission of sample firms in Indian manufacturing from 2000 to 2011 by adopting the IPCC reference approach. The results indicate that there are significant differences in firm-level emission intensity and they, in turn, are systematically related to identifiable firm specific characteristics. This study found size, age, energy intensity and technology intensity as the major determinants of CO_2 emission inten-

sity of Indian manufacturing firms. In addition, capital and labour intensity of the firms are also related to the firms' emission intensity.

Indian manufacturing industries play a significant role in the country's economic growth. However, this sector has to upgrade the technologies and should achieve energy as well as emission efficiency. In addition, specific policy measures should be formulated to encourage medium-sized and older firms to upgrade technology and invest in technology import and research and development pertaining to eco-innovation to reduce CO_2 emission. In addition, by reducing fossil fuel consumption and adopting cleaner and green energy firms will be able to become both energy- and emission-efficient. Summarizing the findings: R&D, technology sourcing, fuel switching should be given due attention for green growth. The contribution of this paper lies in estimating CO_2 emission at the firm level and analyzing the factors that explain inter-firm variation in CO_2 emission.

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Appendix A

Table A1. Estimates of pooled OLS and random effects models

Variables	Coef	RSE	t value	Coef	SE	z value
	Pooled OLS			Random Effect		
Capital Intensity	0.002	0.001	2.320	0.003	0.001	2.700
Labour Intensity	−0.002	0.001	−1.710	−0.002	0.001	−2.630
Energy Intensity	5.096	0.863	5.900	3.409	0.120	6.430
Firm Size	1.219	0.113	5.830	0.881	0.074	5.870
Firm Size^2	−0.174	0.038	−4.550	−0.085	0.023	−3.640
Firm Age	0.011	0.004	2.890	0.013	0.004	3.280
Firm Age^2	−0.003	0.002	−1.790	−0.002	0.001	−2.010
Technology Import Intensity	−0.896	0.378	−2.370	−0.848	0.103	−8.240
R&D Intensity	−0.071	0.123	−1.580	−0.023	0.034	−0.680
MNE	−0.038	0.180	−0.210	−0.042	0.168	−0.250
Constant	−2.850	0.238	−11.960	−2.473	0.198	−12.460
F (10, 2942)	101.130			–		
R^2 (overall)	0.429			0.338		
R^2 (within)	–			0.423		
R^2 (between)	–			0.411		
Root MSE	1.076			–		
Wald chi^2	–			1516		
Number of observations: 2275						

Note: Coef: Coefficient, RSE: Robust Standard Error, SE: Standard Error.
Source: PROWESS, Center for Monitoring Indian Economy.

A Principle of Equitable Access to Sustainable Development — Internalizing Externalities in the Global Climate Talks*

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Abstract. Climate change negotiations require conceptual underpinnings to provide a robust negotiation framework. Principles such as the "common but differentiated responsibilities" or "polluter pays" serve as "political formula" to guide negotiators to achieve mutually acceptable outcomes. Negotiations on technical issues such as emissions reduction often fail due to the lack of guiding principles. After decades of negotiations, the climate change negotiation system is still searching for principles, particularly when the negotiators have realized that the principle of common but differentiated responsibilities seems to inhibit countries to reach an international agreement to reduce greenhouse gas emissions, as it is, for example, increasingly seen to promote free-riding. As the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) introduced the notion of equitable access to sustainable development in the Cancun agreements in the context of a timeframe for global greenhouse gas emissions, the UNFCCC has asked international experts to come up with ideas how the newly agreed principle can be conceptualized, implemented and how it can facilitate the negotiation process, for example, by providing guidelines to overcome the divide between developed and developing countries. This paper aims to contribute its understanding of this principle from the perspective of the negotiation process.

Аннотация. Для обеспечения успеха переговоров по изменению климата требуется надежная концептуальная основа. Принципы "общей, но дифференцированной ответственности" или "загрязнитель платит" служат в качестве политической формулы для достижения взаимоприемлемых результатов. Переговоры по техническим вопросам, таким как сокращение выбросов, часто не приводят к успеху из-за отсутствия руководящих принципов. После десятилетий переговорного процесса система переговоров по изменению климата все еще ищет свои принципы — в частности, когда участники переговоров понимают, что принцип общей, но дифференцированной ответственности тормозит принятие международного соглашения о сокращении выбросов парниковых газов. Поскольку стороны Рамочной конвенции Организации Объединенных Наций об изменении климата (РКИК ООН) в канкунских соглашениях в контексте глобальных выбросов парниковых газов ввели понятие справедливого доступа к устойчивому развитию, РКИК ООН призвала международных экспертов выдвинуть предложения, как реализовать этот новый принцип и как он может облегчить переговорный процесс, в частности, для преодоления разрыва между развитыми и развивающимися странами. Данная статья призвана внести вклад в понимание этого принципа с точки зрения переговорного процесса.

Key words: negotiations, climate change, equity, equitable access to sustainable development, negotiation analysis.

"To go beyond is as wrong as to fall short"
(Confucius)

Economic concepts such as cost-benefit analysis that primarily deal with optimization problems related to decision-making are usually confronted by the complexities arising through the conditions set by power struggles. Theoretically speaking, economic optimization methods assume that rational actors seek optimal outcomes through maximizing behavior, while making adjustments should variables change to maintain the maximum level of utility. Nevertheless, practically speaking, utility may be defined differently as rational actors may follow diverging (subjective) goals that dictate actions as soon as various perspectives enter the decision realm. Under negative-sum conditions

* Роль принципа справедливого доступа к устойчивому развитию в переговорах по изменению климата.

of increasing utility by decreasing that of the others, conflict is inevitable. These goals to maximize utility motivate actions and when actions are confronted by forms of resistance; they become part of a system of power struggles. Decision-makers need to anticipate the weight of resistance and whether this resistance poses risks to the stability of the whole system. Under such a condition, optimization methods, which deal with concrete objects that need to be allocated, are also constrained by conflicts on relationships if not by conflicts on ideologies.

Economic optimization methods need to be complemented by negotiation analysis that looks deeper on reciprocal exchanges of compromises to enable the achievement of outcomes without undermining the whole system. Under conditions of power struggles, the only viable outcome is an outcome in form of a mutually accepted settlement. In this regard, mutual acceptability requires the legitimacy of the whole decision-making process, in which power asymmetry does not constitute a substantial hindering factor for parties to effectively participate in the process. Legitimacy is the state where actors will not challenge existing norms and practices, thus, ensuring stability, that is the predictability of future events. With this, equity becomes a necessary condition in the consensus-making process. As it will be discussed in this paper, actors resist decisions that they perceive as distorting the equitable system or in other cases they seek the restoration of equity by demanding changes in the system. Negotiation, as the mechanism that allows modifications of relationships, becomes the only channel to guarantee equity.

The Parties to the United Nations Framework Convention on Climate Change (UNFCCC) introduced the principle of *equitable access to sustainable development* (EASD) in the Cancun agreements in the context of a timeframe for global greenhouse gas emissions. This principle is seen to complement or even replace the principle of *common but differentiated responsibilities,* which to some participants has just provided resources to free-ride (see Posner and Sunstein, 2010; Penetrante, 2013). Being aware of the additional burdens of climate protection to developing countries which need to shoulder the costs of social and economic development and poverty eradication, the Parties to the convention need to constitute a negotiation framework that would allow developing countries to have more time to reach their peaks than developed nations (UNFCCC, 2012). Only under such a condition can equity be guaranteed.

The principle of equity is not new to the UNFCCC (Vanderheiden, 2008). In the context of the climate change negotiations, equity deals not only with mitigation and adaptation, but it also addresses the way how global decisions are reached. Furthermore, equity moves beyond the questions of acceptable procedures and looks at the quality of participation (Penetrante, 2013b). While justice is directed to the outcome and fairness to the procedure, *equity* pertains to participation. Equity demands that the various background conditions and diverging departure points confronting each actor are appropriately addressed when assessing the "quality" of one actor's participation at the negotiation process. Any sustainable outcome of global climate talks will need not only to adhere to fair procedures and just outcomes, but should also adequately recognize different contributions of individual countries, as well as the differing benefits and rewards under conditions of uncertainty and diminishing resources (Penetrante, 2013b, p. 202).

This paper discusses the most contested equity issues whose lack of resolution inhibits consensus-building. The first contested issue that needs to be resolved is, interestingly, the lack of consensus regarding the definition of equity. At the 17th Conference of the Parties (COP17) in Durban, South Africa, the UNFCCC secretariat and related bodies initiated informal consultations on EASD that led to a workshop at the fifteenth session of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention, which was held on 16 May 2012 in Bonn, Germany (UNFCCC, 2012). The workshop initiated a public discourse on EASD; in particular, the context for equity and EASD, the definition of equity and the application of the equity principle.

THE CLIMATE CHANGE NEGOTIATIONS – FRAMING THE NORTH-SOUTH CONSENSUS DIPLOMACY

The entanglement of the climate change negotiations in the North-South divide is an immediate implication of competing interests between developed and developing countries, whereas countries seek to modify the current structures of the negotiation process according to how they understand justice, fairness and equity (see Penetrante, 2010, 2013a, 2013b). Both developed and developing countries call for more justice, fairness and equity in the decision-making process, whereas there is still no consensus on how such principles are to be defined and implemented.

Furthermore, the relations between the "North" (developed countries) and the "South" (developing countries) inform not only which results are technically viable, but also which procedures are acceptable, particularly when existing decision-making structures are perceived as, on one hand, favoring developed countries and inhibiting the equal participation of develop-

ing countries, but, on the other hand, providing loop holes that allow developing countries to avoid any form of substantial commitment to shoulder financial costs of climate change mitigation. With this, the North-South conflict cleavage moves along the contestation line of how countries understand justice, fairness and equity and how they see themselves profiting when a specific definition of the principle is chosen (Penetrante, 2010, 2013a, 2013b).

The terms "justice" and "fairness" are usually used as synonyms in the academic literature. Nevertheless, the negotiation literature makes a clear distinction between these two terms. While justice refers to whether an outcome satisfies the predetermined goal, fairness pertains to the procedures by which decisions are made. Cecilia Albin (2001, p. 264) follows a similar differentiation between justice and fairness. She notes that agreements (as the outcome of the negotiation process) are just if these agreements are based on principles that the parties themselves consensually agreed. An agreement is fair, she continues, if the circumstances leading to the agreement are reasonable. For example, as parties have agreed to limit global temperature rise to 2 °C, when provisions of a global agreement would fail to meet such a goal, these provisions are not just. Following this logic, when the parties to the UNFCCC have agreed to the principle of sustainable development, an agreement is just if it does not undermine sustainable development of all countries.

However, a just agreement does not guarantee fairness. A just agreement can be unfair for example when the methods applied to reach the goal do not consider the various diverging capacities of actors. For example, when, hypothetically speaking, the global temperature rise has been effectively limited to 2 °C and this has been reached by posing heavy financial burdens upon developed countries, the agreement that allowed this achievement is unfair, when developing countries, although they could, did not shoulder burdens. In the same manner, an agreement is unjust when developing countries, when achieving the 2 °C goal, were *de facto* exposed to more social burdens, as they also need to confront developmental challenges while pursuing climate protection.

The climate change negotiations are inhibited by the situation where countries, due to the lack of consensus on how justice, fairness and equity are to be operationalized, talk past each other. For instance, developing countries, particularly those with the largest emerging economies such as China and India, may demand fairness by seeking exceptions from legally binding GHG emission reduction schemes by arguing that developed countries are held historically and morally responsible for the current concentration of GHGs in the atmosphere. This demand may however be in opposition to the fairness demanded by developed countries, particularly when certain developing nations such as China and India are projected to bypass developed countries in terms of GHG emissions in the next few years or decades. Furthermore, adhering to the claims of fairness of either developed or developing countries may lead to an agreement that is not just, as the 2 °C goal may not be met.

Equity may be undermined when Least Developed Countries (LDCs) see other developing countries with emerging economies such as China and India as hiding behind claims of justice and fairness to underestimate their real capacities to reduce emissions, particularly when the level of economic development of several developing countries are *de facto* comparable to that of developed countries. When countries refuse to participate in burden sharing, although they have the capacity to do so, equitable relationships are distorted.

EQUITY IN CLIMATE CHANGE NEGOTIATIONS — QUESTIONS OF COMPLIANCE AND GLOBAL COMMON GOODS

There is general consensus among Parties to the UNFCCC that issues related to equity are of central importance in global climate talks (Grübler and Fujii, 1991; Ott *et al*., 2004; Buchner and Lehmann, 2005; Heyward, 2007). The resilience and stability of any future climate regime requires the reflection of the equity concerns of all countries (see Penetrante, 2013b). As Katherine Richardson *et al*. (2011) note, response strategies to deal with climate change will invariably confront equity issues such as the allocation of emission rights and emission reduction obligations, as well as the responsibility for funding adaptation and distribution of adaptation funds. The principle of equity has been most frequently applied to the allocation of mitigation costs among countries. Furthermore, dealing with the equity aspects of climate change will depend on the relational structures in the decision making process, whereas existing power asymmetries should not undermine the quality of participation of weaker actors. That the system incurs power asymmetry is an inevitable condition due to diverging levels of economic development, but when a system is to be equitable, mechanisms should be found where differences in power resources do not inhibit participation or puts overburden on weaker parties. This is, for example, the case when the agreement is based on genuine consensus.

The perceived abandonment of equity principles of the UNFCCC and the Kyoto Protocol, as claimed by many experts in developing countries (Najam, 2005; BASIC Experts, 2011), is to a large extent a result of un-

resolved fairness issues due to structural deficits that still need to be confronted. For example, the UNFCCC does not clearly articulate the quantified meaning of equity, but rather has identified only the categories of developed and developing countries. As a principle that involves normative elements, it is not possible to come up with an "objective" technical formula. Equity has become a diffuse term, and the interpretation of how it should be operationalized is easily subordinated to national interests (Heyward, 2007; Kals and Maes, 2011). In light of this, the UNFCCC secretariat has started an academic discourse around equity, to initiate attempts at specifying possible standards of equity, and to explore how equity issues should be pursued in global climate talks. Although it is again not possible to find an optimal formula, what is relevant for the climate change negotiations is the consensus on this principle. In addition, from the negotiation perspective, questions of how equity can ensure compliance should be additional topics of public deliberation (Penetrante 2013b).

Equity is a theoretical concept that describes how actors orient their own behavior in a social environment. John Stacey Adams (1965) suggests that equity is a precondition to engage in contacts with others. The equitable condition is considered as the optimal situation (equilibrium), as actors will no longer experience distress in situations where they are convinced that the ratio of what they contribute (input) and what they earn (output) is generally acceptable (Penetrante, 2013b). Inputs are each participant's contributions to the relational exchange, which entitles one actor to rewards or benefits. Examples of inputs are time, effort, resources, ability, commitment and various forms of liabilities (see Walster *et al*., 1978). Outputs are positive and negative externalities incurred as a consequence of this relational exchange when achieving a common goal. Examples of outputs are financial benefits, recognition, and the achievement of predetermined goals (Walster *et al*., 1978). It is assumed that actors seek to maximize outputs, and that a failure to do so brings distress. As such, when actors encounter distress (for instance, when negotiating with the others), efforts are conducted to restore equity within that relationship.

The theory of equity is only applicable in a social context, as the acceptability of a specific situation or of a specific outcome highly depends on one's assessment of how much input the others have so far contributed (Penetrante, 2013b). Equity is measured by comparing one's ratio of inputs and outputs to that of others. Similar ratios manifest equity whereas actors do not need to contribute equal amounts of inputs in absolute terms nor do they need to receive equal rewards (see Guerrero *et al*., 2010). Equity also covers individual capacities in contributing inputs. Distress occurs when one actor sees another actor with similar capacities but lower contributions receiving similar or greater outputs from the common project. More distress arises when non-contributing free-riders harvest common benefits. Distress inevitably leads to actions.

The social component of equity delivers the identification of equity issues as actors constantly compare their actions with those of the others (Adams, 1965; Guerrero *et al.,* 2010). When actors perceive deficits in the inputs of the others, they aim for additional efforts to restore equity in global climate talks. In the climate talks, differentiated inputs are expected among countries depending on their level of economic development (capability) as well as their historical responsibility. Nevertheless, the incommensurability of inputs is aggravated by conditions of non-exclusivity and yet rivalry as climate change deals with global common goods where actors cannot be clearly attributed with liabilities, benefits and rewards of stabilization of GHG emissions leading to the achievement of 2 °C.

Actors, when seeking equity in their relationships, establish institutions and mechanisms that "equitably" apportion rewards and sanctions among members (see Walster *et al.*, 1973, 1978) to allow alterations of inputs and outputs in order to restore "actual equity" (Walster *et al.,* 1973, p. 6). Various issues of equity are embedded in the UNFCCC (1992) as well as in the Kyoto Protocol to ensure that the outcomes of these rigid and tedious compromises will remain robust against future challenges. The principle of common but differentiated responsibility (as highlighted in Article 2 of the convention) recognizes that while all countries should protect the climate system, developed countries should take the lead in combating climate change, because they bear the greater burden of historical responsibility and possess a superior capacity to respond (Oppenheimer and Petsonk, 2005).

Nevertheless, it has become a huge question whether equity can ever be achieved under huge gaps between what actors understand as equitable. Developing countries allege that some forms of equity were quickly abandoned, particularly by developed countries (Huq and Sokona, 2001; Najam *et al.,* 2003; BASIC Experts, 2011). Doubts become imminent around whether inputs and outputs of countries are in any way commensurable, particularly when the expected output is calculated in relational terms (for example, when dividing the benefits of stabilizing GHG emissions in the atmosphere among all countries). For instance, if the United States would accept legally binding mitigation targets as its input, the impact of this action to the environmental integrity of the agreement would be more significant than any action committed by other coun-

tries. Should inputs which would be highly significant to ensure the effectiveness of the agreement in achieving the predetermined goal be counted, for example, as double when compared with the inputs contributed by smaller countries with very low emissions (such as Fiji or Mali), especially when the preferences for equity between these countries are very different?

Furthermore, when the input of the United States has undergone a very tedious political process (e.g., Congress approval), how is this input to be compared with that of other countries where the political structures allow a rather quick national decision-making? An equitable outcome needs to address diverging national conditions that promote or inhibit participation in the global climate change negotiations. In addition, as the vulnerabilities to climate change are different, the stakes at the negotiation table and the expected liabilities when doing nothing are also different. While for some countries, it is a matter of ensuring economic competitiveness in a globalized world, for others, it is a matter of national survival and the continued existence of their citizens.

Especially when it is not possible to exclude other big polluters from harvesting benefits (the non-exclusion principle of global common goods), and when emission reductions may even encourage emission growths among developing countries through various forms of leakage effects (Finus, 2001; IPCC, 2007, p. 53) undermining just outcomes, equity is only possible under four conditions. These are: 1) when inputs and outputs are comparable, 2) when fair procedures are present when establishing mechanisms for compliance and verification, 3) when equitable behavior is more profitable than inequitable behavior, and 4) when there is no free-riding to ensure just (and therefore effective) outcomes (Penetrante, 2013b).

INTERNALIZING EXTERNALITIES IN A POWER GAME – CALL FOR NETWORK LOCK-IN EFFECTS

Although inputs and outputs are not always comparable, this does not mean that equity is impossible to reach. From the negotiation perspective, the next step for the analysis of equity should focus on finding strategies to increase negative externalities of free-riding compared to the benefits of doing nothing (or "business as usual"), while ensuring fair procedures and just outcomes (Penetrante, 2013b). This is possible by finding a concept of equitable access to sustainable development wherein countries realize that non-compliance (or non-equity) is less profitable than compliance.

As the secretariat of the UNFCCC and its parties prepare for the upcoming COP meetings, with the intention of putting in place a post-Kyoto emission regime, international experts have been asked to come up with ideas how the newly agreed principle of *"equitable access to sustainable development"* (EASD), which would be used by parties to guide their climate policies and their preferences in the next negotiation rounds, should be conceptualized, in a way that parties can overcome various North-South conflict cleavages without undermining the effectiveness of the outcome in addressing climate change. This research project argues that any principle of equity should fulfill the above-mentioned conditions: *de facto commensurability of inputs and outputs, procedural justice (fairness), and profitability of participation through additional negative externalities for free-riding* (Penetrante, 2013b).

The reconciliation of tension between "*global climate optimum*" and the "*national climate optimum*" is a huge challenge for the global climate talks (Endres, 2008, pp. 350–352). The global climate optimum refers to a situation where the total marginal costs of preventing global temperature change from surpassing 2 °C correspond to the total marginal costs caused by climate damages. The national climate optimum, in contrast, is a situation where the marginal costs of national climate protection measures match the total marginal costs of climate damages in one specific country. Due to the asymmetrical distribution of vulnerabilities to climate change, as well as the proposed asymmetrical allocation of emission targets dealing with global common goods, formulating global decisions within the global climate optimum remains a huge challenge (Penetrante, 2013b).

As global decisions are made through a national lens, the national climate optimum dominates the bargaining table, as the paradigm of sovereignty has been locked into the negotiation process. Moving from the national to the global optimum requires, besides the unknown amount of transition costs, an increase in the benefits of committing to a global climate optimum. As climate is a global common good, some national governments are convinced that their total marginal costs for climate protection measures are higher than the total marginal costs of preventing climate damages, not only because they may be less vulnerable, but because they have the capacity to free-ride. As the expected costs of rejecting a contribution for global protection measures are often less than complete participation in the global emission regime, free-riding behavior flourishes (Penetrante, 2013b). Therefore, a country seeking a global climate optimum expects deterioration of welfare as well as of economic competitiveness, for example through the relocation of high emitting companies to countries with more relaxed climate policies

(Finus, 2001). In instances such as these, free-riding is the most rational behavior.

There are already propositions how to bridge the gap between marginal social costs and marginal private costs (Barthold, 1994; Varian, 1994; Farzin, 1996). Internalizing negative (and positive) externalities is seen to prevent this free-riding problem by allocating (monetary) values to common goods, through which the attractiveness of doing nothing diminishes. Examples of internalizing externalities include Pigovian tax directed to the actors either causing the externalities or positively affected by externalities, combined with direct and indirect forms of subsidies to actors affected by negative externalities, where subsidies are shouldered by tax revenues. Internalizing externalities primarily aims to increase the marginal private costs and to compensate those shouldering social costs. Other forms of internalization include environmental pricing schemes such as ecotaxes and trading pollution permits.

Nevertheless, internalizing externalities is confronted by various challenges. For instance, it is not always possible to identify monetary values for externalities. When the value of carbon permits is too low, participating actors may be discouraged from changing their behavior, as the internalizing measure may not really increase marginal private costs and polluting may promise more dividends. When monetary values are set too high, it would be most likely that countries would not agree to any agreement at all, particularly when particular heavily burdened countries would require additional efforts to instigate behavioral change. These highly contextual additional efforts should be included in the calculations. Internalizing externalities can only be effective if the measures taken would increase marginal private costs to a level that surpasses marginal private benefits under the "business as usual" scenario, and that they are made to shoulder more marginal social costs (Penetrante, 2013b).

Another challenge refers to the exact attribution of costs to those actors directly or indirectly causing the externalities. Under conditions of complexity, externalities may not always be relatable to those actors causing externalities. Complexity may also include issues resulting from forward-direct problems (with a given input X under the conditions set by the system, the output Y is determined), inversion problems may arise, whereas tracing back the relevant inputs to the output under certain conditions of the system is highly problematic. The attribution of externalities becomes the subject of fairness, justice and equity deliberations when a specific externality is caused by a collectivity within a specific (long) time period involving multiple generations and even changing political national entities (e.g., can the current Russian Federation government be held accountable for the decisions made by the Soviet Union's government?), and that this externality is only materialized after a specific number, degree or level has been reached (e.g., should the last contributing actor be held accountable to the occurrence of the tipping point?)

For example, several experts claim that European countries have regularly contributed up to 80 per cent of the global GHG concentration in the last centuries (Müller, 1999; Pachauri and Reisinger, 2007). However, when global temperature rise surpasses 2 °C, and the "tipping point" is reached by additional emissions from developing countries, the damages may be easily attributed to the latter emitting countries. Particularly, when past emissions are considered as sunk costs, there is tendency to over-value present costs and disregard sunk costs in the calculation of marginal private costs. This leads to an imbalance of attribution. Additionally, in order to internalize externalities through legally binding measures, a government, legal framework and legislation must already exist at a global level in order to ensure effectiveness. This is presently not the case (Penetrante, 2013b).

Because the internalization of externalities has a compensatory character, it is likely to be a subject of political contestation, moving it away from an economic to a political paradigm. In contrast to an economic paradigm, where decisions are made according to costs and benefits, political paradigms foster power struggles, which may favor powerful parties. When powerful parties are considered as the "entrepreneurs of externalities", an underestimation of externalities may occur. Further, when powerful parties are considered to be "recipients of externalities," compensatory payments may be overestimated. This power game debars the logic of internalizing externalities, as the matching of marginal private costs with marginal social costs will more than likely be distorted (Penetrante, 2013b).

Nevertheless, the profitability of free-riding may be diminished by using the insights of path dependence (see David, 1988; Arthur, 1994). According to path dependence, the adoption of a specific standard becomes more attractive to the participants when alternative standards become more expensive, for instance, through network effects (Liebowitz and Margolis, 1994). When the majority of participants adhere to a specific standard, network effects become significant as this standard becomes "locked-in" and this is then reflected in other technologies and future decisions. A locked-in standard implies that other (competing) standards become more expensive, for instance, when opportunity costs arise by not adopting the lock-in standard. Under network effects, non-adherence to the standard becomes too costly, that actors are motivated to par-

ticipate, whereas the lock-in standard does not need to be the most efficient mechanism or value (Vergne and Durand, 2010; Penetrante, 2013).

In the climate change context, when the majority of countries have adopted climate protection standards, other (high-emission) standards (e.g. business as usual) will eventually be more expensive, particularly when standards related to low emission technologies have been asserted in subsequent technological development. For example, when adhering to the climate protection standard ensures access to additional and niche markets such as the carbon market, or when this standard leads to the type of technological development in related fields that could not have been reached in a "business as usual" situation, countries are motivated — if not forced — to rethink their paradigms if they are to prevent further loss in competitiveness (Penetrante, 2013b).

As countries realize that unacceptable opportunity costs are arising and that their economic competitiveness is undermined by missed opportunities, they will be motivated to follow the majority in adopting the climate protection standard. New pressure groups that benefit and support energy policies and that promote climate protection measures may later on outweigh those that hinder climate protection policies. Groups of this kind represent companies in the renewable energy sector, and forward proposals such as increasing the share of renewables in a country's energy portfolio. With new environmental standards inevitable, governmental agencies and business communities may be more readily prepared to commit to further climate-friendly investments. Free-riding becomes irrelevant, as business as usual is translated into diminishing economic competitiveness when the lock-in standard is not adopted. In this case, compliance becomes optimal as non-compliance means unacceptable additional costs and additional economic disadvantages.

A fundamental question then arises: How can most of the countries be motivated to adopt climate protection standards, particularly when adoption causes short-term economic disadvantages as caused by various leakage effects? As path dependence argues, these short term economic disadvantages when adopting new standards are merely transition costs, that is, the costs of changing pathways. For example, leadership can be tapped in order to facilitate this transition when leaders are willing to shoulder short-term transition or switching costs. This is however only feasible when leading countries see long-term benefits under conditions of uncertainty. By anticipating long-term benefits, including economic advantages as "first movers", major countries may be motivated to initiate ambitious policies and investments that only yield rewards in the long-term.

A PRINCIPLE OF "EQUITABLE ACCESS TO SUSTAINABLE DEVELOPMENT" (EASD)

Finding an overarching principle of EASD requires an integrated outlook on principles that are either mutually complementary or mutually in competition. Embedding the principles of equity, access, (economic) development and sustainability will most likely result in an overarching principle that requires extensive consensus-building. As discussed in the paper, resolving equity issues pre-requires a consensual definition that preempts its usage as pretext to non-actions or as legitimizing factor for actions that undermines the integrity of any resulting outcome. Linking equity to other principles which equally offers political resources for free-riding may further undermine its functionality.

The various definitions of sustainable development as well as many divergent interpretations and practical applications (Gibson, 2005; Hopwood *et al.*, 2005; Elliott, 2013) make public deliberation necessary. With this, the EASD should be clearly consensually defined by the Parties to the UNFCCC. Besides equity, the EASD deals with "access," "development" and "sustainability" which are, similar to equity, loose concepts with diverging possibilities of understanding and operationalizing. The EASD principle will involve various expanded conflict cleavages that are identifiable as moving not only within the various fronts of North-South relations, but also within North-North and South-South relations.

Relating the EASD principle to the global climate talks moves the focus not only to the fairness of procedures but to the providing the basis for just outcomes. Access deals with procedural mechanisms that define how actors enter a mechanism that would enable them to fulfill their goals. The ability of making use of available resources (access) is a procedural question that is very often *de facto* dependent on structures reproducing power asymmetry among actors. As the IPCC Second Assessment Report (SAR) (1995) noted, a climate regime cannot be equitable in its structure and implementation if it does not follow a legitimate process that empowers all actors to effectively participate as social peers (Fraser, 2003). The ability of parties (to access) should not depend on existing power structures because this negates the principle of equity as power capabilities of each actors does not absolutely depend on one's own past actions. Access to resources is only equitable when individual conditions that inhibit inclusions are identified and remedied in a compensatory manner.

Furthermore, the EASD principle needs to deal with another controversial coupling of existing prin-

ciples. "Sustainable development" is a concept that incorporates the understanding that an optimal (sustainable growth) policy is a policy that seeks to maintain an "acceptable" growth of income without depleting the natural environmental stock (Turner, 1988, p. 12; Gibson, 2005). It asserts that "*development that meets the needs of the present generation* [is possible] *without compromising the ability of future generations to meet their own needs*" (WCED, 1987, p. 43). Relating the coupled principle of sustainable development to the climate change negotiations is the direct ramification of externalities. The integration of sustainable development in the EASD intends to promote the analysis at how climate protection measures such as GHG emission reduction can produce co-benefits for sustainable development, particularly to weaken the tensions between sustainability and development arise (Jabareen, 2006).

The global climate talks have been confronted by developmental concerns of parties when climate and developmental agendas have been merged (UNEP, 1992; African Development Bank, 2003; UNDP, 2007; World Bank, 2010). Recent calls to decouple emissions from development (UNFCCC, 2012) have become prominent as a feasible strategy to resolve some highly contested issues. However, insights are still needed how such a decoupling could and should be conducted in a very complex and interdependent system. In particular, when climate protection is taken as pretext to limit access to sustainable development of developing countries, decoupling would require more than mere guarantees. The classification of developed countries to the Annex list and of the developing countries to the Non-Annex list may have institutionalized the North-South conflict cleavages in the negotiation process. Climate issues dealing with questions of population (human settlement), (urban) lifestyles and resource demand and consumption (agricultural and industrial production) involve economic and social activities that are confronted by limits on environmental resources (Ehrlich, 1968; Meadows *et al.*, 1972; Jackson, 2008). Any climate regime that would allocate carbon limits would need to include stringency provisions that would equitably distribute limits among countries.

The drafting of the UNFCCC is part of a process following calls from scientific (epistemic) and advocacy communities for putting environmental issues into the political area of international policy making (Penetrante, 2013b). The UNFCCC is a result of political deliberations between countries which serves as framework for a long and tedious decision-making process without clearly knowing what concrete decisions will be achieved at the end of the process. Under such a condition, the negotiation process can only run in phases or stages to achieve sequential agreements with limitations on durations attached to provisions due to complexity. This condition necessitates constant re-negotiations where set-backs are to be observed as the negotiation process is non-linear. Therefore, the more concrete the terms of negotiation frameworks such as the UNFCCC are drafted, the less are insecurities to be found in following negotiation rounds. For example, the lack of concrete provisions on voting procedures under the UNFCCC is seen as a regular source of delays as parties can always challenge *de facto* premises. Nevertheless, very concrete terms in the paragraphs of a convention may limit the sets of possible instruments and future outcomes as flexibility and creativity may be inhibited when agreements are being drafted.

A further complexity that significantly influences the course of the negotiation process under the UNFCCC is its inter-linkage with other environmental issues. In 1984, the UN commissioned an independent body, the so-called *World Commission on Environment and Development* that published a report entitled "Our Common Future" (1987). The deliberation initiated by this commission has been used as the basis for other conferences, including the UN Conference on Environment and Development in Rio de Janeiro in 1992. This "Earth Summit" has resulted in various agreements including the 1992 Rio Declaration on Environment and Development, Agenda 21 and Forest Principles. Complementing these agreements are the three legally binding agreements: The UNFCCC (1992), the Convention to Combat Desertification (1992) and the Convention on Biological Diversity (1992). Subsequent agreements including the UN's Millennium Development Goals (2000) and Outcome document — Future We Want (2012) reached during the UN Summit "Rio+20" held in Rio de Janeiro in 2012 have secured further political commitment for sustainable development.

The inter-linkage of climate issues is a two-way channel. Not only that climate change negotiations are directly and indirectly affected by other negotiations, the results of climate change negotiations also affect other negotiations. For example, the latest negotiations surrounding the 1972 World Heritage Convention are often conducted in the context of climate change. As climatic changes such as sea level rise pose threats to world heritage sites, climate change negotiations should be consistent with legal obligations under the World Heritage Convention or that policy-makers deciding on world heritage issues may refer to the UNFCCC and COP meeting decisions when, for example, looking for funds for conservation (Australian Climate Justice Program *et al.*, 2008; Earth Justice, 2009).

Guaranteeing environmental integrity in the context of sustainable development currently dominates the political discourse not only in the climate change negotiations but also in other environmental negotiations. Nevertheless, it should be noted that sustainable development is often perceived as the goals only of developing countries. However, when developed countries refuse to agree on global decisions because they see their economic competitiveness threatened, they express the interest to maintain their economic status, which is a legitimate concern. With poverty incidents in developed countries observed as rising and with the increasing middle class in several developing countries seen as economically better situated than a significant part of the population in developed countries, anti-poverty issues are not exclusively concerns of developing countries.

While there is more likely a consensus among countries that poverty is a major cause and effect of global environmental problems such as climate change, and that sustainable development is a central concern of both developed and developing countries, national governments will need to define equitable allocation mechanisms that would allow equitable access to resources and capacities — including carbon emissions in the case of climate change — that enable, maintain and enhance sustainable development. National governments are furthermore uncertain as to how many emission limits are tolerable to guarantee sustainable development without jeopardizing their political legitimacy. Particularly countries in political transition (e.g., neo-colonial or neo-authoritarian regimes) require stable governments. Because climate change poses threats to the ecosystem upon which economic, social and environmental activities of both present and future generations rely, the goals of the UNFCCC, that is, the stabilization of GHG emission concentration that prevents surpassing 2 °C, have become closely linked to the goals of sustainable development. This has inevitably led to the coupling of emissions to sustainable development (Penetrante, 2013b).

As carbon emissions are linked to industrialization and manufacturing, as well as to agricultural outputs (Stern, 2007), setting up a carbon budget that aims to stabilize GHG concentrations is assumed to have negative effects on economic growth, the driving motor of sustainable development (Penetrante, 2013b). Economic growth is then translated to four main areas. These include: increase of per capita income that drives private consumption (Lucas, 1988; Barro, 1997; Pokrovskii, 2011); modernization processes including enhancement of human and social capital that ensure social cohesiveness (Bourdieu, 1983; Becker, 1993; Haq, 1996; Dasgupta and Serageldin, 2000); legitimacy of governance and political structures that ensure political stability (Kooiman, 1993; Fisher and Green, 2004; Ostrom, 2010); and finally technology innovation through investments and financing, which promotes the global competitiveness of individual countries (Jonas, 1984; Carraro and Siniscalco, 1994). Economic growth is therefore the foundation of human well-being (Penetrante, 2013b).

In this sense, trade-offs between climate protection strategies and sustainable development goals may lead to grave concerns in distributing emission cuts among countries, as emission reductions may impose limitations on economic growth and development. Legally binding commitments may distort the competitiveness of countries irrespective of their current economic developmental status. Equally, reaching the goals of sustainable development may generate co-benefits, particularly when enhanced economic capacities may lead to diminishing vulnerabilities or to increasing adaptability to climate change. When the current economic development of a country solely determines the quality of climate protection a country can commit to and when climate protection leads to further economic advantages resulting from co-benefits such as more employment in green technology and more technological innovations, present day developing countries may experience further limitations to its future access to sustainable development. Therefore, a principle of EASD should address complex (present and future) trade-offs between climate protection strategies and sustainable development (Penetrante, 2013b).

The following table simplifies the distribution of shares and entitlements of GHG emissions and illustrates the conflict cleavages between developed and developing countries. It shows the gap between the share of developed and developing countries in historical emissions (1850–2000). The UNFCCC asserts that emissions should be calculated from the beginning of the Industrial Revolution, something that has been recognized by most participating countries. It confirms that developed countries account for 878 Gt of cumulative global emissions between 1850 and 2008, with 310 Gt considered as their fair share (with an overuse of 568 Gt) (Khor, 2012). This poses a huge challenge for any future emission reduction regime when distributing entitlements for future GHG emissions (2000–2049).

The determination of equitable allocation of entitlements in the future carbon budget (2000–2049) between developed and developing countries is not only highly dependent on figures and calculations in the scientific literature, particularly of the IPCC, but is also vulnerable to political conditions. For instance, the identification of 2 °C among possible scenarios (2 °C,

Table 1. Analysis of Shares and Entitlements (Penetrante, 2013b)

Actors (countries)		Developed Countries (Annex)	Developing Countries (Non-Annex)	Total
	Number of countries (percentage to total no. of countries)	41 countries	154 countries [BASIC: 5 countries (3.2% of all developing countries)]	195
	Percentage to total no. of countries	21%	79%	100%
	Share of population	25%	75%	100%
Issues	Historical Emission (1850–2000) in accumulated numbers[1], in GtC	210	55.44 [BASIC: 27]	265
	Historical Emission (1850–2000), contribution in percentage to total concentration	80%	20% [BASIC: 50% of developing countries' historical emissions]	100%
	Cumulative global emission per capita (1850–2008)[2]	878 Gt (72% of total) (fair share with 25% of global population: 310 Gt)	336 Gton (28% of total) (fair share with 75% of global population: 904 Gt)	1214 Gt
Structures	UNFCCC (legal framework)	Parties	Parties	192 parties (191 countries and 1 regional organization)
	Industry norms and standards on environmental protection	Medium or highly advanced	Low or highly advanced	
Processes	Negotiation mode (bilateral and multilateral)	No clear preference on negotiation mode	General preference on multilateral negotiation mode. Tendency for BASIC to conduct bilateral negotiations	
	Coordination	Regional organizations (e.g. EU), coalitions (G8, G20)	Regional organizations (ASEAN, MERCOSUR), coalitions (G77+China; BASIC, AOSIS)	
(Possible) Outcomes (emission reduction, carbon budget)	Achievement of 67% probability of limiting temperature rise to within 2 °C (2010–2050)	21% entitlement: 157.5 Gt 25% entitlement: 187.5 Gt	79% entitlement: 790 Gt 75% entitlement: 562.5 Gt	< 750 Gt
	Achievement of 67% probability of limiting temperature rise to within 1.5 °C (2010–2050)	21% entitlement: 126 Gt 25% entitlement: 150 Gt	79% entitlement: 474 Gt 75% entitlement: 450 Gt	< 600 Gt
	Cumulative total CO_2 emissions. 2000–2049 (with 25% probability of exceeding the 2 °C temp. increase limit)[3]	21% entitlement: 210 Gt 25% entitlement: 250 Gt	79% entitlement: 790 Gt 75% entitlement: 750 Gt	1000 Gt
	Cumulative total CO_2 emissions. 2000–2049 (with 50% probability of exceeding the 2 °C temp. increase limit)[4]	21% entitlement: 302.4 Gt 25% entitlement: 360 Gt	79% entitlement: 1137.6 Gt 75% entitlement: 1080 Gt	1440 Gt
	AWG-KP's wording of the level of its ambition (August 2007) [5]	25% to 40% emission reduction below 1990 levels in 2020	"Deviation from baseline"	emissions peak by 2017 to 2022 and at least 50% emission reduction of the 2000 level by 2050

[1] Starting year 1850, excluding historical LULUCF, data source: CAIT (WRI, 2009, 2012).
[2] Source: Khor, 2012.
[3] Source: Meinshausen, 2009.
[4] Source: Meinshausen, 2009.
[5] Source: Den Elzen and Höhne, 2008.

3 °C, or 4 °C) is a political decision which addresses (still) acceptable consequences of climate change with a global temperature rise of 2 °C. Because the 2 °C refers to a global average, some countries or regions may actually experience a temperature rise of more than 2 °C which define their positions on the responsibilities the others should be fulfilling. As vulnerabilities vary among countries, with some able to adapt quickly because of their economic status, equitable allocation mechanisms should consider introducing "adaptation rebates" that depends on their exposure to climatic effects. With this, in parallel to negotiations referring to adaptation, the entitlement the countries should get needs to depend on how vulnerable they are to the effects of climate change to allow a level of economic development that enables countries to adapt without undermining development. This should not, however, be exclusive to developing countries.

Nevertheless, as political decisions are now oriented towards the principle of equitable access to sustainable development, categories such as historical responsibility, per capita income, national capabilities and national vulnerabilities are needed to determine entitlements, carbon budget and how efforts/burdens are to be equitably distributed. However, political decisions assume that all countries require the same amount of emissions to achieve industrialization, whereas new technologies tend to produce low emissions, particularly when efficiency is coupled with less energy consumption (Penetrante, 2013b).

As the table illustrates, entitlements to cumulative total CO_2 emissions (2000–2049) can be equally (in absolute numbers) distributed among countries (the "desert" strategy). However, equality does not always correspond with equity as equality does not always address the individual circumstances that inhibit or promote participation in the decision making process. Allocation of emission rights to countries, as several countries demand, should address the relative share of the country's population in the global population in a given specific base year. This allocation scheme is, however, rejected by smaller countries with smaller populations. Per capita calculations do not address economies of scale which foresee decreasing emission rebates as the population increases. Countries with small population need to use a threshold of resources such as infrastructures to maintain certain living standards. For example, Qatar, Kuwait and Bahrain belong to the five highest per capita emitters as a result of small populations producing high emission commodities for export. Similarly, a number of small-island states rank relatively high in terms of per capita emissions, including Trinidad and Tobago, Antigua and Barbuda, Singapore, Palau and Nauru (Baumert *et al.,* 2005, p. 21). In this case, the level of emissions of countries is no longer determined by its contribution to the GHG concentration in the atmosphere. The most effective solution in this case would be to increase its population to mitigate climate change which does not serve the UNFCCC's (environmental) goals.

Furthermore, a formula that focuses on per capita emissions may be unjust as it distorts environmental integrity. Sticking to per capita emission allocation may prevent the achievement of an agreement that would adequately mitigate climate change to an acceptable level. As such, entitlements for future emissions as conveyed by the UNFCCC will need to include not only current emissions, but also historical emissions (Grübler and Fujii, 1991; Smith, 1991). Developing countries are also expected to have large positive entitlements as a result of the negative entitlements of developed countries for the period of 2000–2049 (BASIC Experts, 2011), which may further undermine the environmental integrity of any proposed outcome, because developed countries are then expected to have negative emissions (baseline 1990), which to date remain politically unacceptable.

Negative entitlements for developed countries remain a highly contested issue as developed countries are not likely to find it equitable that current generations are to be "punished" for the actions of older generations. In addition, as negative entitlements for developed countries would mean positive entitlements for developing countries, contra-productive leakage effects may take place, overturning all gains from climate policies and leading to "unjust" outcomes that undermine the environmental integrity of the agreement (Penetrante, 2013b). In addition to business companies using high emitting technologies, and relocating to (developing) countries with more relaxed climate policies (a leakage effect of 100%) (Gerlagh and Kuik, 2007), developing countries may be motivated to increase their use of high emitting fossil fuels (more than the initially intended level) due to falling world prices following more ambitious climate policies in developed countries, thus, further increasing emissions from developing countries (Endres, 2008). In addition, sinking prices for fossil fuels may actually inhibit investment in renewable technologies, delaying the development of more efficient and less costly renewable energy technologies. With such leakage effects, estimated by IPCC (IPCC, 2007, p. 53) to range between 5–20 percent (with Kyoto Protocol in place), the benefits of ambitious climate policies may be less than the mitigation costs. These are similarly legitimate concerns that need to be addressed.

While developed countries have contributed the most emissions in the past, developing countries are

projected to produce most of future emissions, while their per capita emissions are projected to stay below the levels of developed countries (IPCC, 2007). In addition, future emissions vary in how they translate to responsibility, as various types of emissions — "survival emissions", "developmental emissions" and "luxury emissions" (Agarwal and Narain, 1991; Shue, 1993; Rao and Baer, 2012) — are to have different meanings, leading to more integrated and comprehensive political assessments. Therefore, the financing of low-emission technologies as well as the means to increase energy efficiency should become priorities for developing countries. The UNFCCC (2007) estimates that at least $65 billion is needed in additional mitigation investments by 2030 to enable developing countries to maintain their entitlement. In addition to the question of how this considerable amount for investment is to be shouldered (and by whom), additional hidden costs such as transition costs in choosing a low emission technology path may not be bearable for individual developing countries, particularly when a significant amount of financial resources are already needed to cope with the damages brought on by climate change (Penetrante, 2013b).

Furthermore, measures are also needed to equitably distribute emission rights among developing countries, particularly when the five BASIC countries are expected to contribute the most to the increase of emissions (IPCC, 2007). This raises the question of how national conditions are to be considered in any allocation mechanism. While some countries — such as Australia, Canada and China — are highly dependent on certain high emission technologies (including coal and shale gas), others possess natural resources favoring low emission technologies, such as Norway and Russia. Thus, national conditions favoring or hindering low emission technologies should be subjects of allocation calculations (Penetrante, 2013b).

CONCLUSION

With economic optimization methods unable to address power struggles, climate change mitigation highly depends on the negotiation process to resolve issues caught between various conflict cleavages. Maximizing utility basically means finding a settlement, because any agreement is collectively speaking better off than a situation without any agreement. An agreement through negotiations will need to be just, fair and equitable for it to guarantee its purpose and implementation.

The entanglement of the climate change negotiations in the North-South divide will be resolved when power asymmetries are overcome through effective compensation mechanisms that debar any factor that qualitatively limits the participation of any actor — both weak and strong, both in the center and in the periphery of global decision-making. Particularly equity is central to the negotiation framework as only through participation can a system be legitimate. Nevertheless, the first big step for country governments is to find a common understanding of equity that is not a subject to national interests if equity is not to be reduced as merely pretext to national agenda. Although a theoretical concept with various possible definitions, equity can be consensually defined by identifying its meaning for the negotiation process and for any outcome that can be achieved.

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Using Simulation Models for Green Economy Policy Making: A Comparative Assessment*

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Abstract. In the run up to Rio+20 one area of research that has received considerable attention is the development of methodologies and tools for the identification of worrying economic, social and environmental trends, and the evaluation of potential interventions through the analysis of alternative future scenarios. In fact, the main contribution of a green economy approach has been identified as being the integration of sectoral interventions in a coherent, cross-sectoral framework of analysis. This study analyses the main methodologies and models currently available to carry out a green economy assessment and concludes that the selection of these tools should be done on a case-by-case basis, depending on specific country needs and priorities. In addition, different models could be combined to inform the various phases of the policy cycle, and maximize the effectiveness of green economy interventions.

Аннотация. В период до «Рио+20» (Конференции ООН по устойчивому развитию в Рио-де-Жанейро 2012 г.) значительное внимание уделялось исследованиям методик и инструментариев для выявления тревожных экономических, социальных и экологических тенденций и оценки возможных интервенций на основе анализа альтернативных сценариев будущего. Основным вкладом «зеленой экономики» как подхода является интеграция секторальных интервенций в единую межсекторальную систему анализа. Это исследование анализирует основные сегодняшние методики и модели для оценки «зеленой экономики» и делает вывод, что выбор этих инструментов должен проводиться на индивидуальной основе в зависимости от потребностей и приоритетов каждой страны. Кроме того, различные модели могут быть объединены, чтобы обеспечить поддержку политического цикла в различных его фазах и максимально повысить эффективность интервенций «зеленой экономики».

Key words: green economy, simulation models, quantitative methods, integrated analysis, sustainable development.

INTRODUCTION

The misallocation of capital in the last two decades has contributed to the manifestation of several concurrent crises: climate, biodiversity, energy, food, water, as well as the global financial and economic crisis. In response to these systemic crises, UNEP has stressed the need for a shift to more sustainable and inclusive economic, social and environmental policies, which can enable the transition to a green economy. At the visionary level, UNEP (2011) considers the green economy as:

"An economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities."

The report by the United Nations Environment Management Group's (EMG) (2011) points out that at the operational level, the green economy is seen as one whose growth in income and employment is driven by investments (e.g. in human capital, social institutions, infrastructure) that:

- Reduce carbon emissions and pollution;
- Enhance energy and resource efficiency;
- Prevent the loss of biodiversity and ecosystem services.

In short, the green economy represents an attempt to guide countries through more action-oriented pathways to sustainable development. In this context, given that no single approach exists for sustainable development, policy makers need support through studies and analyses to help them better identify and understand upcoming challenges and opportunities, as well as to design, choose and implement policy interventions. The Agenda 21 (UNCED, 1992) also reflects the main goal of strategy and planning exercises on the green economy,

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that is, to inform and influence the policymaking cycle so as to effectively progress towards sustainable development. On the other hand, while there is a common and broadly shared goal, involving cross-sectoral amalgamation and integrated assessments, the vast majority of models available to governments are sectoral and cannot be easily coupled with each others. As a result of this disconnect (single and integrated goal vs. multiple disconnected tools), the selection and use of models and their effectiveness in informing decision makers ultimately highly depends on what needs to be measured and analyzed.

For the reasons outlined above, starting from the definition of the green economy (what needs to be measured and analyzed), this paper aims to provide (1) a framework for the review and selection of methodologies and models and (2) information on what tools are available to governments, and are currently being used to support the analysis of green economy strategies at the national and sectoral levels.

This study offers a critical review of the strengths and weaknesses of various methodologies, and of the adequacy of models to help countries to assess their economies and develop green economy strategies. On the other hand, this report does not aim at identifying the best approaches for the formulation and evaluation of green economy strategies, instead it provides key information for the ministries tasked with planning and implementing responsibilities to evaluate the adequacy of various models in meeting their specific needs.

1. CRITERIA FOR REVIEW AND EVALUATION

Various criteria are considered for the review and assessment of methodologies and models with a particular focus on the concerns and needs of developing countries. These criteria primarily focus on tangible dimensions to be reviewed and analyzed[1]. Further, the present study only assesses the methodologies and models that are most commonly used in developing countries for analyzing interventions for a green economy transition. Many[2] studies provide more information on the breadth of models available, but the framework presented here does not intend to be exhaustive but rather to contribute to a better understanding of how useful and adequate methodologies and models can be in supporting country-led green economy policy formulation and evaluation exercises.

The key criteria to assess the methodologies depend on the extent or nature of their contribution to various stages of the policymaking process. In addition, the complementarity of the methodological approaches is also considered, together with the inclusiveness (i.e., stakeholder involvement) of the process to implement them.

The following methodologies are considered: data frameworks and modeling methodologies that can be used to generate and analyze simulations of social, economic and environmental pathways or scenarios. Methodologies, or the underlying body of knowledge for the creation of different types of simulation models, can be "static" (data frameworks) or "dynamic" (modeling approaches). Both types are then used to create and simulate quantitative models.

— It is worth noting that modeling approaches may make use of data frameworks. Actually, data frameworks often represent the backbone of models, also depending on the flexibility and degree of customization offered by the modeling approach utilized. Data frameworks are "static", and can be used in two main ways: (1) in isolation, to investigate and understand the history and current state of system, and (2) embedded in simulation models, to generate simulations of future trends for all the indicators included in the framework selected. Data frameworks include:

- Indicators;
- Input-Output frameworks (I-O);
- Social Accounting Matrix (SAM); and
- Geographic Information Systems (GIS).

— Modeling approaches instead refer to the underlying mathematical theories and frameworks that can be used to create and simulate (or solve) quantitative simulation models. These methodologies could therefore be considered "dynamic" as they allow to generate future projections. Modeling methodologies include:

- Econometrics;
- Optimization; and
- System Dynamics (SD).

Concerning models, the criteria focus more explicitly on the definition of the green economy (which would vary depending on the national context), and the quantitative outputs required to effectively inform decision-making. As a result, the main criteria that were considered include the capability of models to represent the social, economic and environmental dimensions of the problems and opportunities analyzed, as well as their capability to carry out investment and policy analysis.

Further, as an additional layer of the analysis, models are assessed for their ease of customization and use. This

[1] While it is acknowledged that the political dimension is crucial, there are limitations on the extent to which this can be captured by the use of models. As a result, although the process of model building and calibration is often affected by political dynamics, this criterion is not explicitly considered in the analysis presented in this report.

[2] These include, among others: CE and SERI (2010), for a review of macroeconomic models and their approach to sustainability, IEEP *et al.* (2009) for a review of models used to project scenarios of biodiversity and ecosystem services, GEO-5 (UNEP, 2012) for a review of scenarios across sectors.

is relevant for specific country implementation, where data, time and financial resources may be scarce, and tradeoffs need to be addressed.

The following sectoral and macro models are considered:

- Input-Output (I-O) models (employment ILO, 2012a and 2012b; material flows IGES, 2010);
- System engineering models (models of an engineered system, e.g., energy supply) (energy planning Loulou *et al.,* 2005; IAEA, 2001);
- Geographic Information System (GIS) and natural capital valuation models (e.g. WWF and Natural Capital Project, Van Paddenburg *et al.* 2012);
- Computable general Equilibrium (CGE) models (including those coupled with system engineering modules) (IFPRI model Lofgren *et al.,* 2002; MAMS Logfren and Diaz-Bonilla, 2010); and
- System Dynamics (SD) models (Bassi, 2009, 2010, 2011; UNEP, 2013).

These models use different data frameworks (e.g., CGE models use the SAM) and modeling approaches (e.g., optimization in systems engineering models).

1.1. METHODOLOGIES

The growth in income and employment in the green economy is driven by investments. For these investments to be catalyzed and leveraged, **public expenditure**, **policy reforms** and **regulation changes** are needed. As a result, methodologies and models are needed that can support the policymaking process (see Figure 1), allowing to quantitatively project and evaluate trends (*issue identification, stage 1*), identify entry points for interventions and set targets (*policy formulation, stage 2*), assess *ex-ante* the potential impact across sectors and the effectiveness in solving stated problems (or exploiting opportunities) of selected interventions (*policy assessment, stage 2*), as well as monitor and evaluate the impact of the interventions chosen against a baseline scenario (*policy monitoring and evaluation ex-post assessment / analysis, stage 5*).

Various methodologies can be utilized to effectively support policy formulation and assessment (identification of problems, and then policy options that would have the desired impact, also of the magnitude desired, on the system) and evaluation (simulation of selected intervention options against real events). In this respect, it is worth mentioning that the methodologies presented in this report are most commonly used when the analysis is done *ex ante*, or before the actual implementation of the interventions (issue identification and agenda setting, and policy formulation and assessment), but they can also be used to carry out *ex post* (policy monitoring and evaluation) analysis:

- *Ex-ante* modeling methodologies can generate "what if" projections on scenarios with no action, and on the expected (and unexpected) impacts of proposed policy options on a variety of key indicators. In addition, various methodologies can assist in the cost-benefit and multi-criteria analysis, and subsequent prioritization of policy options.
- *Ex-post* modeling methodologies can support impact evaluation by improving the understanding of the relations existing among key variables in the system and by comparing the projected performance with initial conditions and historical data. This can be done by considering individual interventions or a policy package. Improvements to the model and updated projections allow decision-makers to refine targets and objectives, building on synergies and positive spillovers across sectors.

On top of their capability to support issue identification and agenda setting, policy formulation and assessment, and policy monitoring and evaluation, the methodologies are evaluated based on their complementarity with other approaches and their capability to involve a variety of stakeholders in model development and use.

Complementarity is important as it allows to strengthen the analysis and address some of the weaknesses of each methodology with inputs from others. Further, the simultaneous use of different methodologies supports the broader involvement of various stakeholders (technical and political) in policy formulation and evaluation. This latter aspect is particularly important in the context of the green economy. The goal being sustainable development, it is crucial that a green economy strategy is developed, and analyzed, for its impacts across sectors. The simultaneous evaluation of social, economic and environmental dimensions can only be carried to with the adoption of a multi-stakeholder approach in which projected impacts are evaluated, and if necessary, mitigating and/or complementary actions are designed and evaluated.

1.2. MODELS

The review and assessment of models use two main criteria: relevance to the concept and definition of the green economy, and ease of creation and use.[3] More specifically, the former is assessed by evaluating the capability of models to:

[3] A variety of additional, and more technical criteria could be proposed to assess models, such as the use of discrete or continuous simulation, and how they handle uncertainty. On the other hand, this report is seen as an introductory document, and a more detailed assessment of the strengths and weaknesses of simulation models in relation to specific policy analysis will be included in the upcoming Volume II of this study.

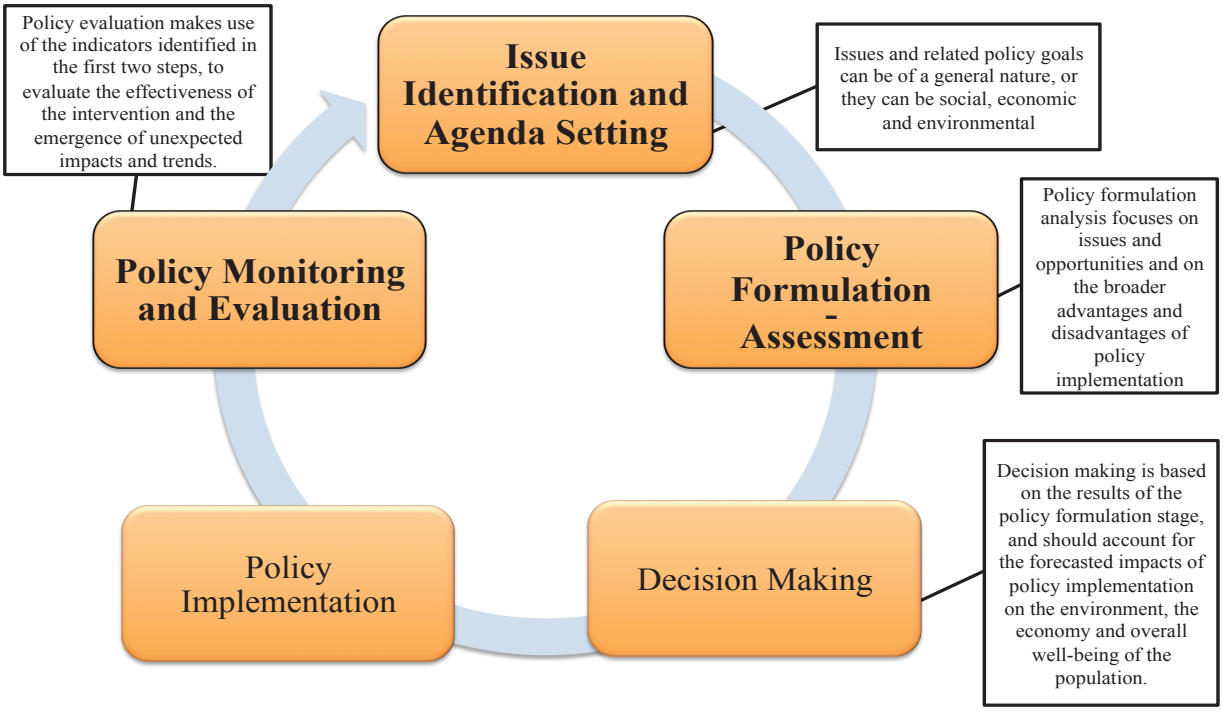

Figure 1. The Integrated Policymaking cycle, highlighting the three main stages supported by the use of quantitative methodologies

• Represent the social, economic and environmental dimensions of the problems and opportunities analyzed, also incorporating human, economic and natural capital in a single framework of analysis;

• Address climate change, a fundamental upcoming challenge, by forecasting impacts as well as analyzing mitigation and adaptation options; and

• Contribute to green economy investment and policy analysis.

The second set of criteria instead considers model creation and use from a developing country perspective, where data, time and financial resources may be scarce, and tradeoffs need to be addressed. In this case factors such as applicability to a country's context, transparency, implementation and maintenance time, and audience and IP support, take center stage.

2. REVIEW OF METHODOLOGIES

The review of methodologies starts with a brief introduction of their strengths and weaknesses to continue with a comparative analysis of their contribution to the policymaking process, respective complementarity with other approaches and accessibility, or multi-stakeholder participation, in the process of model creation.

2.1. DATA FRAMEWORKS

2.1.1. Indicators

An indicator is an instrument that provides an indication, generally used to describe and/or give an order of magnitude to a given condition. Indicators provide information on the historical and current state of a given system, and are particularly useful to highlight trends that can shed light on causal relations among the elements composing the system and in analyzing whether progress is made in reaching a given policy target.

When used in the context of policymaking, indicators are useful instruments to inform decision-making (UNEP, 2012). Using inventory data and/or surveys, indicators can be grouped in four main categories *(1) indicators for issue identification and agenda setting; (2) indicators for policy formulation; (3) indicators for policy assessment and (4) indicators for policy monitoring and evaluation.*

2.1.2. Input – Output

Input-Output (I-O) frameworks depict inter-industry relationships within an economy or across economies, estimating how output from one sector may become an input to another sector. Inputs and outputs can be measured in economic (e.g., the monetary value of trade) and physical terms (e.g., material flows and emissions, or employment). In a typical I-O matrix, columns would represent inputs to a sector, while rows would represent outputs from a given sector. This approach is frequently used to estimate impacts of investments and policies on the value chain of specific products and industries.

2.1.3. Social Accounting Matrix

A Social Accounting Matrix (SAM) is an accounting framework that captures the transactions and trans-

fers between the main actors in the economy. As a result, for any given year, the SAM provides information on the monetary flows that have taken place between, for instance, the government and households, ensuring that all inflows equal the sum of the outflows. The focus on households makes the SAM "social", and makes it an adequate *backbone* for Computable General Equilibrium (CGE) and other macroeconomic models to carry out analysis that spans across the whole economy.

2.1.4. Geographic Information System

A Geographic Information System (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. In the simplest terms, GIS is the merging of cartography, statistical analysis, and computer science technology, and is used to analyze land use changes.

GIS applications use geographically disaggregated data presented in maps. Technically there is no restriction in the type of data that can be included in GIS tools, which often incorporate social, economic and environmental indicators. On the other hand, there could be a scaling problem when the coupling of spatially disaggregated data is not possible (e.g., when attempting to couple detailed local GIS information with economic data that may only be available at the national level).

2.2. MODELING APPROACHES

2.2.1. Econometrics

Econometrics measures the relation between two or more variables, running statistical analysis of historical data and finding correlation between specific selected variables. Econometric exercises include three stages — specification, estimation, and forecasting. The structure of the system is specified by a set of equations, describing both physical relations and behavior, and their strength is defined by estimating the correlation among variables (such as elasticities: coefficients relating changes in one variable to changes in another) using historical data. Forecasts are obtained by simulating changes in exogenous input parameters that are then used to calculate a number of variables forming the structure of the model (e.g., population and economic growth).

The most important limitations of econometrics are related to the assumptions characterizing the most commonly used economic theories: full rationality of human behavior, availability of perfect information and market equilibrium. When looking at the results produced by econometric models, issues arise with the validation of projections (that cannot backtrack historical data) and with the reliability of forecasts that are only based on historical developments and on exogenous assumptions.

2.2.2. Optimization

The use of optimization in policymaking generates "a statement of the best way to accomplish some goal" (Sterman, 1988). Optimization leads to models that are normative, or prescriptive, and provide information on what to do to make the best of a given situation (the actual one). In order to optimize a given situation, these models use three main inputs: (1) the goals to be met (i.e., objective function, such as minimizing the cost of energy supply), (2) the areas of interventions and (3) the constraints to be satisfied.

Optimization is also used to estimate the impact of external shocks (e.g., policies), such as in the case of CGE models. Here optimization is primarily used to solve the mathematics underlying the model. The assumption is that agents are maximizing welfare (profits or consumption), and the model is solved by finding the price vector that optimizes overall welfare as a representation of how the economy might be thought of as functioning.

The challenges related to optimization models include the correct definition of an objective function, the extensive use of linearity, the limited representation of feedback and dynamics. Such models usually do not provide forecasts, but some of them, such as CGE models (Coady, 2006) as well as MARKAL (Fishbone *et al.,* 1983; Loulou *et al.,* 2004) and MESSAGE (IIASA, 2001, 2002) in the energy sector, provide snapshots of the optimum state of the system with specific time intervals. Such models use exogenous population and economic growth rates, among other exogenous variables.

2.2.2. System Dynamics

System Dynamics is a methodology used to create models that are descriptive, and focuses on the identification of causal relations influencing the creation and evolution of the issues being investigated. System Dynamics models are in fact most commonly used as "what if" tools that provide information on what would happen in case a policy is implemented at a specific point in time and within a specific context.

System Dynamics aims at understanding what the main drivers for the behavior of the system are. This implies identifying properties of real systems, such as feedback loops, nonlinearity and delays, via the selection and representation of causal relations existing within the system analyzed. Potential limitations of simulation models include the correct definition of system's boundaries and a realistic identification of the causal relations characterizing the functioning of systems be-

ing analyzed (e.g., relating to the use of causality rather than correlation).

2.3. COMPARATIVE ASSESSMENT

A comparative assessment of the methodologies analyzed in this study is provided in Table 1. This table does not aim at identifying what is the best methodology, but to review their main strengths and weaknesses, how they contribute to the policymaking process, as well as their complementarity and accessibility. The choice of the best methodology and model to use depends on a variety of additional criteria.

With regard to data frameworks, and concerning the policy process, while the use of indicators can support each phase, I-O and SAM can primarily support policy formulation and assessment, by testing the impact of policies. GIS tools instead can be used to identify problems (by observing trends), support policy formulation (by testing the extent to which a policy, often regulation, would impact land use, among others) as well as policy M&E (by monitoring the evolution of the system over time). Concerning complementarity, indicators, SAM and GIS could be relatively easily incorporated in other types of assessments (provided that data are coherently disaggregated), while the specificity of I-O tables (especially concerning employment and material flows) makes them particularly useful for detailed studies but of more difficult incorporation in other analyses. Regarding accessibility, indicators and GIS are likely to capture the interest of a larger set of stakeholders, mostly due to their cross-sectoral coverage.

With regard to modeling approaches, System Dynamics provides a degree of flexibility that makes it useful and relevant for all policymaking stages. While this does not mean that a single model may be relevant throughout the policy cycle, the methodology allows for the creation of a suite of models that can effectively inform decision makers. Further, econometrics can most effectively contribute to issue identification (by projecting trends based on historical observed behavior), and optimization is better suited for policy formulation and assessment (especially by setting targets and providing information on the best system setup to reach them). Concerning complementarity, elements of econometrics and optimization (especially if used in simulation mode, for solving the underlying mathematics of models) can be easily utilized in several models used for green economy assessments. System Dynamics facilitates the incorporation of knowledge in a single framework of analysis, and can also be coupled with other approaches (e.g., econometrics and optimization, and more increasingly GIS as well). Regarding accessibility, econometrics and optimization generally target a focused target audience, which would change depending on the scope of the analysis (e.g., energy, economic planning). The use of a systemic approach to develop System Dynamics models makes it instead better suited to broaden the range of stakeholders involved in the modeling process and planning. This is primarily due to the ease of incorporating cross-sectoral factors in the model (e.g., energy-economy-environment nexus).

Beyond Table 1, the study also presents the complementarity of various methodologies through the coupling of models. In fact, among others, System Dynamics models can be optimized and may use econometric inputs, and/or include I-O tables and spatially disaggregated data. CGE models run an optimization routine, use the SAM as their underlying economic accounting framework and can include I-O employment and material flow tables. Spatial models, using GIS data as foundation, can be used to run simulations (optimizing future trend and/or simulating "what if" scenarios).

3. REVIEW OF MODELS

The review of models focuses on the comparative assessment of their respective key contributions to a green economy assessment. More details on the main characteristics of these models are available in UNEP (2014).

A comparative assessment of the models is provided in Table 2, which shows how models include the different dimensions relevant to green economy. No model can capture all the facets of the green economy. However, CGEs coupled with sectoral biophysical models and System Dynamics could potentially satisfy most criteria if some information from the other models is available (e.g., InVEST, concerning natural capital).

More specifically, I-O models can provide a high level of sectoral disaggregation and generate results analyzed across the value chain of selected products and technologies, tracking employment, material and/or emission flows. Regional I-O models extend this analysis to trade among countries. These models can capture economic and human capital, sustainable consumption and production (SCP) and competitiveness, as well as support investment analysis.

Energy and other system engineering models specifically focus on one or two sectors and can track manufactured capital (even if expressed in physical terms, as built up capital), climate change mitigation options (e.g., in the case of energy) and potentially also climate change adaptation (e.g., in the case of water). These models can support both green economy investment and policy analysis (especially regulation).

GIS-based models (e.g., LCM) and InVEST, being spatially disaggregated and focusing on land use changes, specialize in natural capital and are able to capture eco-

Table 1. Review of methodologies for green economy assessments; contribution to the policy process, complementarity and stakeholder participation.

Methodology	Main strengths in assessing the Green Economy	Main weaknesses relative to the Green Economy	Problem identification	Policy formulation	Policy assessment	Policy M&E	Complementarity	Accessibility — participation
Static								
Indicators	Support the entire policy cycle, quantify trends.	Require harmonization; primarily limited to (quantitatively) measurable variables.	✓	✓	✓	✓	✓	✓
Input-Output	Represent value chain impacts, and ripple effects across sectors.	Data intensive; material flows not generally available.		✓	✓			
Social Accounting Matrix	Estimates economic flows across the main economic actors.	Covers exclusively monetary flows; lacks feedbacks.		✓	✓		✓	
Geographic Information System	Captures local trends, based on geographical maps; fully accounts for natural resources and ecosystem services.	Data intensive; may miss economic dimensions; uneven data resolution may pose challenges.	✓	✓		✓	✓	✓
Dynamic (Projections)								
Econometrics	Entirely based on historical trends; quick implementation.	Lacks the explicit representation of feedbacks and does not capture possible emerging dynamics.	✓				✓	
Optimization	Supports the estimation of targets, understanding key limits of the system.	Provides and "end" with little insights on the "means". Not viable for highly dynamic and cross-sectoral systems.		✓	✓			
System Dynamics	Focuses on structure to drive behavior; horizontal sectoral representation; knowledge integrator (ad hoc).	Highly reliant on knowledge available in other fields; relatively long implementation time for national models.	✓	✓	✓	✓	✓	✓

logical scarcities and environmental risks. These tools can also support the analysis of human well-being, with access to resources and vulnerability to climate change, being capable of analyzing impacts, mitigation (especially sinks, through land use) and adaptation options. Spatial models are generally better suited to analyze policy impacts (e.g., regulation), rather than green economy investments.

CGE models cover the economic sphere of sustainable development, accounting for manufactured capital, competitiveness and social equity (e.g., through the estimation of income distribution). Human capital can also be estimated, despite methodological constraints, regarding employment, skills, as well as salary and wages. CGE models can effectively support both investment and (fiscal and monetary) policy analysis.

When coupled with system engineering models, CGEs can more effectively incorporate natural capital (primarily by representing natural resource stock and flows) and ecological scarcities. This allows a fuller estimation of competitiveness, also including SCP and the analysis of capital misallocation (now possible due to the cross-sectoral nature of the model, capable of estimating ecological scarcities). Further, by adding natural resources, the model would be able to analyze climate change mitigation and adaptation options, and make use of spatial information to potentially incorporate impacts as well.

Table 2. Review of models for green economy analysis; relevance to the green economy definition and assessment.

		Representation of key pillars (and capitals) of sustainable development										**Analysis of Climate Change**			**GE Intervention Analysis**	
		Economic dimension				**Social dimension**			**Environmental dimension**							
Model	**Scope of the analysis**	Economic capital	Sustainable Consumption and Production	Competitiveness	Capital misallocation	Human capital	Human well being	Social equity	Natural capital	Ecological scarcities	Environmental risks	CC impacts	CC mitigation	CC adaptation	Investment analysis	Policy Analysis
Input-Output (I-O)	Macro, with high level of sectoral disaggregation, for monetary and physical flows	✓	✓	✓		✓									✓	
Energy and other System Engineering models	Sectoral analysis, with high level of detail	✓											✓	✓	✓	✓
Geographical Information System (GIS) and InVest	Highly geographically disaggregated, with analysis ranging from local to national						*		✓	✓	✓	✓	✓	✓		✓
Computable General Equilibrium (CGE)	Macro, with sectoral disaggregation	✓		✓		*		✓							✓	✓
CGE and System Engineering (energy and natural resources)	Macro, with sectoral detail.	✓	✓	✓	✓	*	*	✓	*	✓		*	✓	✓	✓	✓
System Dynamics (SD) models (e.g., T21)	Macro, with the possibility to add sectoral detail with social, economic and environmental variables	✓	✓	*	✓	✓	*	✓	*	✓	*	*	✓	✓	✓	✓

The * indicates the possibility to include basic variables and to address the criteria more extensively with the availability of information generated by other models.

System Dynamic models, both sectoral and integrated, can endogenously represent economic, human and natural capital. The strength of the model and the level of detail of the analysis depend on the identification and understanding of the key drivers of the system, and on the availability of inputs from more detailed employment and natural capital assessments. By accounting for natural resource stocks and flows, ecological scarcities can be estimated, with resulting environmental risks and vulnerabilities (incorporated using results of an InVEST analysis, for instance). At the economic level, given the typical high level of aggregation of System Dynamic models, SCP could be simulated and analyzed from a macro perspective, tracking consumption of the most relevant inputs to production (especially natural resources). Further, competiveness and capital misallocation would be endogenously estimated, providing insights on the key — past, present and future — drivers of economic growth. Concerning social dimensions, while social equity would be estimated through income distribution, the calculation of human well-being could use indicators from a variety of sectors, including environmental ones. As in the case of CGEs with system engineering modules, climate change impacts could be incorporated if science is available, and the model could simulate and support the evaluation of mitigation and adaptation options using cross-sectoral indicators (including direct, indirect

and induced impacts). Finally, System Dynamics models can be used to carry out both green economy investment and policy analysis.

This section reviewed some of the various criteria for choosing the best model to use, criteria which relate primarily to the problem to be analyzed, the stage of the policymaking process to influence and the constraints relating to timing, budget and human resources (e.g., local knowledge of modeling techniques and time availability).

4. EXPLOITING THE COMPLEMENTARITY OF EXISTING METHODOLOGIES AND MODELS FOR A GREEN ECONOMY ASSESSMENT

The green economy work carried out so far has focused on filling gaps in the policy process to fully incorporate the environmental dimension in national planning. With respect to simulation models, gaps have been identified in the inclusion of the social and environmental dimensions of development in modeling exercises related to national planning, and in the use of long-term projections to inform policy making.

As the field of the green economy evolves and new challenges arise, it is becoming more and more evident — and not surprisingly so — that no perfect model exists, and that certain contexts may require a suite of highly customized models to effectively inform policymaking. Before model (s) can be selected, the goals and issues should be clearly identified and the state of the policymaking process analyzed. It may well turn out that more than a model is needed to solve a given problem or support a single policy process, especially if cross-sectoral linkages are important and both short and longer term analysis is needed. In addition, certain governments may have already embarked in modeling work and may want to make use of their existing models and knowledge to support ongoing planning efforts. They may at the same time need to develop other models *ad hoc*. For these reasons, complementarity will play a key role in determining the usefulness of quantitative assessments for policy formulation and evaluation at the country level.[4]

Table 3 highlights the key commonalities and interdependencies of various models, indicating how apparently different streams of work can complement each other. This table should be analyzed in conjunction with Table 2. While the specific technical characteristics and capabilities of each model are analyzed in Table 2, the following one refers to the analysis that could originate from aligning the use of different models.

The complementarity of models in creating a coherent green economy analysis is evident when considering their sectoral coverage, time horizon, and also when taking into account their support to the policymaking process (see Table 1). Some models are better suited to help decision makers in the issue identification phase (e.g., the analysis of historical trends with InVEST), while others are designed to shape policy formulation (e.g., with the identification of goals and targets, such as in the case of optimization). As mentioned above, an additional layer of complementarity is the time horizon of the analysis created with simulation models. Due to methodological characteristics (both strengths and weaknesses), some models are better suited for short-term analysis (e.g., I-O), while others are designed to address medium and longer-term trends (e.g., T21).

A case study is provided to highlight the potential to combine various models for a comprehensive green economy assessment. The example refers to a specific problem or policy objective, namely fossil fuel subsidy removal.

4.1. CASE STUDY: FOSSIL-FUEL SUBSIDY REMOVAL

Assessing the implications of the rationalization of fossil-fuel subsidies requires a cross-sectoral analysis, touching upon economic and social indicators, and also affecting energy (fossil fuel) consumption and production, and as a consequence impacting the environment (Bassi, 2012). As a result, several methods and tools are needed to carry out a comprehensive and solid analysis of the impacts of fossil-fuel subsidies removal.

Most of the efforts in designing the analytical framework and methodology for a study carried out by IISD for the Asian Development Bank (ADB)[5] consisted in the identification of the synergies that can be created by using existing methods and tools. With the goal to adopt a framework that is of easy implementation and replication, but still solid and rigorous, the team has selected three main tools, all based on (and supported by) quantitative data. These are (1) the MARKAL energy model, (2) a Macro Economic CGE model, and (3) the SAM. Strong synergies can be created when using simultaneously the three tools, as they can (and should) all feed results to each other to allow for a comprehensive and solid assessment.

With respect to the analysis of the impacts of fossil-fuel subsidies it can be argued that:

[4] Considerable amount of work is being done to improve the integration of social, economic and environmental factors in Integrated Assessment Models. While this type of work is beyond the scope of the report, more information can be found at the Integrated Assessment Modeling Consortium website (http://www.globalchange.umd.edu/iamc).

[5] The project is "TA-7834 REG: Assessment and Implications of Rationalizing Fossil-Fuel Subsidies", done in the context of IISD's Global Subsidies Initiative.

Table 3. Review of the complementarity of models in creating a green economy analysis.

		Information Provided				
	Model	**Input-Output (I-O)**	**Energy and other System Engineering models**	**Geographical Information System (GIS) and InVEST**	**Computable General Equilibrium (CGE models)**	**System Dynamics (SD) (e.g., T21)**
Information received	**Input-Output (I-O)**		* Projections, planned capacity expansion	Spatial distribution of employment, material flow	* Projections, economic growth across sectors	* Projections, with feedbacks across sectors
	Energy and other System Engineering models	Energy flow, for value chain analysis		Water availability for cooling, proximity of transport means for fuels (e.g., coal)	GDP, for energy demand estimation	Socio-economic impacts of energy choices, repercussions on energy demand
	Geographical Information System (GIS) and InVEST	Employment in sectors affecting or impacted by the environment	Emissions and fuel/water requirements from/for power generation		Economic growth	Socio-economic impacts of environmental trends/policies: direct, indirect and induced.
	Computable General Equilibrium (CGE models)	Employment and material flow (for extended CGEs)	Energy price (production cost) and investment information	Spatial information, natural resource stocks (for extended CGEs)		Long-term feedback responses (e.g., rebound effect)
	System Dynamics (SD) (e.g., T21)	Employment, material and energy flow	Energy system structure, construction, O&M costs	Spatial information, natural resource stocks, ecosystem services	SAM structure	

* Input-Output tables generally only provide information to other models. These data, used as inputs are then simulated using econometrics, optimization and System Dynamics.

• The SAM and MACRO are particularly useful in analyzing consumer subsidies from a macroeconomic perspective, with data (such as household surveys) being necessary to carry out a detailed assessment of the impact on household (e.g., considering income classes, regional differences among the population and other social factors).

• MARKAL and MACRO are needed instead to analyze producer subsidies, with the former emphasizing the biophysical dimensions of the energy sector, and the latter estimating the economic impacts of decisions on energy supply.

As mentioned above, the MARKAL, MACRO and the SAM can be very complementary, strengthening the analysis that otherwise would be carried out with each of them used independently. In fact, the basic accounting structure and much of the underlying data of CGE models are derived from a SAM, making them useful and easy to implement for the analysis of consumer subsidies; and MARKAL has been improved and expanded by linking it with CGE models, making them excellent tools to use in conjunction when analyzing producer subsidies.

The figure below shows how the three tools can be used in a synergetic manner to make use of the strengths of each of them and carry out a solid and easily replicable analysis of the implications of rationalizing fossil fuels.

The combined utilization of these three tools is necessary to generate coherent projections, and analyze them in the context of the rationalization of fossil-fuel subsidies. In this respect, several policy-related questions can be analyzed, starting from the various options for subsidy removal (e.g., what reduction, by when, and in which shape/form), and ending with the potential reallocation of avoided public expenditure (to which household groups, and with which policy intervention option). Additional analyses become relevant depending on the scenarios simulated, and these include the differences between short and long term impacts, as well as policy and system responses.

5. CONCLUSIONS

While not aiming at identifying the best methodologies and models for the definition and analysis of green

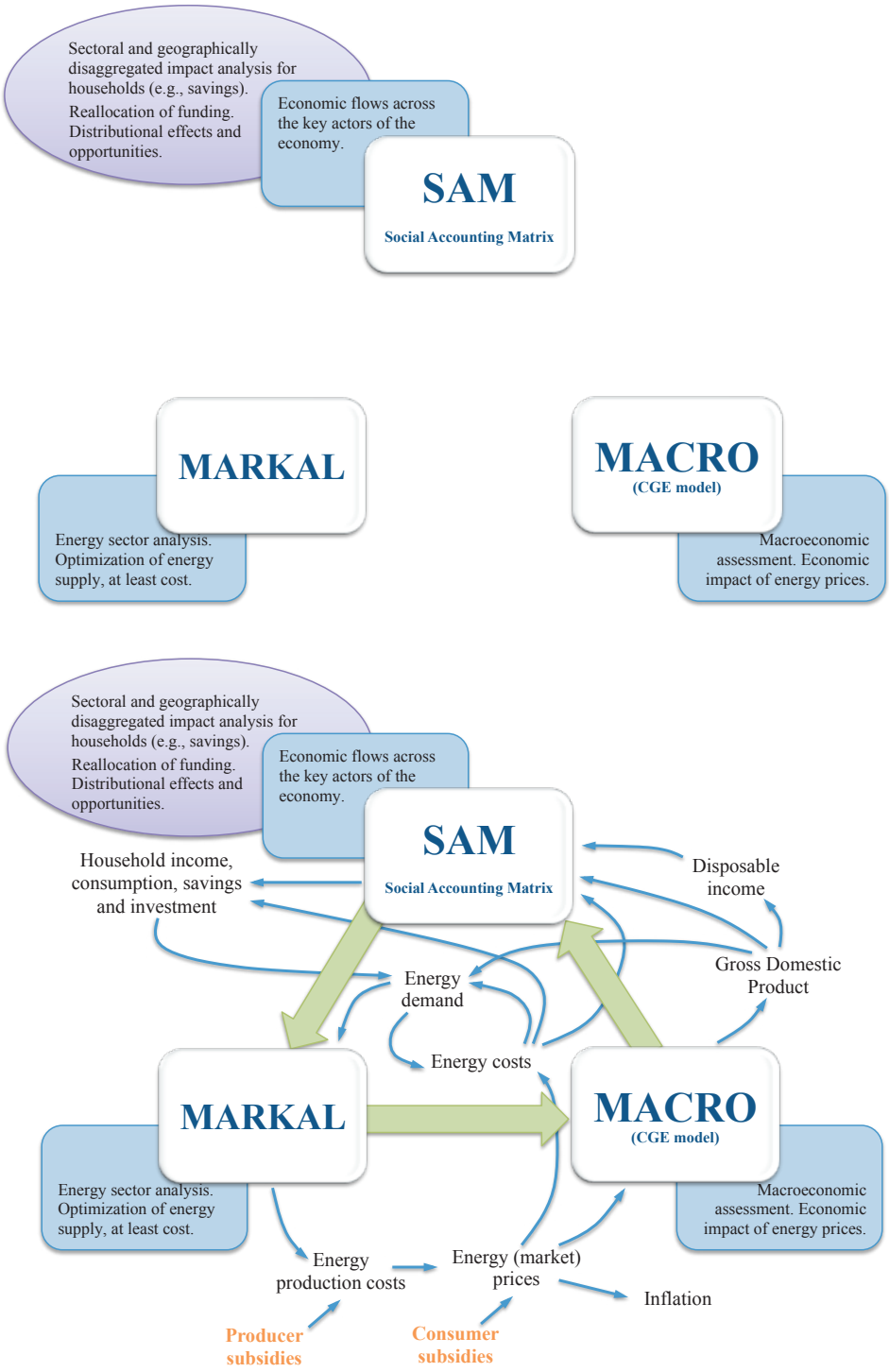

Figure 2. Key elements of integration of MARKAL, MACRO and SAM for the analysis of the implications of rationalizing fossil fuels.

MARKAL is used to generate information on energy production costs, taking into account producer subsidies. With energy costs and consumer subsidies, energy market prices can be estimated. Energy prices are then used to estimate energy demand (and possibly GDP and other macro-economic flows) in MACRO, and inflation. MACRO is used in conjunction with the SAM to estimate GDP and household income, as well as consumption, savings and investment. With data from the household survey it is possible to disaggregate impacts by income classes and location, and also estimate household energy costs. This is done by combining estimates on energy demand (potentially using driving needs – e.g., distance from the workplace – and household or housing size) and energy prices, obtained from the MARKAL and MACRO. Finally, income, originating from the SAM and the household survey will also be used to estimate household energy demand at the micro level, on top of using prices and specific needs.

economy strategies, this study provides key information for researchers and policy makers interested in green economy policy assessment to evaluate the adequacy of various models in meeting their specific and unique needs. As discussed in the paper, integrating and/or linking different modeling approaches and models is often required for the types of complex questions posed by a green economy assessment. In this respect, there are two critical factors to consider:

1. The peculiarities of the local context; and
2. The analysis carried out with models.

The former was already addressed in this report and includes, among others, data availability, knowledge and skills available within critical ministries and national research organizations. The latter refers to the fact that the potential to effectively inform the policymaking process is highly dependent on the type and breadth of the analysis carried out, as models may be misused or utilized below their potential. For this reason the evaluation of models emphasizes the need to ensure broad stakeholder involvement, the necessity to estimate impacts across sectors, for the short, medium and longer term, while considering direct, indirect and induced impacts of action and inaction.

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Design and Economics of a Hybrid Desalination System Applied to an Offshore Platform*

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Abstract. Water scarcity is a major problem that needs to be efficiently solved to ensure water availability for future generations. Desalination is an alternative technology for water production based on salt separation from water. However, the energy requirements for that process are high and can be a problem, mainly in isolated areas. Renewable energy sources are the best way to supply energy needs, because they can be available near the desalination plant, avoiding environmental and availability problems that are associated with fossil fuels. In this paper two forms of renewable energies suited for desalination plant are examined: wind power and wave power. The aim of this study is to present an innovative project which is based on a wind turbine located in a floating platform combined with a wave energy conversion device close to main platform for producing electricity for a desalination plant's energy needs. The whole project can meet the needs of water demand on islands and it has particular characteristics, as it is floating, autonomous and meets its energy needs in an environmental way, utilizing the wave and wind energy. Also, in the paper the cost and benefits analysis on the unit level is presented, as well as the creation of scenarios to come more closely to real world with regard to implementation of such projects. Also, the requirements of installation, the optimal size of the unit and the weather conditions of installation site are examined.

Аннотация. Нехватка воды является важнейшей проблемой, которая должна быть эффективно решена для обеспечения доступной водой будущих поколений. Опреснение — это альтернативная технология производства питьевой воды посредством выделения соли из морской воды. Однако потребности в электроэнергии для этого процесса высоки и могут представлять собой проблему, особенно в удаленных районах. Возобновляемые источники энергии предоставляют наилучший выход для обеспечения энергетических потребностей, так как они могут быть в наличии рядом с опреснительной установкой, и таким образом можно решить проблемы доступности и экологичности, характерные для ископаемого топлива. В этой статье рассматриваются два вида возобновляемых источников энергии, годных для опреснительной установки: энергия ветра и энергия волн. Целью данного исследования является представление инновационного проекта, в основе которого находится установление ветровой турбины, находящейся на плавучей платформе, в сочетании с устройством для преобразования энергии волн поблизости от основной платформы, с целью производства электроэнергии для энергетических потребностей опреснительной установки. Проект может в целом удовлетворить спрос на воду на островах и обладает особыми характеристиками, так как данная установка держится на поверхности воды, автономна, и ее энергетические нужды обеспечиваются в соответствии с требованиями экологии благодаря использованию энергии волн и ветра. Также в документе представлен анализ затрат и выгод на уровне отдельных частей установки, а также разрабатываются сценарии для более полного соответствия практическим требованиям, возникающим при реализации подобных проектов. Также рассматриваются требования к сооружению, оптимальный размер установки и учет погодных условий в месте ее сооружения.

Key words: floating platform, desalination unit, wind and wave energy conversion, desalination costs, full-cost assessment.

* Технико-экономические аспекты проекта гибридной системы опреснения для применения на морской платформе.

INTRODUCTION

Freshwater and energy are two inseparable and essential commodities for sustaining human life on earth. Rapid population growth and industrialization, especially in developing countries in the recent past, have placed pressing demands for both freshwater and energy. Supply of freshwater requires energy and, unfortunately, many countries in the world that lack freshwater sources are also deficient in energy sources. Desalination is an alternative technology for water production based on salt separation from water. However, the energy requirements for that process are high and can be a problem, mainly in isolated areas. Renewable energy sources are the best way to supply energy needs. Although, as desalination technologies are energy-intensive, they would be appropriate in areas where: there is no alternative (islands), cost of other resources are high (transportation costs), low-cost energy is readily available (Middle East oil-reach countries), and high living standards override the cost factor (the case of tourism) (Wade, 2001).

Until now the most part of desalination processes are powered by fossil fuels, contributing to climate change, releasing greenhouse gases and other harmful emissions. Also, apart from the above, the Kyoto Protocol requires global per capita emissions to drop to 0.2–0.7 ton C/cap/year from the current levels of 0.3 in developing countries, 5.5 in USA and 2.5 in Western Europe (Lamei, 2008). Furthermore, the limitation of fossil fuels has necessitated the use of new and alternative energy sources for energy security reasons and future sustainable development. It is worth mentioning that the petroleum reserves are estimated to be depleted in less than 50 years according to present rate of consumption (Demirbas, 2009).

In Table 1 we can see the world population growth with increased desalination capacity and the oil requirements to produce freshwater through desalination technologies and associated greenhouse gas emissions over the past five decades. Until now the world desalination capacity is only 7.5% of world's total minimum freshwater demand, which requires 1.42 million tons of oil/day. And now the most important question, which should be answered, is why we should continue to use conventional source of energy with so much expenses, contributing in greenhouse effect and depleting the natural energy sources, which threaten the human life. In contrast to this, it is considered necessary to develop new alternatives to replace conventional energy sources in desalination process with renewable energy and reduce the energy requirements for desalination by developing new, innovative and low-cost technologies like hybrid models.

This paper presents a possible combination of two renewable energy sources, wave and wind, in a desalination unit placed in a floating platform consisting of a four peripheral cylinders grid with a bigger cylinder at the center. The energy needs of desalination plant are covered by wind and wave devices. The whole project can meet the needs of water demand; it is floating, autonomous and meets its energy needs in an environmental way, utilizing the wave and wind energy. Also, in the paper the cost and benefits analysis on the unit level is presented, as well as the creation of scenarios to come more closely to real world with regard to implementation such projects. Also, the requirements of installation, the optimal unit size and the weather conditions of installation site are examined.

1. STATE OF THE ART

The available desalination technologies until now can be categorized as follows:

(a) Phase change processes that involve heating the feed to boiling point at the operating pressure to

Table 1. World population, desalination capacity, oil requirements & greenhouse gas emissions over past five decades.

Year	World Population (billions)	World DesalinationCapacity (million m^3/day)	Oil Required (million metric tons/day)	GHG Emissions (Metric tons CO_2 / day)
1960	3.1	0.12	0.00	0.36
1970	3.8	0.72	0.02	2.16
1980	4.5	4.4	0.12	13.2
1990	5.3	13	0.36	39
2000	6.0	23	0.63	69
2008	6.8	52	1.42	156

produce steam, and condensing the steam in a condenser unit to produce freshwater. Applications of this category include solar distillation (SD), multi-effect distillation (MED), multi-stage flash distillation (MSF), mechanical vapor compression (MVC) and thermal vapor compression (TVC).

(b) Non-phase change processes that involve separation of dissolved salts from the feed waters by mechanical or chemical/electrical means using a membrane barrier between the feed and product. Applications of this category are electrodialysis (ED) and reverse osmosis (RO).

(c) Hybrid processes involve a combination of phase change and separation techniques in a single unit or in steps to produce pure or potable water. Prime examples of this category are membrane distillation (MD) and reverse osmosis combined with MSF or MED processes (Gude, 2010).

2. RES-BASED DESALINATION PROCESSES

Desalination of water based on renewable energy sources can be a sustainable way to produce clean water. This way of desalination is expected to become economically attractive, as the cost of renewable technologies continues to decline and the price of fossil fuels continues to increase. So, using locally available renewable energy sources for the desalination of water can be a low-cost solution especially for remote areas, with low population and poor infrastructure for fresh water and electricity transmission and distribution. The presence of renewable energy in desalination process corresponds to less than 1% of desalination capacity based on conventional fossil fuels (EU, 2008). This percentage is not considered representative for the advantages which renewable energy technologies offer to us.

Renewable desalination is mostly based on RO process (62%), followed by thermal processes such as MSF and MED. Now, regarding the kind of renewable energy, the dominant energy is considered the solar energy (solar photovoltaic) (PV), which is used in some 43% of the existing applications, followed by solar thermal and wind energy.

The right coupling of a renewable energy source with a desalination plant is considered the key to match power and water demand economically, efficiently and in an environment-friendly way.

So, the right coupling is determined by various criteria such as the system's efficiency, the investment and operational cost, availability of operational personnel, the suitability of the system to the characteristics of the location, the possibility for future increase of the system capacity etc. (Mathioulakis, 2007).

Desalination plants based on renewable energy sources can be seen in Cyprus, Greece, Egypt, Jordan, Morocco, Turkey, UAE (Abu Dhabi), Canary Islands etc. (IEA-ETSAP and IRENA, 2012).

3. ECONOMIC ELEMENTS OF A DESALINATION PLANT

3.1 FACTORS AFFECTING DESALINATION COST

Cost is a major factor in implementing desalination technologies. In general, cost factor associated with implementing a desalination plant is site-specific and depends on several variables. Details about desalination costs are provided in various documents (Desalting Handbook for Planners, 2003).

So, the most important parameters which affect the desalination cost are the following:

Quality of Feedwater: The quality of feedwater is considered a crucial parameter. Low TDS[1] concentration in feedwater requires less energy for treatment compared to high TDS feedwater. Low TDS allows for higher conversion rates and the plant can operate with less dosing of antiscale chemicals. The pretreatment of surface waters such as tidal waters will be more costly compared to brackish groundwater because of the potential existence of more contaminants in these waters.

Plant Capacity: Plant capacity is also an important parameter. This factor can affect the size of treatment units, pumping, water storage tank, and water distribution system. In general we can say that large capacity plants require high initial capital investment compared to low capacity plants. But due to the economy of scale, the unit production cost for large capacity plants can be lower.

Site characteristics: Site-specific aspects have a significant impact on final costs (IEA-ETSAP and IRENA, 2012). For example, for desalination plants which are placed on land, the availability of land as well as the land conditions can determine the cost. The proximity of land location to water source and concentrate discharge point are other factors. Pumping cost and costs of pipe installation will be substantially reduced if the plant is located near the water source and if the plant concentrate is discharged to a nearby water body. Also, costs associated with water intake, pre-treatment and concentrate disposal can be substantially reduced if the plant is an expansion of an existing water treatment plant, as compared to constructing a new plant.

[1] TDS: Total Dissolved Solids

Regulatory Requirements: these costs are associated with meeting local/state permits and regulatory requirements (Younos, 2005).

3.2. DESALINATION IMPLEMENTATION COSTS

Estimation of the capital and production cost of desalination plants is very difficult due to the following reasons: Variable energy, material and labor costs by geographic areas, the type of desalination process/design/size, salinity of feedwater source and financing packages (National Research Council, 2008).

There are three types of costs associated with desalination typically mentioned in the bibliography. These include the capital cost (CAPEX), operating cost (OPEX), and the total water cost (TWC).

The capital cost is often referred as *Capital Expenditure* or CAPEX, and it describes the capital expenditures required to complete the project. Capital costs for a desalination plant typically are associated with the construction of the over-all infrastructure. The construction cost of plant is 50–80% of the initial investment cost. The remaining percentage, i.e. 20–50%, has to do with costs of design, licensing and loans of investment.

Operating Costs (OPEX), which are requiring costs, typically on annual basis, include, but are not limited to, operating and maintenance labor (O&M), energy consumption, maintenance parts, insurance, laboratory analysis and monitoring etc.

The OPEX is divided into two parameters — the fixed and the variable cost. Fixed costs include insurance and amortization. Usually insurance cost is estimated as 0.5 percent of the total capital cost. Amortization compensates for the annual interest payments for direct and indirect and depends on the interest rate and the lifetime of the plant. Typically, an amortization rate in the range of 5–10% is used. Variable costs include the costs of labor, energy, chemicals and maintenance. Labor costs can be site-specific and also depend on plant ownership or special arrangements such as outsourcing of plant operation. Energy costs depend on availability of inexpensive electricity. Chemical use depends mainly on feedwater quality and degree of pre/post treatment and cleaning process.

The major maintenance cost pertains to the frequency of membrane replacement, which is affected by the feedwater quality. For low TDS brackish water the replacement rate is about 5% per year. For high TDS seawater, the replacement could be as high as 20%. The cost of maintenance and spare parts is typically less than 2% of the total capital cost on annual basis.

Total Water Cost (TWC) is frequently quoted in desalination industry bibliography as a common comparison between projects. TWC has been defined as the annual operating cost + the annualized capital cost (or dept. service).

3.3. DESALINATION COST ESTIMATIONS

During the last few decades the operating costs of producing desalinated water have steadily decreased due to continuous technological progress. Though still a costly water supply option compared to natural water resources such as ground or surface water, desalination may soon be a competitive alternative even in non-water stressed areas. It is worth mentioning that costs for conventional water sources are expected to increase, while costs for desalting are expected to decrease as technology improves (Reddy & Ghaffour, 2007).

The international bibliography has shown that the reduction of cost has occurred in three main cost areas: capital, energy, operation and maintenance due to:

- Technological developments;
- Increasing size of plant;
- Lower interest rate and energy costs;
- Changes in managing enterprise performance;
- Intense competition between equipment suppliers worldwide.

Specific improvements that have contributed to cost reduction, among many others, have been optimization of design process and thermodynamic efficiency, use of newer materials with better heat transfer properties, and development of new construction and transportation techniques for MSF, technological improvements of membranes, optimization of pre-treatment options, and use of energy recovery devices for RO (Fritzmann *et al.*, 2007; Reddy & Ghaffour, 2007).

It is commonly known that desalination possesses require significant quantities of energy to achieve separation of salts from seawater. Existing MSF and RO plants are powered by conventional energy sources because they still represent the most economical way to satisfy the energy needs of a desalination plant. However, coupling of renewable energy source and desalination plants holds great promise as a feasible solution to water scarcity in remote areas where drinking water and conventional energy infrastructure are currently lacking.

Already several desalination plants driven by solar, wind or geothermal energy have been installed throughout the world, and the majority of them have been successfully in operation for a number of years (Bernat *et al.*, 2010).

However, it is clear that RES are still much more expensive than the conventional sources, although the higher cost of RES is counterbalanced by its en-

Table 2. Comparative costs for common renewable desalination. (Papapetrou, 2010).

	Technical Capacity	Energy Demand (KWh/m³)	Water Cost (USD/m³)*	Development Stage
Solar Stills	<0.1 m³/d	Solar Passive	1.3–6.5	Application
Solar-Multiple Effect Humidification	1–100 m³/d	Thermal:100 Electrical:1.5	2.6–6.5	R&D Application
Solar-Membrane Distilation	0.15–10 m³/d	Thermal:150–200	10.4–19.5	R&D
Solar/CSP-Multiple Effect Distillation	>5.000 m³/d	Thermal:60–70 Electrical:1.5–2	2.3–2.9 (possible cost)	R&D
Photovoltaic-Reverse Osmosis	<100 m³/d	Electrical: Brackish Water:	Brackish Water:	R&D Application
Photovoltaic-Electridialysis Reversed	<100 m³/d	Electrical:	Brackish Water:	R&D
Wind-Reverse Osmosis	50–2.000 m³/d	Electrical:	Units under 100 m³/d:	R&D Application
Wind-Mechanical Vapor Compression	<100 m³/d	Electrical:	5.2–7.8	Basic Research
Wind-Electrodialysis	–	–	Brackish Water:	–
Geothermal-Multi Effect Distillation	–	–	Seawater:	–

* Cost calculated at the exchange rate of 1.13 from euro to USD.

Table 3. Investment cost for desalination processes with capacities in range 200–40.000 m³/day. (Wabgnick, 1989 & Ettouney, 2004).

Desalination Process	**Capacity (m³/day)**													
	200		600		1200		2000		3000		20.000		30.000–40.000	
	Cost Unit ($/m³)	Investment (M$)	Cost Unit ($/m³)	Investment (M$)	Cost Unit ($/m³)	Investment (M$)	Cost Unit ($/m³)	Investment (M$)	Cost Unit ($/m³)	Investment (M$)	Cost Unit ($/m³)	Investment (M$)	Cost Unit ($/m³)	Investment (M$)
MVC	3.8	0.75	2.65	1.7	2.25/3.22	3.2/1/58								
RO	3.25	0.5	2.35	1.1	2.15	2	2	3	1.85	4.2				
MED					1.6	2.3	0.825	3.25	0.65	4.85	1.24	35	1.31/1.08	67 70
MED-TVC	3.3	0.5	2.25	1	1.85	1.65	1.8	2.5	1.7	3.3	1.55	35		

vironmental benefits. Although due to rapid decrease of renewable energy costs, technical advances and increasing number of installations, renewable desalination is likely to reduce significantly its cost in the near future and become an important source of water supply for areas affected by water scarcity.

Desalination costs of produced water for different desalination processes coupled with renewable energy sources are described in the following table.

Also, capital investment and desalination costs for different desalination processes powered by conventional energy in the capacity range of 200–40.000m³/day are described in Table 3.

Generally, the desalination cost is considered lower for higher desalination capacities whether they are powered by conventional energy or renewable energy.

The high range of desalination cost is due to the fact that the small-scale applications powered either by renewable energy sources or conventional energy sources require high capital costs (Karagiannis, 2008; Ayoub, 1996; Rheinlander, 2001). The capital cost as well as the operation and maintenance cost can be reduced, if a hybrid energy source comprising both fossil fuel energy and renewable energy is considered (Sagiea, 2001). So, such a hybrid plant can reduce the production cost of desalinated water. Also through

this combination we can have lower emissions of CO_2 and lower electricity consumption. The combination of desalination processes powered by renewable energy sources worldwide is as follows: reverse osmosis 62%, electrodialysis 5%, MSF 10%, MED 10%, VC 5% and others 4%, out of which 43% of the desalination processes are powered by solar PV energy, 27% by solar thermal, 20% by wind and 10% by hybrid combinations. So, photovoltaic energy and wind energy are more promising source of energy to power desalination processes, but the high cost of photovoltaic modules and the unpredictable nature of wind are the main barriers for their use.

With regard to remote areas the renewable energy applications for very small-scale applications are still viable where the transportation cost to supply fresh water is higher. The value of freshwater increases especially in areas which encounter both water scarcity and energy problems. So, installation of an autonomous renewable energy-driven desalination plant will not only ensure the supply of freshwater but also will bring down the cost of freshwater production. However, the factor of desalination cost can be counterbalanced by the environmental benefits offered by renewable energy sources.

In conclusion, nowadays the renewable energy-powered desalination plants may not compete with conventional systems in terms of direct cost of water produced. Nevertheless, their use is steadily expanding in certain areas and it seems clear that they will become a competitive alternative to conventional energy-powered plants in the future, as fuel prices keep rising and fuel supplies are decreasing (Reddy & Ghaffour, 2007).

4. DESIGN OF HYBRID WAVE & WIND POWERED DESALINATION SYSTEM

4.1. DESIGN ISSUES

System's design and development combine research from several scientific domains. The most important requisites we had to satisfy were that the system is environment-friendly and autonomous.

Environment-friendly means that it does not have any side effects, and autonomous means that the floating platform operates unmanned and that energy comes from renewable source (Lilas, 2007). The solution focused on the development of the required subsystems, their integration on a suitable floating structure and operation under the supervision of intelligent control system.

From an operational point of view potable water is produced from the sea water desalination unit, which requires energy. This energy is provided by the wind generator and wave device which is placed close to main platform.

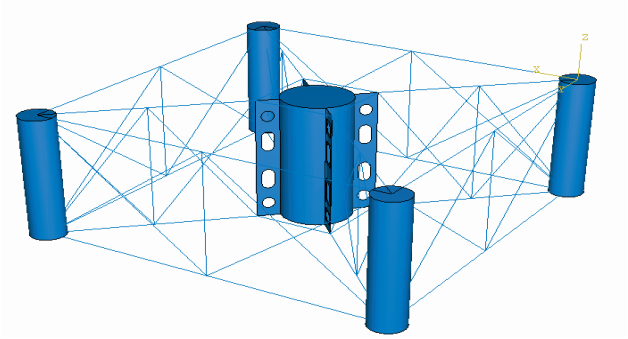

Figure 1. The tubular mesh and cylinders.

Also energy management is very important and has three main targets: (a) Ensure system survival in case of prolonged period without significant energy input, (b) Extract as much energy as possible from wind and wave and maximize water production, (c) Reduce maintenance cost.

In addition, the research has focused at the following targets: (a) Optimizing energy efficiency of desalination unit over a wide range of water output according to available power, (b) Environment-friendly operation without any chemical additives (Younos, 2005; Rachel, 2003), (c) Design of the floating structure to be stable and not be affected by waves, and providing safe operation of all components, (d) Design of control and teleoperation system.

4.2. DESIGN ISSUES OF THE FLOATING PLATFORM

The design of the floating structure in order to fulfill some requirements went over the following phases: (a) Survey of studies worldwide for floating wind turbines (Sklavounos, 2008; Skaare, 2006), (b) Design of a feasible solution that can fulfill the requirements, (c) Optimization of design characteristics to improve performance and reduce cost, (d) Final stability study and load analysis of optimized design.

The optimization targets were to minimize movements from waves, improve the operation conditions for the wind turbine and wave device and withstand extreme weather conditions. Concerning our project, the first step was to examine the shape and the dimensions of the structure. Also, it was examined which is the appropriate number of peripheral floaters around the central floating structure. So, four peripheral floaters were selected, because this design provides better stability and it has construction advantages. So, the final design of floating platform consists of four peripheral floating cylinders with total height of 8 meters and diameter 2 meters each,

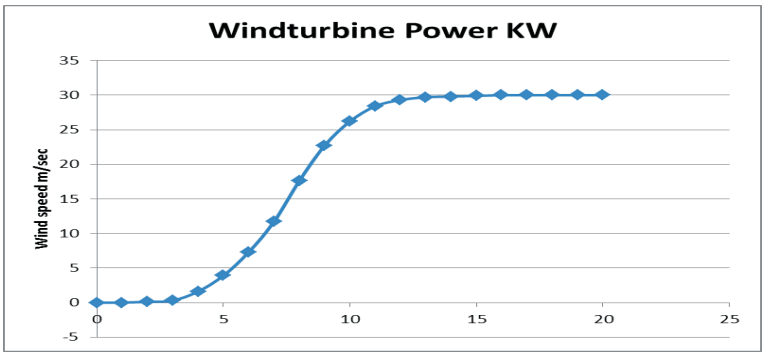

Chart 1. Wind turbine power curve.

and a central floating cylinder with diameter of 4 meters and height of 8 meters.

The wind turbine will be placed in the central floating cylinder. Also the connection of all cylinders is made with a tubular mesh. The system has automatic control via GPS for monitoring and remote control. In addition it is worth mentioning that whole construction can operate even in adverse weather conditions.

4.3. DESIGN ISSUES AND ECONOMICS ELEMENTS OF WIND TURBINE

Almost all countries in the world have the wind energy sources in some areas. Wind conditions in the mountains, coastal areas, in deep sea and in islands are favorable for wind-powered desalination plants. For the operation of a wind-powered desalination plant, it is important to have a suitable process that is insensitive to repeated start-up and shutdown cycles caused by rapidly changing wind conditions.

With regard to position of the wind turbine in the specific project, it is placed at the center of the floating cylinder. The features of this specific wind turbine are the following: (a) It has 30 kW in power, (b) Variable pitch of blades and (c) Variable speed. The role of the wind turbine is to provide energy for the desalination of sea water. So, it becomes understandable that when wind speed is high, the system produces more water, so power consumption increases, whereas when it is low, it decreases. The power supply to the desalination unit is energy that comes from the wind generator and wave device, without using the national supply grid or any kind of diesel generator. In the following chart you can see the power curve of wind turbine.

The economics of a wind-powered desalination plant differ from conventional plant economics since it is almost entirely based on the fixed costs of the systems. Even though there are no fuel costs for the plant, the cost of the wind turbine is considered the main capital expenditure, which replaces the fuel costs of the system. Therefore, energy efficiency is not the main factor, but rather the economics of the process.

Due to intermittence in the production of wind energy, suitable combinations of other renewable energy sources can be employed to provide smooth operating conditions.

Wind generator and wave energy combination can drive the desalination process to operate all day with the help of the battery bank system (Tzen, 2008), as in intervals in which we have «good wind» we usually have also strong waves. Combining these two renewable energy sources with desalination may have several inherent advantages.

4.4. DESIGN ISSUES AND ECONOMICS ELEMENTS OF WAVE DEVICE

Wave energy is ideal for desalination in coastal areas where both energy and seawater are available. Wave-powered technology to produce electricity has an experimental history of at least 30 years. Six wave energy technologies can potentially power reverse-osmosis and vapor compression, are two main technologies are successful at full scale operation (Davies, 2005).

With regard to our project, a system of wave energy was studied and designed, which was implemented and put into autonomous operation as a trial.

The specific wave device has a wave front of 8 meters, and produces hydraulic power 25 kW, even if the waves have more power. Also, the wave device utilizes 11% of the available wave energy. Waves will generally be available where seawater is desalinated. But the harnessing of wave energy is, as with other forms of renewable energy, expensive in terms of capital plant and the effort needed to develop the technology.

Even though, the capital and investment cost of wave- and wind-powered desalination system are high compared to conventional desalination system, under certain circumstances, for example, in remote areas, where distributed energy generation is

more convenient than centralized energy generation, transmission and distribution, renewable desalination could compete with conventional systems (Papapetrou *et al.,* 2010).

4.5. DESIGN ISSUES OF THE DESALINATION PLANT

The most promising potential market for wind/wave powered RO is in present or potential future island touristic developments in places such as Mediterranean islands, Pacific islands etc.

So, for this specific project the method of RO was selected, as the most appropriate desalination method. The desalination unit is installed on the floating platform as well as the control center system for remote operation and the storage tank of potable water. The main issues to be environment-friendly were not to treat brackish water which is also scarce, the use of chemicals to treat water, and the disposal of brine with chemicals. The whole system performed at Elefsis bay. The reverse osmosis unit operates from 8 kW up to 25 kW. Energy storage is small and therefore water production should follow available power, by varying flow and pressure.

5. ECONOMIC EVALUATION OF INSTALLATION FLOATING DESALINATION UNIT POWERED BY WIND AND WAVE

5.1. THE EXISTING SITUATION

Greece is one of seven countries of EE which face water scarcity problems together with Malta, Spain, Cyprus, Belgium, Portugal and Italy. In our country, the problem is becoming more intense in the islands, due to their ground morphology and the minimum water sources, which usually are not drinkable but brackish. The situation reaches its peak in the summer due to high temperatures, drought as well as the increase in consumption due to tourism in these areas. The situation is not the same in every island. The problems are more intense in the waterless islands of Cyclades and Dodecanese. Also the problem of scarcity is encountered more in small islands and in islands with low touristic development. This fact is expected, as these islands do not have the necessary resources for expensive solutions to be financed, and also because in these islands there is drinking water scarcity, something that rightly leads to the name «deserted islands». As a temporary solution to the problem, the state has chosen to transfer the water to the islands by ships. However, the amount which is spent on this practice is increasing, as the problem is still unsolved. It is worth mentioning that between 1997 and 2007 the transfer cost has grown tenfold from 1.244.881€ to 11.206.409€ with increasing trend of about 10% for the next years (Group ITA, 2006). In 2007 the Ministry of the Aegean and Islands Policy paid 4,91€/m^3 for transportable water for Dodecanese and 8,32€/m^3 for transportable water for the Cyclades.

Also, in many cases the transferred water is not enough to meet the summer needs of some islands, with constant interruptions and many problems in economic and social activities of residents. Also, it is worth mentioning that the quantities of transferred water do not meet the standards of potable water due to insufficient hygiene conditions in transfer vessels. Also, the isolated areas and the islands have difficult

Table 4. Characteristics of installation point.

Installation Area	Iraklia Island
Island Complex	Cyclades
Area	18.078 km^2
Population	151 residents
Mean Wind Speed	6m/sec
Mean Significant Wave Height	0.8 m
Mean Wave Period	4.8 s
Mean Wave Slope	1.8 p
Depth of installation point	30 m
Distance from the cost of desalination unit	4 km

Table 5. Mean annual coverage of water supply needs of iraklia island.

Desalination (%)	–
Transported Quantities (%)	91,99
Quantities transported water m^3/year	16.818
Reservoir of Water (%)	–
Groundwaters (%)	4.35
Coverage of Water Supply Needs (%)	96.35
Population (2001)	151
Total Requirements in water (m^3) Current Situation	55
Total Deficit (%) Current Situation	5.9
Total Requirements in water (m^3) Foreseeable Situation in 2020	67
Total Deficit (%) Foreseeable Situation in 2020	64.3

Source: Aquatic Consortium System of the Aegean, behalf on Ministry of Development

access, resulting in difficulties with electricity supply. These areas are not interconnected with the mainland grid of Greece or are interconnected with weak and low capacity local grids, which are fed from diesel generators. Consequently, the cover of energy needs of desalination methods by conventional source of energy is often not possible, as the local electrical grids are low-power and unable to meet other loads. Even when there is the possibility of energy supply, this solution is not considered cost-effective and economically advantageous, as the available energy sources are considered costly, like diesel in contrast to cheap but polluting lignite.

So, the combination of desalination units powered by RES is considered the most appropriate method for production of potable water in waterless and isolated areas.

5.2. THE CASE STUDY

So, taking everything into consideration, it was decided that an installation of desalination unit in specific areas in Greece would be feasible.

According to data from a study, which was made by the Consortium of Aquatic Systems of Aegean Sea, on behalf of Ministry of Development, it was found that the current needs of Aegean islands are 170.942.219 m^3 per annum and the total deficit is 19.049.212 m^3. In 2020 the total needs are forecasted to reach at 224.157.511 m^3 and the total deficit to reach 24.462.470 m^3. These predictions were based on a number of parameters such as expected growth of population and tourism activity, reduction of consumption of agriculture and livestock as well as the hydrological characteristics of each island.

So, according to these data and taking into account the morphological characteristics, the wind and the wave potential, the bathometric characteristics, as well as the non-existence of natura areas, it was decided that a desalination unit could be installed in Iraklia island.

5.3. SUSTAINABILITY OF DESALINATION PLANT

Calculation of future results, Internal Rate of Return (IRR), Net Present Value (NPV) and Profitability Index (PI): To analyze the viability of this desalination unit in specific installation area, the techno-economic data of the unit should be taken into account.

The assumptions are the followings:

Size Unit: 70m^3/day

***Type*:** Reverse Osmosis (RO) with wind turbine and wave device

Mean Wind Speed: 6m/sec

Table 6. Economic Evaluation of Investment.

Total Initial Cost	*800.000*
Percentage of State Subsidy	40%
Payback Period	5th – 6th year
Net Present Value	712.342.88€.
Profitability Index	1.49
Internal Rate of Return	21.8

Table 7. Economic Evaluation for Various Operation Scenarios.

Internal Rate of Return (IRR), Net Present Value (NPV) & Profitability Index (PI) for various operation scenarios of desalination unit		
	Scenario #1 *Water production. Probability (20%) higher production from mean production according to wind & wave conditions of location*	***Scenario #2*** *Water production. Probability (20%) lower production from mean production according to wind & wave conditions of location*
Net Present Value	1.038.142,22 €	532.518,96 €
Payback Period	3rd – 4th year	6th – 7th
Internal Rate of Return	27.6	17.6
Profitability Index	1.89	1.26
Total Annual Production of the Unit (m^3)	28.046,016 m^3	18.697,34 m^3

Mean Significant Wave Height: 0.8 m

Maintenance etc: 0,3 €/m^3

Total Annual Production (Sales) of the Unit: 23.506 m^3

Availability of Unit: 92% due to maintenance, cleaning of membranes, filters, etc

Total Investment Cost: 800.000€ *(*including the floating platform, wind turbine, wave device, piping, studies, licensing)

Scheme of Investment Financing: 40% state subsidy (according to Law 3299/2004, as in force after its amendment with the Article 37 of Law 3522/2006), 30% equity, 30% bank loans

Operating Conditions: The investment cost is undertaken by individuals (30% equity, 30% bank loans), with operating duration 15 years. After this period the facility will be given to municipality. When the

unit will be given in municipality it should be in good condition and fully operational. The municipality undertakes the costs of connection to the network as well as the cost of storage (water tanks) Also, the municipality is committed to buy the guaranteed quantity of drinking water for 15 years, at a price that exceeds the production cost, to ensure the viability of the unit.

Inflation: 1.5%

Interest Rate: 5%

Cost of Water Transportation by Ship: 8–10€/m^3 (Karagiannis, 2010)

Selling Price of Water: 5 €/m^3

The results of economic analysis of the desalination unit are the following:

The total net annual cash flows of the project for 15 years are around 1.192.342,88 €. So, the NPV of the investment, subtracting from the amount of 1.192.342.88€ the initial investment cost (not including the subsidy), we conclude that the NPV amounts to 712.342.88€.

The results of the model for the cost-effectiveness of the desalination unit, from both the main case study and two scenarios show that such an investment can become especially attractive for private investors with good payback period, NPV, IRR and profitability index for all cases. Also, as we can observe from data of the table, the annual water production from both main case study and two scenarios are sufficient to cover the annual needs of Iraklia island (16.818 m^3), even in case of minimum water production (Scenario 2).

CONCLUSIONS

The effects of climate change, the depletion of groundwater resources, as well as the demographic and other changes (population growth, tourism etc) cause serious problems of water shortage in the islands and in some coastal areas, especially during the summer season. The mismanagement of water resources is considered one of the most important factors, which cause water scarcity. This fact is caused by overexploitation of ground and surface water, the lack of project management, poor infrastructure, as well as temporary or ineffective efforts made in the past. In many cases the alternative solutions, which were implemented, were not effective or economically viable, and despite the high costs they did not succeed to solve the problem of water scarcity.

The severity of current problems, the lack of alternatives and mainly the predicted growing needs for the next 10 years, require the desalination as the most reliable and appropriate solution. Already several countries of Mediterranean and Middle East, such as Israel, Cyprus, Malta, Spain and many others, cover the greater part of their water needs by using desalination systems.

In a first phase, the desalination should be considered as the only viable solution that would replace the water transportation to waterless islands, as it could provide high quality water and reduce the cost compared to cost of water transportation. In the second phase, desalination could be extended to coastal areas with serious degradation problems of groundwater, for which the water transfer is unprofitable or difficult.

Based on current technology and production costs, the sustainability of desalination plants, which will be created by municipalities or private investors, can be ensured, with relatively low price levels compared to those in islands.

Apart from the radical solution of water scarcity, the use of available comparative benefits which our country has for the technology development of floating desalination plants, it could contribute to economic growth through the creation of an extremely promising industrial activity, (offshore floating wind parks, exports of floating desalination units to other island countries or developing regions which encounter serious problems of potable water quality).

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