A Market Potential Index for Improved Maize Seeds in Mexico

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Abstract

The bottleneck for enhancing the use of and benefiting from improved seeds is the development of a strong seed sector that reaches producers and meets their needs. Market studies are the key to seed product development and marketing strategies that strengthen the links between technologies and beneficial impact on adopters. This article develops a market potential index for improved seeds based on the market potential index for emerging markets. The index is used to examining the potential and limitations for increasing the use of improved maize seeds in Mexico. The focus is on the development of a representation of the market size and market profiles for improved maize seeds that is useful for identifying and seizing market opportunities. Our proposed market potential index is based on five key dimensions of the market demand for improved seeds. The possibilities and limitations of the market potential index as a marketing management tool are discussed.

Keywords: agrifood marketing, demand estimation, market profiles, marketing effort, seed product innovation.

JEL Classifications: Q12, Q13, M31

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Introduction

Genetic improvement and seed product innovation have been a crucial factor in increasing the productivity of maize and the income of producers worldwide. In Mexico, in particular in the rain-fed areas, the demand for improved seeds is heterogeneous and adoption outcome is uncertain. For maize producers in Mexico to choose to use improved seed technologies, they need to provide an advantage in terms of increased profitability and/or other outcomes that producers value. In addition, seeds need to be made more available and accessible. These challenges include developing new seed products, managing low production costs and affordable prices, wide distribution channels throughout the country and segmenting markets.

The extent to which improved seeds can effectively deliver their potential benefits depends on the organization and coordination between key value chain actors such as crop breeders, seed firms and producers. In the case of Mexico, a key challenge to such organization is that most maize producers are small, low income farmers who produce for their own consumption as well as for selling to the market. In addition, Mexico is the center of origin of maize and farmers traditionally plant various maize populations and commonly recycle maize seed; mixing seeds of different origins and exchanging seeds with other farmers (Bellon and Berthaud, 2006). Furthermore, difficult productive and socioeconomic conditions and underdeveloped agricultural markets place specific constraints to seed product development, quality and added value for smallholder farmers (Wiersinga et al., 2010).

In this paper, a market potential index (MPI) is proposed for evaluating the growth, opportunities and challenges of the improved maize seed market in Mexico. The MPI for improved seeds in Mexico postulates that improved seed forecasted sales are a function of the area planted to maize, the current use of improved seeds, the maize producers' economic capacity, the land production potential for maize, and the difference in profitability from using improved seed. The calculated measure is used to examine the following research questions:

- What is the market potential for improved seeds in Mexico in the different production areas?
- How much seed needs to be produced?
- What are the different market profiles in Mexico?

The focus is on the development of a representation of the market size and market segments and profiles of improved maize seeds that is useful for identifying and seizing market opportunities. Our proposed MPI is based on five key dimensions of the market demand for improved seeds. The index is applied to examining the potential and limitations for increasing the use of improved maize seeds in Mexico. The possibilities and limitations of the market potential index as a marketing management tool are discussed.

Market studies are the basis of information sharing for linking more effectively the breeding programs of research organizations and the product development and marketing strategies of seed firms. Knowledge about consumers' characteristics and preferences, help seed suppliers better match their product, service and information to the needs of their customers (Gloy and Akridge, 1999; Alexander, 2005; Cummins, 2007). Specifically, a MPI can help crop breeders ensure that their breeding programs are more responsive to producers´ needs. In the case of a seed supply chain, with many participants and integrated agrifood production networks, sharing information and developing market indicators and other performance measures can be very important for guiding and achieving collective competitiveness (Aramyan et al., 2006).

Mexican maize producers can be seen as underserved consumers and markets for improved seeds as there is a dearth of integral seed solutions tailored to their specific needs. The interest on small maize producers as a market segment for improved seeds must focus on their key role in improving food production and productivity in Mexico. The idea of smallholder farmers as creative entrepreneurs who value new technological opportunities and who constitute a potential market for innovative and more sustainable technologies is elaborated by the Base of the Pyramid (BoP) approach (Prahalad, 2010; London and Hart, 2004).

Maize sector in Mexico

Mexico is the center of maize diversity and maize is central to the livelihoods of millions of producers. In Mexico, farmers domesticated maize about 9,000 years ago and since then have diversified the crop through constant selection into many landraces and populations (Bellon and Berthaud, 2006).

Maize is produced in a continuum of production systems running from traditional to commercial. Traditional production are characterized by landscapes with multiple maize populations, seed recycling and exchange of local varieties called *criollos* and ‘creolization’, when these mix with hybrids (Bellon and Berthaud, 2006). In the traditional production systems maize is grown together with other crops in a multiple crops system. Commercial agriculture is characterized by landscapes planted with a few maize seed materials, high inputs use and high productivity of a single crop.

Maize production regions in Mexico

Maize is grown throughout Mexico in a wide variety of production environments in terms of altitude, temperature, moisture regimes, land, soil types and production technologies. For the purpose of this paper, we define 11 maize production regions, which correspond to relatively homogeneous geographic areas in terms of the climatic, agro-ecological and socioeconomic features that influence maize production and the potential for developing seed markets (Figure 1).

Figure 1. Maize production regions in Mexico

Table 1 shows most important climatic parameters that characterize each maize production region. The 11 regions include two with predominant features of highland (High Valleys and Central Valley). Bajio is a transition region between 1,500 and 2,300 meters. Three of the regions are predominately tropical environments (Atlantic and Pacific Lower Tropics and Humid Tropics). Three of the regions are subtropical environments (Middle Input, Chihuahua and Northern Gulf) and two predominantly dry environments (Northern Pacific and North Central).

Table 1. Climatic parameters of maize production regions in Mexico

Region	Latitude			Altitude			Temperature*			Precipitation		
	Minimum	**Maximum**	**Mean**	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**	**Mean**
High Valleys	18.1	21.3	19.5	605	2,909	2,107	11.3	22.3	16.1	388	3,374	973
Bajio	19.8	21.9	20.6	1,536	2,288	1,812	16.1	20.9	18.9	525	969	726
Central Valleys	16.2	18.2	17.2	1,026	2,605	1,803	14.2	22.2	18.1	521	2,685	871
Pacific Lowland Tropics	14.7	22.6	18.4	8	2,584	1,144	12.9	29.3	21.9	314	3,992	1,093
Atlantic Lowland Tropics	17.9	22.5	20.3	2	1,907	297	14.8	27.0	24.1	466	3,785	1,482
Humid Tropics	14.8	18.6	17.1	4	2,863	634	11.5	28.0	23.4	881	4,513	2,294
Middle Input	21.2	31.3	24.6	8	2,554	1,464	11.8	25.2	19.2	274	1,673	545
Northern Pacific	23.1	32.7	28.6	5	778	217	16.5	25.9	22.5	74	668	306
Chihuahua	26.1	31.7	28.3	433	2,394	1,500	11.6	23.8	17.3	215	1,083	473
North Central	23.4	29.3	26.1	43	2,690	919	13.8	23.9	20.9	167	592	393
Northern Gulf	22.0	26.7	24.7	4	1,484	307	18.4	25.6	23.0	419	1,418	749

Sources: Elaboration CIMMYT, GIS lab with data from Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978; INEGI, Continuo de elevaciones mexicano (CEM 2.0); García, E. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), (1998). "Climas (Clasificación de Koppen, modificado por García)

The role of improved maize seeds in Mexico

Since the 1980, Mexico has been increasingly more dependent on imports, especially yellow maize imports for animal feed and industrial use. Figure 2 shows maize production, imports and consumption in Mexico since 2000 and their forecasts to 2018.

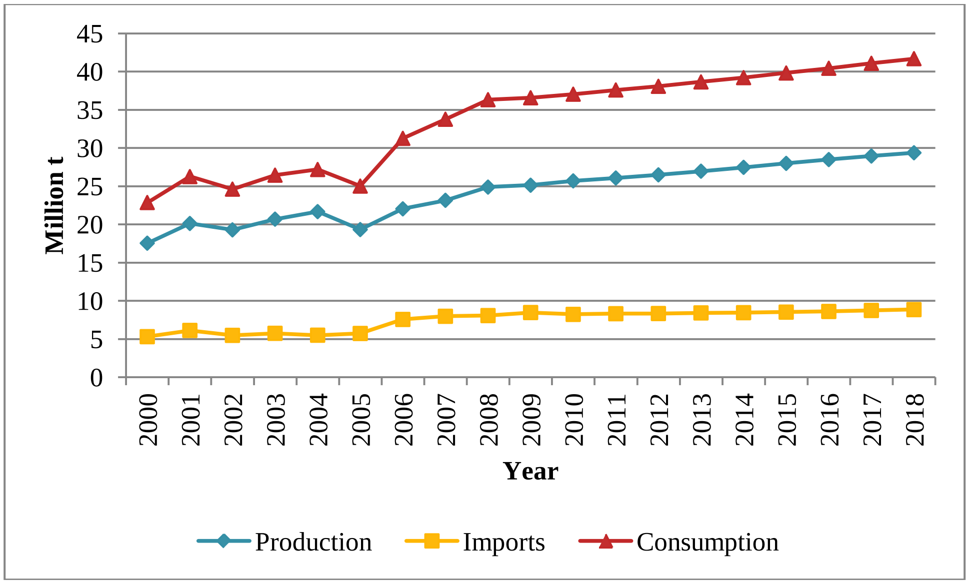


Figure 2. Maize grain production, consumption and imports in Mexico.
Source: SFA Escenario Base 2009-2018 and SIAP 2009.

There is a high interest in Mexico meeting their maize consumption with own production and reducing import in the coming years. A major initiative towards this goal is the *Sustainable Modernization of Traditional Agriculture* (MasAgro). MasAgro, an initiative of the Mexican Federal Government, is a network of value chain actors that includes farmers, research and development organizations, private seed companies and extension agents. MasAgro aims to increasing maize productivity by enhancing farmers' access to appropriate technologies, including improved seeds.

Improved seeds are those which have been improved by conventional plant breeding as opposed to local landraces or traditional varieties which have not been improved using conventional breeding procedures (Perales et al., 1998; Morris et al., 1999). In maize conventional plant breeding mainly entails hybridization by means of development of pure-lines by self-pollination, production of crosses between derived lines, identification of hybrids having consistent and reliable performance across an extensive number of environments, and production of the best hybrid for use by the farmer (Hallauer and Carena, 2009). The focus of MasAgro in maize, through one of its components, the International Maize Improvement Consortium for Latin America (IMIC-LA) is to bridge seed technologies with maize producers by developing a strong seed sector that serves the needs of a large portion of Mexican maize farmers. A vibrant and efficient seed sector is expected to play a major role in ensuring widespread distribution of new maize varieties to increase productivity and farmers' income. The initiative is similar to projects in Africa (see DTMA, 2011; Langyintuo, 2010; Morris, 1998).

In Mexico, key actors in the seed sector include the International Maize and Wheat Improvement Center (CIMMYT) and the National Institute for Forestry, Agriculture and Livestock (INIFAP), the national seed companies and the transnationals. The seed sector is becoming more dynamic and there is an increased interest and participation by different seed sector actors. INIFAP multiplies and keeps the seeds of this variety in the original categories, basic and registered. This last category of seed can be purchased by seed producers, as did several seed companies to increase it in 2010 in order to meet the needs of sowing in the Highland Valleys. CIMMYT produces germplasm for three major environments including the Highland Valleys, Tropics and Sub-tropics. These materials are available to seed companies for commercial multiplication and further crossing. Through MasAgro, CIMMYT is developing partnerships with seed firms to increase the use of these materials including augmenting the location trials for elite germplasm, i.e. hybrids with outstanding performance.

Literature review

The first step in evaluating marketing opportunities for any product is to estimate total market demand (Kotler and Keller, 2011). Market demand for a product is defined as the total volume that would be bought by a defined customer group in a defined marketing environment under a defined marketing effort. Market demand is not a fixed number but a function of the stated conditions (Kotler and Keller, 2011). Figure 3 shows the market demand curve and its minimum, forecast and potential levels. Market potential is the upper limit of demand attainable as marketing expenditures increase up to a certain level beyond which demand will not increase further. The minimum demand is the amount of product that can be sold without effort. The distance between the minimum and the market potential shows the sensitivity of the demand to marketing expenditures in the industry. Market forecast is the realized demand with an actual marketing effort, e.g. in the case of the seed sector advertising by national and international seed companies.

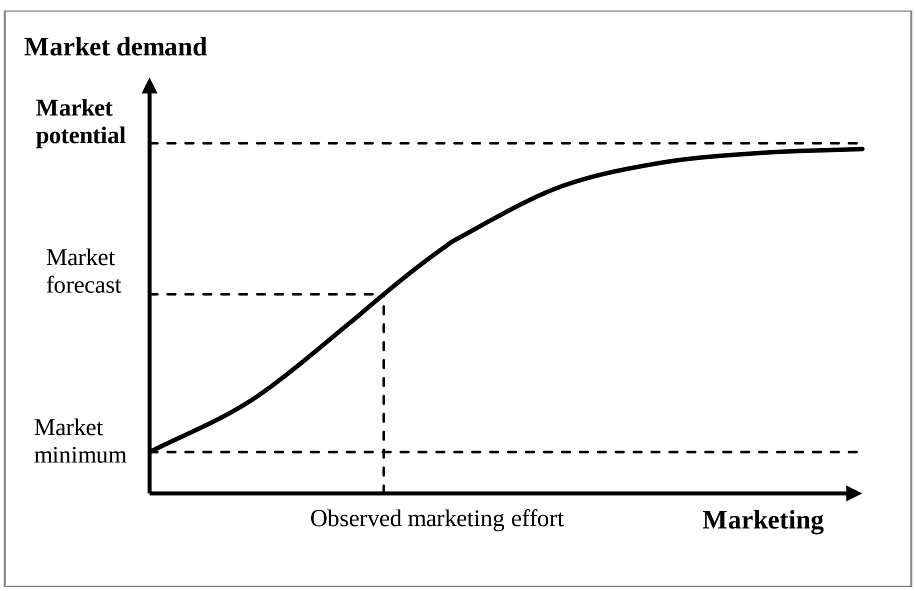


Figure 3. Marketing demand as a function of the marketing effort. Source: Kotler and Keller, 2011.

When assessing and measuring market potential the major concepts are market demand, market environment and market penetration. The market environment is the set of factors affecting firms' business over which they have not direct influence including demographic and economic factors and natural resources involved in the value chain. Demographic dimensions include age, ethnicity and sex of the population of interest. In the economic environment is important to include income variables as well as resources variables that determine costs for sellers and buyers in the market. Finally, market penetration of a product is the percentage of ownership or use of a product or service in a population. When assessing market potential, firms usually assume that the lower the market penetration percentage, the higher the market potential; with the caution that this also assumes everyone will eventually be in the market for the product (Kottler and Keller, 2011), something that may be even more unrealistic when it comes to the maize seed sector in Mexico where farmers can recycle landrace seed and that of open pollinated varieties, but not hybrids, without declines in productivity.

An approach to assessing market potential is to use indexes or compound indicators. An index approach is to combine relevant indicators to provide "a bottom line" representation of the situation. This approach is useful to capture in a single figure the relevance and interest of the market major dimensions and therefore the attention of decision makers (Sharpe, 2004). Market potential indexes are used by managers in different industries to determining which markets to enter and with which marketing strategies to use.

An example of an index is the Market Potential Index (MPI) conducted by the International Business Center of Michigan State University. The index focuses on the market potential of emerging countries and uses eight dimensions to rate the market potential of a country over a scale of 1 to 100. Data used in the estimation includes urban population, real GDP growth, percentage share of middle-class, cellular mobile subscribers, number of PCs and paved road density (GlobalEdge, 2011).

Another example is the Market Potential Value (MPV) of a town developed by the RK Swamy BBDO Guide to Marketing Planning (2008; Bijapukar, 2004). The index is a function of five indicators including the population of the town, a composite of income and wealth, demonstrated consumption behavior (in high and low priced durables), awareness levels (estimated using a composite of exposure to media and extent of female literacy) and the extent of market support (estimated by a composite indicator of employment and bank credit to trade and transport). These four indicators of market capacity, consumption, awareness and support are used in a per capita way, and combined together using specific weights. Table 2 summarizes major concepts, dimensions and indicators for assessing market potential in this study.

Table 2: Conceptual framework of the market potential of improved seeds in Mexico

Major concept in demand measurement	**Market potential dimension**	**Market potential indicator**	**Description**
Market maximum	Size	(Log of) maize area	Maximum number of bags of improved seeds that can be sold
Product penetration percentage	Penetration	Percentage use of improved seed	Number of consumers who are not yet part of the market
Market environment	Capacity	Combined of farm size, farm productivity and socioeconomic level	Accessibility, acceptability and affordability resistance and improved seed
	Intensity	Percentage area with high production potential	Feature of the market situation or increasing-intensity-demand

	Receptivity	Differential profitability with improved seed	Responding to change and willingness to adopt improved seed
Market potential: Upper limit as marketing expenditures in a given marketing environment cannot further increase demand			

Source: Based on Kotler and Keller (2011); GlobalEdge (2011) and RK Swamy BBDO Guide to Marketing Planning (2008).

Assessing the Market Potential of Improved Seeds

Basics of indexes

A composite indicator or index is any combination or aggregation of indicators, which are called component indicators (Mondejar and Vargas, 2008; OECD, 2008; Schuschny and Soto, 2009). A composite indicator is the sum of its parts, so that their strengths and weaknesses stem largely on the quality of the component indicators, although not always indicators of good quality produce strong composite indicators (Freudenberg, 2003).

The construction of a composite indicator requires two basic conditions which grant the validity of the indicator. The first is the clear definition of the attribute being measured; this will give the conceptual support composite indicator. The second is the existence of reliable information to perform the measurement (Schuschny and Soto, 2009).

Composite indicators are valued because they reduce the number of indicators presented and because they can make quick comparisons of the units of analysis. At a minimum, all composite indicators should be as transparent as possible and provide detailed information on the methodology and data sources (Freudenberg, 2003). The three basic functions of composite indicators are: simplification, quantification and communication (Castro, 2004).

Construction of the market potential index for improved seeds in Mexico

The market potential index is constructed following the steps of conceptualization, data selection, Imputation of missing data, normalization, weighting and aggregation and sensitivity analysis following (Nardo et al., 2005; OECD, 2008; Schuschny and Soto, 2009). The Market Potential Index (MPI) proposed in this study is defined as follows:

$$MPI\ (x_1, x_2, x_3, x_4, x_5) = \frac{1}{5}\sum_{i=1}^{5} x_i$$

Where:

x_{ij}: is the value of the indicator *i* for the unit of analysis *j*.

Note: the unit of analysis *j* is the region.

IPM is a real function of five variables:

$$MPI:\ D \subset \mathbb{R}^5 \ \rightarrow \mathbb{R}$$

$$\underline{\mathbf{x}} \ \rightarrow \frac{1}{5}\sum_{i=1}^{5} x_i$$

Where $\underline{\mathbf{x}} = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix}$ are the five indicators of the index, as follows.

Indicator 1: Maize area. The maize area is estimated as follows:

$$Maize\ area = Ln(Area\ planted\ to\ maize)$$

Logarithmic transformation is used because the frequency distribution of the area has a positive asymmetry.

Indicator 2: Percentage use of improved seed: Current use of improved seed is calculated as the ratio between sales of improved seeds and the planted area to maize. A density of one and 1.5 bags of improved seeds per hectare are assumed for rainfed and irrigated areas.

$$Current\ use\ of\ improved\ seed = \left(\frac{Improved\ seed\ sales}{Rainfed\ maize\ area + 1.5 * Irrigated\ maize\ area}\right) * 100$$

Indicator 3: Producer capacity is a combined of farm size, farm productivity and socioeconomic level. The weights are calculated using principal component analysis of the variables using the correlation matrix.

$$Producer\ capacity = 0.62 * Farm\ size + 0.56 * Maize\ yield - 0.55 * Socioeconomic\ level$$

Indicator 4: Production potential is calculated as the ratio between the area with high production potential for maize and the area actually planted to maize.

$$Production\ potential = \left(\frac{Area\ with\ high\ production\ potential\ for\ maiz}{Area\ planted\ to\ maize}\right) * 100$$

Indicator 5: Change in profitability with improved seed

$$Change\ in\ profitability = \left(\frac{Benefit}{cost}\ improved\ seed\right) - \left(\frac{Benefit}{Cost}\ criollo\ seed\right)$$

Data

Table 3 shows the data and sources used in the calculation of the index. All data are available at the aggregation level of municipality except for sales of improved seed which is available for regional level.

Table 3. Data for the market potential index of improved seeds in Mexico

Market potential dimension	**Market potential indicator**	**Data**	**Source**
Market size	(Log of) maize area	Area planted to maize (ha)	Agrifood and Fishery Information Service (SIAP)
Market penetration	Percentage use of improved seed	Sales of improved seed (bags)	Seed firms
Market capacity	Combined of farm size, farm productivity and socioeconomic level	Index of social backwardness	National Council for Evaluation of Social Development Policy (CONEVAL)
		Farm size supported by government program Procampo (ha)	Support and Services for Agricultural Marketing (ASERCA)
		Maize yield (t/ha)	SIAP
Market intensity	Percentage area with high maize production potential	Maize production potential (ha)	National Institute for Forestry, Agriculture and Livestock (INIFAP)
Market receptivity	Change in profitability with improved seed	Revenue and costs of production with improved seeds and with *criollos*	Strategic Support Program for Producers in the Maize and Bean Chains (PROMAF)

Properties

The MPI has the following properties outlined by Pena (1977 cited in Castro, 2004) as the conditions that must be demanded on a generic index.

Property 1: Existence and Determination: The mathematical function that defines the index has to exist and have a solution.

Proof: Addition and multiplication are closed operations in real numbers; therefore the function that determines the IPM exists and has the real solution.

Property 2 Monotonicity: The index has to respond positively to a positive change in the components and negatively to a negative change.

Proof: Assume x_i undergoes a change in Δx_i.

Denote as *IPM* the index before x_i has changed.

Call $x_{i'} = x_i + \Delta x_i$ y $IPM_{i\prime}$ to the index once x_i has changed, then

$$IPM_{i\prime} = \frac{1}{5}\left(\sum_{\substack{i=1 \\ i\neq i\prime}}^{5} x_i + x_{i'}\right) = \frac{1}{5}\left(\sum_{\substack{i=1 \\ i\neq i\prime}}^{5} x_i + x_i + \Delta x_i\right) = \frac{1}{5}\left(\sum_{i=1}^{5} x_i + \Delta x_i\right) = \frac{1}{5}\sum_{i=1}^{5} x_i + \frac{1}{5}\Delta x_i$$

$$= IPM + \frac{1}{5}\Delta x_i$$

If $\Delta x_i > 0$ then $\frac{1}{5}\Delta x_i > 0$ y $IPM_{i\prime} > IPM$

If $\Delta x_i < 0$ then $\frac{1}{5}\Delta x_i < 0$ y $IPM_{i\prime} < IPM$

Similarly if more than one indicator undergoes a change.

Property 3: Unicity: The index must be unique for a given situation.

Proof: Because the index is defined by a mathematical function, each situation defined by the vector of

x variables can only be associated with a single index value.

Property 4: Invariance: The index must be invariant under a change of origin or the measurement scale of the levels of their components.

Proof: To be demonstrated in the robustness and sensitivity analysis using bootstrap / Montecarlo.

Property 5: Homogeneity: The mathematical function that defines the index has to be homogeneous of degree one.

Proof: A function is homogeneous of degree one if it complies with:

$f(cx_1, \ldots, cx_n) = cf(x_1, \ldots, x_n)$

IPM is defined by a homogeneous function of degree one:

$$IPM(cx_1, cx_2, cx_3, cx_4, cx_5) = \frac{1}{5}\sum_{i=1}^{5} cx_i = \frac{c}{5}\sum_{i=1}^{5} x_i = c\left(\frac{1}{5}\sum_{i=1}^{5} x_i\right)$$

$$= cIPM(cx_1, cx_2, cx_3, cx_4, cx_5)$$

Property 6: Transitivity: If a, b and c are three different situations of measurable objective for the index, and I(a), I(b) e I(c) are the values for these three situations, it should be that:

If I(a) > I(b) > I(c) then I(a) > I(c)

Proof: If a, b and c are real numbers, the relation "<" between them is transitive: if a> b and b> c then a> c. Therefore, since MPI is a real number, the IPM is transitive.

Property 7: Exhaustivity: The index must be such as to make the most useful form and the information provided by simple indicators.

Proof: To be demonstrated in the robustness and sensitivity analysis.

Statistical testing and sensitivity

The uncertainties associated with the composite indicator can be linked to each step in the design, but are mainly concentrated in the imputation of missing data, standardization, weighting and aggregation (Nardo et al., 2005; Schuschny and Soto, 2009). Since the indicator value and ranking of the unit of analysis depends on the decisions that were taken at each step is necessary to conduct an uncertainty analysis and sensitivity to analyze the impact of every decision made on the results of the composite indicator (Freudenberg, 2003).

The sensitivity of ranking of the resulting representations of the MPI will be analyzed for stability and meaningfulness in the interpretation using a bootstrap or Montecarlo procedure.

Results

MPI of Mexican maize production regions

The estimation, using data from seed firms and from government statistics, indicate different potential and business opportunities for seed firms in the different areas in Mexico (Table 4). The region with the highest potential for increasing the use of improved seeds is Pacific Lowland Tropics, with a MPI of 3.6. The highest value of the indicator shows the region with the best overall quality as a potential market for improved seeds. Second is Middle Input, with an index of 3.3. In the third and fourth place are the High Valleys and Bajio both with an MPI of 3.2. These values indicate very good potential for companies interested in offering seed products in these regions. A second group includes the Humid Tropic, the Atlantic Lowland Tropic and the Northern Gulf with values of 3.1, 3.0 and 3.0 respectively. North Pacific, Chihuahua, Central Valley and North Central, give a less attractive as potential markets, with values of less than 3 IPM.

Table 4: MPI and ranking for improved seeds in Mexican maize production regions

Regions / Dimension	**Size**	**Penetration**	**Capacity**	**Intensity**	**Receptivity**	**MPI**	**Ranking**
High Valleys	4.3	4.7	2.0	1.2	4.0	3.2	3
Bajio	3.2	1.7	3.8	3.9	3.4	3.2	4
Central Valleys	2.5	5.0	1.4	2.3	1.0	2.4	10
Pacific Lowland Tropics	4.6	3.3	2.3	3.4	4.2	3.6	1
Atlantic Lowland Tropics	3.7	5.0	1.6	3.8	1.0	3.0	6
Humid Tropics	3.7	4.6	1.5	2.1	3.5	3.1	5
Middle Input	3.6	5.0	2.9	1.6	3.4	3.3	2
Northern Pacific	3.1	0.0	4.6	1.1	4.5	2.7	8
Chihuahua	2.5	1.5	3.8	1.1	4.0	2.6	9
North Central	2.0	2.7	2.6	1.1	1.0	1.9	11
Northern Gulf	1.8	1.5	2.7	4.3	4.5	3.0	7

Improved seed quantity needs

The comparison between the market potential and actual size indicates a potential for increased maize sales of about four million bags of improved seeds (Table 5). This estimate is the basis for seed firms to decide which markets to target, to assign their marketing budget optimally, and to review their performance in different markets.

Table 5: Current size of the market as the supply of improved seed production in each region (bags)

Regions / Bags	Current	Potential	Total
High Valleys	120,000	954,197	1,074,197
Bajio*	400,000	337,233	-
Central Valleys	0	122,712	122,712
Pacific Lowland Tropics	750,000	1,485,272	2,235,272
Atlantic Lowland Tropics	0	518,473	518,473
Humid Tropics	80,000	534,279	614,279
Middle Input	0	513,886	513,886
Northern Pacific*	900,000	260,101	-
Chihuahua*	210,000	127,772	-
North Central*	80,000	58,039	-
Northern Gulf*	120,000	76,072	-
Total	2,660,000	4,988,034	7,648,034

Source: Data from seed companies and SNICS, stock in April 2011.

*The calculated potential in these regions is below the actual use of improved seeds because these are important irrigation areas and the MPI is calculated using production potential of the rainfed area.

The current sales level of 2.66 million bags represents the efforts of the companies currently participating in the market. The results of this study show a potential for improved seed market in Mexico about 5 million bags, an additional amount of just under double the bags sold today. The potential market is the additional amount of bags that could be sold with feasible, non infinite extra effort. In other words, this amount is within the market's sensitivity to the marketing strategies of seed companies. The sum of the two amounts represents the maximum demand for improved seeds in Mexico of approximately 7.6 million bags.

With 1.5 million bags, the Pacific Lowland Tropics has largest potential in terms of the number of bags that can be sold, followed by High Valleys with 1 million bags. There are three markets with a potential of about 0.5 million bags, namely, the Humid Tropics, Atlantic Lowland Tropics and Middle Input. In the other possible sales are less than 0.4 million. Central Valleys appears with a potential for selling 122,000 bags of improved seeds. The remaining four regions are already developed markets for improved seeds. According to the MPI the market potential of these regions is below their respective current sales. This is because the index proposed in this study uses the indicator of production potential which accounts for the area with high maize production under rainfed conditions. These four areas are largely irrigated areas which use hybrids and therefore the calculated potential is low as compared to the actual improved seed sales.

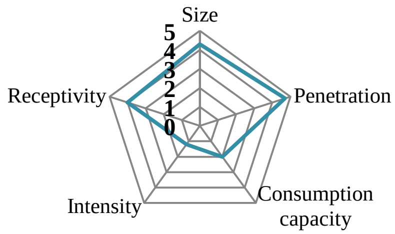
The estimate of the number of bags that can be sold in each region gives an idea of whether a particular company can justify their participation, in terms of costs and competition. Small and medium seed businesses can operate effectively in most of the Mexican maize regions. In addition, the potential markets of over one million bags in the Pacific Lowland Tropics and in High Valleys are particularly attractive for large companies.

Profiles of the market potential by region

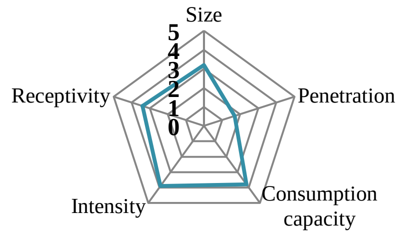
The combination of the five dimensions of the potential in each region results in a spider web diagram. The diagrams clearly represent the opportunities and constraints of the market potential of improved seeds in each region of maize production. Three examples are provided.

The profile of the market potential of Central Highlands (Figure 4) is characterized by a large area with virtually no penetration of improved seed. The impact on profitability with improved seed is positive and the greatest limitation is the type of producer. The average production potential of the lands is intermediate with some areas of high yield potential. Seed firms' strategy has to point to a low-cost seed with key attributes that help to overcome the limitations of productive potential, i.e. locally adapted seeds that can cope with agro-climatic fluctuations. The strategy should underpin the positive impact on the result as a promotion for rapidly increasing the use of improved seeds. Such promotion in the context of Mexico is best spearheaded by national seed companies; these companies in turn have expressed much interest in the MPI.

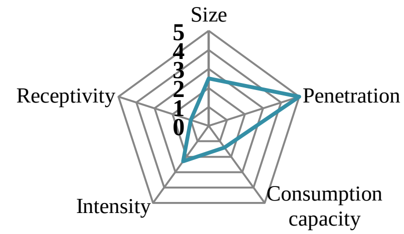
High Valleys



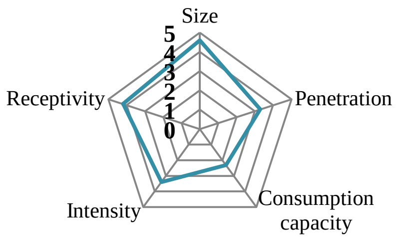
Bajio



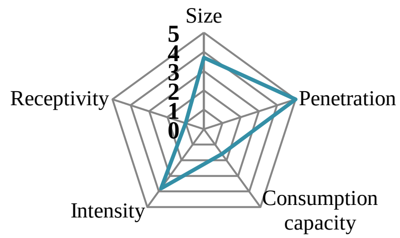
Central Valleys



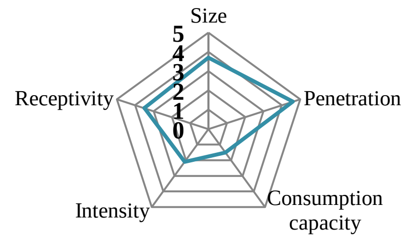
Pacific Lowland Tropics



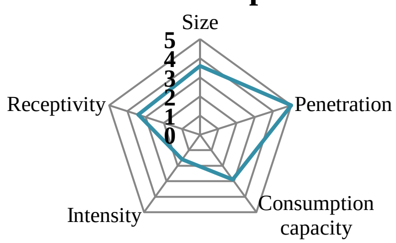
Atlantic Lowland Tropics



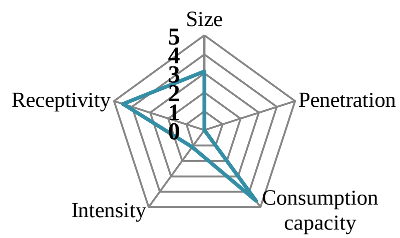
Humid Tropics



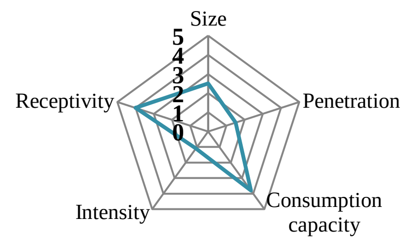
Middle Input



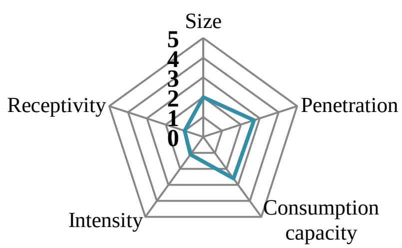
Northern Pacific



Chihuahua



North Central



Northern Gulf

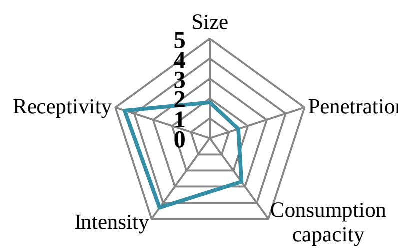


Figure 5: Profiles of the market potential for maize improved seeds in maize production regions in Mexico

Pacific Lowland Tropics is the region with the greatest potential as seen from its cobweb profile having the greatest area. It has the largest size in hectares, high receptivity in terms of positive impact of improved seed in profitability and high intensity due to the maize production potential of the rainfed areas. The main limitation is the producers' capacity to purchase seeds. The marketing strategy should underpin the three market strengths with low cost seeds. Large scale is an advantage to achieving cost economies in seed production.

The region with the second largest potential is Middle Input. The strengths include very low current penetration of improved seeds, large size and good capacity for consumption. The major limitation is intensity due to low production potential of rainfed areas. Companies should focus on drought tolerant and stable materials under rain uncertain years. In High Valleys, the third best potential, the major limitation is also the production potential. Again, improved seed materials need to provide a robust performance under uncertain weather conditions. Seed firms need to provide agronomic advice with crop management practices that preserve soil humidity such as crop rotations and zero tillage.

Identifying Areas of Greatest Immediate Potential

What are the regions where the benefits of improved seeds are clearer to producers and therefore the use of improved seed may grow faster? Table 6 presents the names of the two municipalities in each region that have the highest MPI. Despite heterogeneity in all regions, the municipalities are sub-areas with potential greater than 3 as a reference for an attainable marketing effort. Pacific Lowland Tropics, Middle Input and High Valleys are the regions where these areas are much more accessible and more widespread than in other regions, as seen through the ranks of municipalities.

Table 6. The two municipalities with the highest market potential of improved seeds in each maize production region

Region	**Municipality**	**Size**	**Penetration**	**Capacity**	**Intensity**	**Receptivity**	**MPI**	**Ranking**
High Valleys	Yecapixtla	3.1	4.7	2.3	5.0	4.0	3.8	17
High Valleys	Atlatlahucan	2.6	4.7	2.5	5.0	4.0	3.8	33
Bajio	Arandas	3.6	1.7	3.8	5.0	3.4	3.5	148
Bajio	Jesús María	3.8	1.7	3.4	5.0	3.4	3.5	166
Central Valleys	Miahuatlán de Porfirio Díaz	3.5	5.0	2.1	5.0	1.0	3.3	244
Central Valleys	Heroica Ciudad de Ejutla de Crespo	3.3	5.0	2.1	5.0	1.0	3.3	274
Pacific Lowland Tropics	Atotonilco el Alto	3.9	3.3	4.0	5.0	4.2	4.1	1
Pacific Lowland Tropics	Tepatitlán de Morelos	3.9	3.3	3.9	5.0	4.2	4.1	2
Atlantic	Papantla	4.1	5.0	2.1	5.0	1.0	3.4	181

Lowland Tropics								
Atlantic Lowland Tropics	Acayucan	3.6	5.0	2.4	5.0	1.0	3.4	203
Humid Tropics	Hueyapan de Ocampo	3.9	4.6	2.2	5.0	3.5	3.8	14
Humid Tropics	Santiago Tuxtla	3.6	4.6	2.3	5.0	3.5	3.8	21
Middle Input	Mocorito	4.0	5.0	3.8	3.2	3.4	3.9	9
Middle Input	Ciudad del Maíz	3.6	5.0	2.2	5.0	3.4	3.8	16
Northern Pacific	Culiacán	4.7	0.0	4.3	1.2	4.5	2.9	709
Northern Pacific	Elota	3.9	0.0	4.6	1.2	4.5	2.8	952
Chihuahua	Ocampo	2.8	1.5	1.9	3.6	4.0	2.8	1151
Chihuahua	Guerrero	3.8	1.5	3.1	1.1	4.0	2.7	1229
North Central	Aramberri	3.4	2.7	2.3	1.3	1.0	2.1	1975
North Central	General Francisco R. Murguía	3.8	2.7	3.0	0.0	1.0	2.1	2013
Northern Gulf	González	3.3	1.5	3.2	5.0	4.5	3.5	149
Northern Gulf	Altamira	3.0	1.5	3.5	5.0	4.5	3.5	150

Table 6 is an example of how to use the MPI tool to identify locations and areas with specific characteristics of interest to decision makers in seed companies and organizations to increase the use of improved maize seeds.

Conclusions and managerial implications

Market studies are key to developing seed products and marketing strategies that strengthen the links between technologies and beneficial impact on adopters. The MPI for improved seeds in Mexico postulates that improved seed forecasted sales are a function of the area planted to maize, the current use of improved seeds by maize producers, their economic means for purchasing the seed, the production potential, i.e. yield expectation of their lands and the difference in profitability from using improved seed. These five variables are used as indicators of the market size, penetration, capacity, intensity and receptivity.

The index is applied to examining the potential and limitations for increasing the use of improved maize seeds in Mexico.

The MPI provides a conceptual framework for understanding the market for improved seeds, providing insights for strategic market decisions including what products to develop, where and how to compete, how much marketing effort to grow the next mile. As a platform for joint public-private analysis, it is a basis for testing opinions and hypothesis, and exploring alternative viewpoints about growth, development, poverty and the role of improved seeds.

The MPI proposed in this study is can be a useful tool for marketing planning at the micro level of seed firms as well as at the macro level of supporting policies to developing of a strong maize seed sector in Mexico that reaches producers and meets their needs.

The evaluation of the market profiles indicates the need for a diversified portfolio of products and the development of product, services and other marketing strategies to overcome specific limitations in each production region.

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