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Transdisciplinary Credit Allocation Policy to Foster Regional Economic Development Through Financial Institutions

Federico TRIGOS[1] and Carlos Mario ALDANA
Tecnologico de Monterrey, EGADE Business School, Mexico

Abstract. Corporate philosophies of multiple financial institutions, including development banks, address regional economic development as their corporate driver. Regardless the latter, regional development financial institutions usual priority focuses primarily on individual application credit risk assessment, without a designed long term policy to impact strategic industries and its regional key economic objectives. With a transdisciplinary approach that involves a number of engineering (engineering economics, mathematical programming) and non engineering disciplines (finance, accounting, banking, policy making) that takes into account the full set of stakeholders (credit applicants, financial institutions, society at large, governments, among others), the contribution of this work impact the future of engineering practice by providing a framework (a method that includes a ready to use decision support tool) to design a transdisciplinary credit allocation policy that financial institutions could rely on to have a targeted aim significant impact in the strategic economic transformation of focused regions. A numerical illustration is provided to highlight the specifics of this transdisciplinary policy for the benefit of practitioners and society.

Keywords. Accounting, credit allocation, credit portfolio design, decision support tools and methods, decisions in a multi-stakeholder environment, development banking, finance, financial institutions, flexibility, engineering practice, engineering economics, mathematical programming, multiobjective optimization, options, policy making, regional development, strategic planning and budgeting

Introduction

Many Microfinancing Institutions (MFIs) started with socially-oriented missions; however, many of them have later transformed themselves into profit-seeking organizations [1]. Academic literature identifies the conflict between these institutions' social impact and Financial Sustainability (FS) [2]. Development banking is also an example of this Conflicted Dual Objective (CDO). The emphasis on FS of MFIs is also of concern as it could negatively impact their key goal of achieving social outreach [3] and regional economic development. The issue is clear, but how to solve it remains unclear [4].

Ertas suggests that "neither mono-disciplinarity nor inter- or multi-disciplinarity provides an environment that promotes collaboration… and produces truly creative and

[1] Corresponding Author, Mail: ftrigos@tec.mx.

innovative solutions to large-scale, complex problems" [5]. Engineering/management tools like multiobjective mathematical programming can handle several objectives in conflict from a theoretical stand [6]. Transdisciplinarity is adequate for practitioners to solve the CDO [5, 7]. Wognum et al. recognize as a challenge "the identification of engineering problems that require a transdisciplinary approach" [7]. In this spirit, the Transdisciplinary approach could be the key to solving MFIs conflicting objectives (financial return, social and economic impact) by including engineering and non-engineering disciplines, considering all the stakeholders (financial institutions, entrepreneurs, workers, and suppliers, among others) to design an acceptable solution for society with a higher opportunity to pass the test of time.

Multiobjective optimization has been applied in industrial engineering, management, economics, and logistics, among other fields, to analyze trade-offs between conflicting objectives [8]. The formulations of linear and non-linear goal programming (GP), lexicographical GP, weighted GP, polynomial GP, and fuzzy GP are widely used [6], [9]-[11] in engineering [12]. From financial decision makers' preferences, the focus is to minimize risk and maximize return in portfolio management [13-14]. To the best of our knowledge, none of these methods have been aimed at transdisciplinary applications focusing on financial, social, and economic aggregated spillovers to stakeholders.

Economic Development (ED) and Credit Allocation (CA) by Financial Institutions (FIs) are highly related [14]. Responsible banking practices yield endogenous economic growth; thus, banks' loans are an accelerator for the economies [15]. The leading objective of CA is to foster wealth creation and social impact [16]. In this sense, contracts are instrumental to achieving this purpose. These contracts contain embedded multicriteria elements to achieve coordinated institutional use of capital [17]. In some economies, funding sources are taken from financial markets, while banks are critical to encounter financial needs in many countries. In said banked-economies, FIs enforce contracts [18] for DO fulfillment. FIs ought to have an "intelligent" financial product design to maximize the social and economic outreach of financial resources. Hence, diversity of FIs (cooperative banks, savings banks, private banks) creates economic wealth for local economies [19].

Robust FIs could pave the way for strengthening the international financial flow [20] for wealth creation and social development. Local FIs (LFIs) differ from traditional banks, especially when they are registered as a non-profit organization mutual fund or cooperative credit societies (savers contribute to the financial capital of the institution through contributions, maintaining equitable rights over the performance of the loans). With changing global environment and uncertain situations like the economic recession of 2008, FIs turned towards FS, widening their scope of financial services to function with reduced government and donor funding. This resulted in sustainable FIs who charged interest rates covering the total cost of their financial services and providing financial instruments like savings services per local needs [21]. Nevertheless, there has been increasing concern that focusing on FS may hurt the primary objective of social outreach. Therefore, in the current context, two types of productivity can be attributed to this financial sector. These are based on financial performance and the social outreach of creating social benefits through financing aid [22]. Thus, there is a need to understand FIs productivity and merge the anticipated gaps between FS and social outreach to ensure the sector's success. Also, there is the need for the government and concerned authorities [in developing banking] to bring in innovative models and business practices to ensure the sectoral growth of LFIs, which would help them to serve their key goal of providing financial benefit to the opportunity-inequitable section of the society.

The contribution of this work impacts the future of engineering practice by providing a framework (a method that includes a ready to use tool for decision making support) to design a Transdisciplinary Credit Allocation Policy (TCAP) that financial institutions could rely on to have a targeted aim significant impact in the strategic economic transformation of focused regions.

This paper is organized as follows: In Section 1, DO are imperative in FIs, society's viewpoint; Section 2 presents a transdisciplinary policy for its achievement; Section 3 shows a case for illustrating a policy-making route to foster regional economic development that responds to a changing global environment. Section 4 includes conclusions and further research.

1. DO decision making in FIs

In microfinance institutions, the primary decision is based on allocating the investment to the different schemes. The approach in this paper focuses on the dual for-profit and non-profit purposes of microfinance institutions, such as credit unions. Academic literature on the use of optimization techniques in investment planning in credit unions is scant. However, the central problem is to define the proper priorities in the allocation process [23].

Banks as social accountants, screening for credit allocation, the moral and technical aspects for assessing creditworthiness are widely discussed in the literature [24, 25, 26]. Technically, placing the TCAP in the process undertaken by FIs for credit allocation, we assume a two-stage credit rating system [27]. The first phase computes the probability of default to predict if the beneficiary is a non-defaulter considering indebtedness and credit history. While a second phase assesses the returns, the TCAP will focus on the multiple impacts of the credit, taking the list of applications resulted from the first stage as input data.

The uncertainty of cash flows and the need for regional development requires that local financial institutions solve mathematical models for efficient portfolios that respond to the purposes of society [28]. To foster sustainable regional economic development (sustainable economic and social development), the CA to the formation, transformation, and accumulation of capital is considered integral [16], and a transdisciplinary solution is of fit.

2. The Transdisciplinary Credit Allocation Policy

Table 1 describes the contribution of this research as a TCAP. This policy is designed to be implemented by a particular FI. Examples of FI that can benefit from TCAP are Development banking, Microcredit institutions, National banks, among others. The policy is divided into two steps: 1) identifies the region to be the focus of the endeavor, the decision-making time horizon, the number of industries within the region to be focused on; in addition it identifies a number of Key Economic Objectives (KEO) to impact, along with their weights. Some examples of these KEOs could be the impact of credit allocation on labor (which could be further divide into Minorities, gender, etc.), regional suppliers, infrastructure, environment, and entrepreneurship, among others. In this way stakeholders' impacts are identified and considered. Since the lifetime of each CA varies the use of Net Present Value or Annual Equivalent methods from Engineering

economics is in order [29]. Strategic planning from the financial institution sets periodical budgets and expected portfolio return from CA. 2) For every industry at each decision making period a number of credit submissions is received at the FI. A pre-screen of each submission is in order, to discard the ones beyond the industry and institution risk levels. Bessis, J. [30] highlight the importance of satisfying banking regulations. Once a set of financially solid applications is assembled. Each application cash flow is analyzed to identify the impact of the credit on each KEO. Then a multiobjective mathematical programming model (3) through (6) is used to select the CA portfolio that maximizes a weighted average of KEO and satisfies the FI budget and minimum portfolio expected return for the selected industry in the period under analysis. In this way a transdisciplinary approach is achieved. For each credit application selected by (3)-(4) contracts must be drawn and signed to meet the obligations stated by the key economic objectives ($O_{i,j,t,k}$) stated in section 2.2 of Table 1.

In addition, Figure 1 shows a graphical representation of the policy identifying in addition the possible users of the TCAP as: private, local of public financial institutions. This policy could also be used as key issue to seek external funding from domestic/international, private or public institutions, in order to prove an objective mechanism for CA to impact in a designed fashion the economic development of a particular region.

3. A numerical example

The purpose of this section is to illustrate the mechanics of TCAP shown on Table 1 in a small numerical instance for the benefit of practitioners. A national financial institution is planning on having an annual strong influence on the economic development of the fourteen state of the nation (Step 1.1) for a planned horizon of five ($T = 5$, where $1 \leq t \leq T$) years (Step 1.2). The financial institution has identified three ($m = 3$ where $1 \leq i \leq m$) major economic industries to influence (Step 1.3): agriculture ($i = 1$), electronics ($i = 2$), software development ($i = 3$).

For the purpose of simplification, the TCAP will be illustrated for industry 1 (agriculture), where four ($n_1 = 4$ where $1 \leq j \leq n_1$) key economic objetives were identified: entrepreneurship net profit, labor, regional suppliers' profit, and non domestic suppliers profit (Step 1.4). It has been defined an annual budget of $2,000,000 to be allocated for the planning horizon ($B_{1,t} = \$2{,}000{,}000$, where $1 \leq t \leq T$). The financial institution expects a minimum annual credit allocation portfolio return for this industry given by $\{R_{1,t}\} = (40\%, 41\%, 42\%, 42\%, 43\%)$. Table 2 summarizes the data for TCAP in agriculture Step 1. At the beginning of the first year 150 credit submissions related to agriculture were received. The institutional financial screening found that only forty ($C_{1,1} = 40$) of them were financially solid (Step 2.1). The requested capital ($Fo_{1,1,k}$), the return for the financial institution ($r_{1,1,k}$), and the impact on every key economic objective ($O_{1,1,k}$) defined for this industry is shown on Table 3 for every credit submission (k). This completes Step 2.2. With this information the credit allocation multiobjective binary optimization model (3) through (6) can be written and solved.

The model was implemented in GAMS using a MacBook Air under macOS Monterrey Version 12.2.1.

Table 1. Transdisciplinary Credit Allocation Policy.

Steps	Description
1. Policy setup and budgeting	1.1 Select a specific economical region. 1.2 Define the time horizon of T decision making periods (with $1 \leq t \leq T$). 1.3 Select m industries (with $1 \leq i \leq m$) to impact within the region. 1.4 For every industry i identify n_i key economic objectives (with $1 \leq j \leq n_i$) aimed to impact. 1.5 Define the budgets ($B_{i,t}$), expected portfolio returns ($R_{i,t}$) of credit allocation selections, and the impact policy weights ($w_{i,j,t}$) per industry i, economic key attributes j and period t. The weights must satisfy for every industry i and period t $\sum_{j=1}^{n_i} w_{i,j,t} = 1$ (1) $w_{i,j,t} \geq 0 \ \forall j$ (2) In order to complete this step, the Transdisciplinary Team requires deep knowledge of local and international regulations, markets, industries, economic sectors and politics.
2. Periodical credit allocation decision making	For every industry i at period t several credit submissions are received to be analyzed by the finacial institution 2.1 Pre-screen every credit submission received at the beginning of period t related to the development of industry i, using general (include institutional national, and international standards as needed) accepted banking principles (local and international) resulting in $C_{i,t}$ financially solid credits (with $1 \leq k \leq C_{i,t}$). This pre-screening step requires the Transdisciplinary Team to have deep knowledge and understanding of local and international banking regulations, industrial standards, credit risk assessment methodologies, and ethical compliance factors 2.2 For every credit submission k identify the expected regional impacts for every key economic objective ($O_{i,j,t,k}$), its return for the financial institution ($r_{i,t,k}$), and the funds requested ($Fo_{i,t,k}$). 2.3 Mathematical optimization The following credit allocation multiobjective binary optimization model will determine the portfolio (the set of $x_{i,t,k} = 1$) of accepted credits for industry i at periods t. $Max \sum_{j=1}^{n_i} \sum_{k=1}^{C_{i,t}} w_{i,j,t} O_{i,j,t,k} x_{i,t,k}$ (3) Subject to $\sum_{k=1}^{C_{i,t}} Fo_{i,t,k} x_{i,t,k} \leq B_{i,t}$ (4) $\frac{\sum_{k=1}^{C_{i,t}} r_{i,t,k} Fo_{i,t,k} x_{i,t,k}}{\sum_{k=1}^{C_{i,t}} r_{i,t,k} x_{i,t,k}} \geq R_{i,t}$ (5) $x_{i,t,k} = 0$ or $1 \ \forall i,t,k$ (6) The portfolio of accepted credit submissions proposed by the latter model should be review by the banking executive credit committee to check for qualitative considerations not including in the model in to order to make a final decision on the credits to be accepted in this period (t).

The following results for $t = 1$ were obtained in negligible computer time by solving the model in (3) through (6). The subset of credit applications (with $x_{1,1,k} = 1$) selected by the model were {1, 2, 3, 5, 10, 15, 16, 17, 18, 21, 27, 29, 32, 35, 37, 38, 39, 40} making a portfolio return of 40.27% using $1,998,042 of the budget. The impact on the key economic objectives for this industry at period 1 is: net profit $951,595; labor $30,549; domestic supplier $98,586; non domestic supplier $26,237.

With the latter results from the model the next step is to present them to the local development banking credit committee in order to make the final decisions to setup the portfolio of accepted credits.

By running the policy stated in Table 1 for industry 2 and 3 in the region, the set of credits approved is defined. By executing this policy at periods 2 through 5 in all the 3 industries, the maximum impact on the region is obtained according to the elements considered.

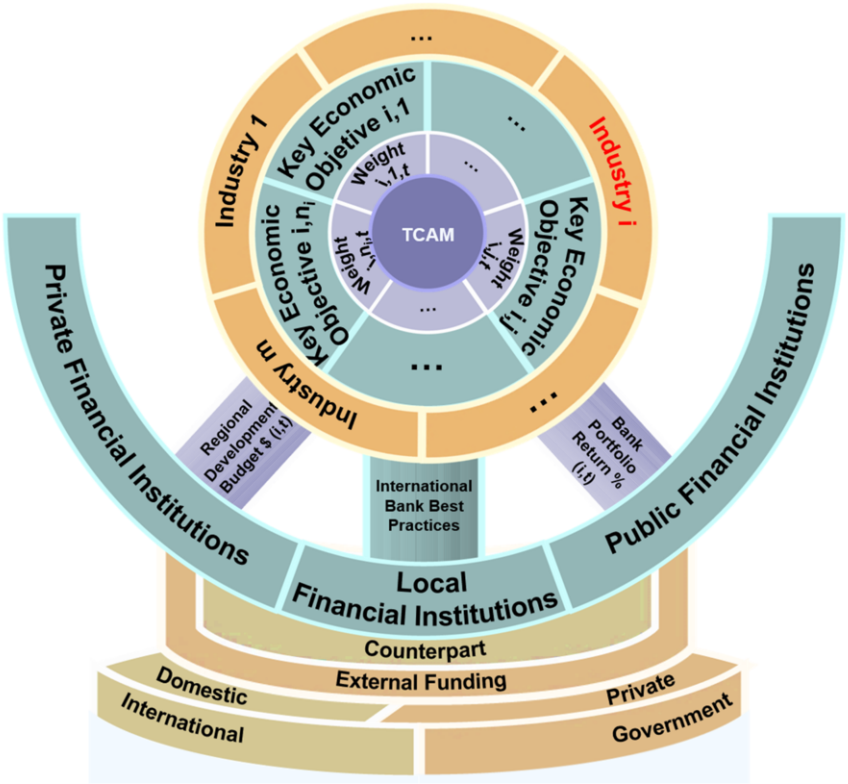

Figure 1. The Model for the Transdisciplinary Credit Allocation Policy.

Table 2. Agriculture, industry policy setup and budgeting data (TCAP Step 1).

	Planning Periods (t)				
	1	**2**	**3**	**4**	**5**
$B_{1,t}$ **($)**	2,000,000	1,900,000	1,900,000	1,700,000	1,600,000
$R_{1,t}$ **(%)**	40	41	42	42	43
Key Economic Objective (*j*)	**Impact Policy Weights ($w_{1,j,t}$)**				
Net profit	0	10	20	20	25
Labor	30	30	20	30	25
Domestic supplier	40	30	30	25	25
Non domestic Supplier	30	30	30	25	25
Sum	100	100	100	100	100

Table 3. Set of 40 pre-screened credit applications considering 4 regional objectives for industry i at time for the numerical example.

Pre-screened submissions (*k*)	Net profit ($)	Labor ($)	Domestic supplier ($)	Non domestic supplier ($)	Loan cost (%)	Requested capital ($)	Pre-screened submissions (*k*)	Net profit ($)	Labor ($)	Domestic supplier ($)	Non domestic supplier ($)	Loan cost (%)	Requested capital ($)
1	52,281	1,235	5,603	1,518	41	133,908	21	60,876	2,971	5,261	1,928	61	145,467
2	50,792	1,354	5,157	1,579	47	110,810	22	51,687	1,943	5,967	1,343	60	139,509
3	60,604	1,218	5,901	1,305	18	114,688	23	10,392	2,348	5,162	1,095	51	126,923
4	14,345	1,815	5,664	1,313	62	107,501	24	37,438	1,459	5,378	1,317	28	126,942
5	49,614	1,120	5,059	1,169	34	106,798	25	41,004	2,103	5,224	1,350	13	146,804
6	21,516	2,953	5,177	1,719	52	134,296	26	34,165	2,866	5,557	1,988	33	128,349
7	30,437	2,805	5,469	1,330	59	124,703	27	56,580	1,463	5,595	1,683	47	117,885
8	24,274	2,757	5,257	1,238	37	104,341	28	26,486	2,504	5,735	1,895	22	140,995
9	18,499	1,017	5,561	1,151	50	145,819	29	69,633	1,689	5,348	1,302	22	113,120
10	33,684	2,542	5,015	1,868	43	86,038	30	35,566	1,992	5,776	1,326	61	137,869
11	52,354	1,871	5,736	1,324	65	138,864	31	10,192	1,557	5,069	1,470	13	130,545
12	25,188	2,572	5,283	1,958	31	141,515	32	57,906	1,582	5,315	1,320	64	123,492
13	57,114	1,604	5,657	1,747	24	148,043	33	35,801	1,210	5,346	1,094	11	93,737
14	12,962	2,773	5,591	1,872	10	120,697	34	22,885	1,188	5,614	1,189	16	101,524
15	62,618	1,614	5,009	1,355	50	124,904	35	53,398	1,001	5,862	1,716	39	120,708
16	50,793	1,868	5,781	1,494	45	90,897	36	38,514	2,790	5,812	1,385	38	144,601
17	35,092	1,165	5,611	1,320	41	87,710	37	62,643	1,105	5,601	1,610	52	88,877
18	37,128	2,527	5,938	1,692	47	104,851	38	50,912	2,690	5,545	1,029	11	121,791
19	46,574	1,335	5,449	1,280	24	109,595	39	56,560	1,516	5,732	1,009	51	94,096
20	41,549	2,052	5,623	1,003	33	117,024	40	50,481	1,889	5,253	1,340	11	112,002

4. Conclusions and further research

Credit allocation to impact regions at a targeted social and economic level during a planning horizon while keeping generally accepted risk banking practices is a complex problem documented in literature, but solutions are scant.

This paper contributes to the future of transdisciplinary engineering by providing a transdisciplinary credit allocation policy that uses a number of engineering and non engineering disciplines that can be implemented by a Financial Institution to impact by design, the economic development of a region, through the design of credit allocation portfolios that take into account all stake holders, and accepted risk management banking practices. The policy could aid the financial institution to obtain additional funding from

local/international public/private institution since it shows a systemic way to locate funding with general objective of regional economic development.

Further research pend ahead since the policy could be modified for governmental (national, state or municipal level) as well as corporate purposes to establish budgeting strategic planning policies. The introduction of stochastic process and behavioral finance could be researched to be included in the policy. Furthermore, this transdisciplinary approach could be modified to be applied in more multiperiod complex situation existing in the economic and financial sectors.

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