PROFMEX Journal Mexico and the World
ISSN: 1535-0630
Vol. 17.1 (Winter 2011)
Available online http://www.profmex.org/webjournal_listedbyvoldat.html

A SYSTEM DYNAMICS MODEL OF EMPLOYMENT AND MIGRATION FOR MICHOACÁN

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Accepted: December 16, 2011

ABSTRACT
This paper analyzes the phenomenon of migration between Mexico and the United States. Particularly, it seeks to understand how migration from Michoacán to California contributes to improving the welfare of their families in their home-country. In so doing, we use the system dynamics (SD) methods to develop a model that integrates into the same analysis a set of variables that influence directly or indirectly the migration flows. The SD approach is characterized by taking as part of the analysis time delays and feedback effects between variables influencing the migration phenomenon. The results of this research suggest that the SD approach is suitable to analyze and understand the phenomenon of migration between Mexico and the United States. In this paper, three alternative scenarios are evaluated through the simulation model.

Keywords: migration; remittances; social welfare; system dynamics; Michoacán.

1. INTRODUCTION

Migration has been an issue of great interest in the bilateral agenda between Mexico and the United States for many years. Indeed, migration flows from Mexico have recently

increased making remittances to become the second most important source of foreign incomes to this country. Particularly, the province of Michoacán in Mexico is one of the most important suppliers of migrants to the United States. Remittances from migrants are the main source of incomes in this province. In 2010, for example, Michoacán got more than 2 billion dollars in remittances (Banxico, 2010).

Using system dynamics (SD) methods, this paper analyzes the migration phenomenon originated in Michoacán that addresses to the United States. The SD approach allows analyzing the migratory phenomenon by integrating in the same analysis a set of quantitative and qualitative variables that influence and determine this phenomenon. This approach also allows studying the migration phenomenon from the perspective of the complex systems.

In addition to this introduction, this paper contains five sections and Appendix A on the Human Development Index (HDI). Section 2 presents some theoretical and methodological elements of SD methods. Section 3 reviews the most important features of migration flows between Mexico and the United States emphasizing the case of Michoacán. Section 4 describes the *Model of Employment and Migration of Michoacán* (MODEMM). Section 5 analyzes the simulation results from MODEMM aiming to evaluate a baseline scenario and two other alternative scenarios. Section 6 synthesizes the main conclusions of this research. Finally, Appendix A clarifies the role of the HDI.

2. THE SYSTEM DYNAMICS APPROACH

The methods derived from the SD approach allow analyzing complex systems. In this sense, SD methods are an appropriate response to demands imposed by the nature of complex systems. Forrester (1975) and Ford (1999) suggest that SD methods are a way of investigating complex systems. Actually, this approach involves six steps when developing a research project (Forrester, 1975): (1) identification of a problem, (2) development of a dynamic hypothesis, (3) construction of a model for simulation, (4) model validation, (5) evaluation of alternative scenarios, and (6) policy implementation and solutions. Through the SD approach, it is possible at the same time to use quantitative and qualitative variables. In this sense, the SD models take into account a wide range of sources of information and mental models to achieve a better understanding about changes in a system (Forrester, 1975, 1994).

An important tool in SD model analysis **involves development of causal** loop diagrams (CLD). A CLD is composed of several reinforcing (positive) feedback loops, as well as several balancing (negative) feedback loops. A loop is a closed sequence of causes and effects, or a closed path of actions and information (Richardson and Pugh, 1981).

Consequently, a reinforcing or positive loop can be expressed as a change in time that generates and reinforces major changes. On the other hand, a balancing or negative loop (balance) aims to achieve a target value (Kirkwood, 1998). Importantly, a negative feedback loop with a significant time delay can lead to an oscillatory behavior. However, when positive and negative loops are combined, they can generate a variety of patterns. Moreover, from combining different reinforcing and balancing loops, it would be possible to establish a close relationship between structure, complexity and uncertainty.

Indeed, from the perspective of the SD methods, complexity means that systems are constantly evolving. Forrester (1975) and Sterman (2000) emphasize that complexity in a system arises from the following features: **dynamic, tightly coupled, governed by feedbacks, nonlinear, history-dependent, self-organizing, adaptive, counterintuitive, policy resistant, characterized by trade-offs**.

On the other hand, SD models are developed making use of the following tools (Forrester, 1975; Wolstenholme et al., 1993): (1) feedback loops, (2) stock and flows variables, (3) time delays, and (4) nonlinearities. SD models assume that cause-effect relationships are usually generated in different space and time. In turn, these features generate some kind of resistance to policies implemented in this system (bounded rationality). In addition, SD models are characterized by time delays and feedbacks featuring the equations that represent the relationships in the system.

In fact, the behavior of a system is simulated making use of a set of linear equations of first order. Technically, the structure of a SD model is a set of interconnected rate and level variables. The level variables are measurable quantities of a resource in a system at any point in time. On the other hand, the rate variables represent the speed at which these resources are transformed between different states and depend on the levels since these variables are measurable. Rate variables are generally referred as policy, strategies or decision variables.

3. MIGRATION BETWEEN MEXICO AND THE UNITED STATES

Migration flows from Mexico to the United States has become an important issue in the economic, political and social affairs in this country. Recently, the remittances as a percentage of the Gross Domestic Product (GDP) have increased its importance, as they become the second most important source of income in Mexico (Table 1).

Table 1. Foreign Incomes in Mexico, 2004 – 2010 (millions of dollars)

	2004	2005	2006	2007	2008	2009	2010
Oil Exports	23667	31891	39022	43018	50656	30901	40684
Remittances	18331	21689	25567	26069	25137	21181	21254
FDI	23816	22345	19779	27311	23170	11417	17725
Tourism	8382	9146	9559	10340	10817	9221	11871
Total	74196	85071	93927	106738	109780	72720	31850

Source: BANXICO, 2011.

Michoacán economy is mainly based on agricultural and service activities. The dynamics of the economy of this province has generated a high rate of migration. Migration flows principally in three directions: (1) migration from rural to urban areas that result from searching better living conditions (employment, income, education, and public services), (2) migration to other provinces within the country such as rural workers for the harvest periods (Sinaloa, Veracruz or Chihuahua), and (3) labor force emigrating to other countries, mainly to the United States and Canada (Drucker, 2006).

Michoacán contributes as one of the main sources of emigrants to the United States. In 1999, for example, migration from Michoacán to the United States accounted 11.8% of the total migration of Mexicans to United States (Garcia, 2006). However, Michoacán, Jalisco, Zacatecas, and Guanajuato accounted one third of the total Mexican migrants to the United States in 2000. Today, it is estimated that there are 2.5 millions of migrants from Michoacán living in the United States (Drucker, 2006). Yet, 165,502 people migrated to the United States in 2000 (128,034 men and 37,468 women). In same year, 10.55% of all migrants came from the province of Michoacán, 10.88% from Jalisco, and 10.41% from Guanajuato. On the other hand, 31,075 migrants returned to Michoacán in 2000 (25,546 men, and 5,529 women). This data places Michoacán in the second place at national level by the number of people returning to Mexico in 2000 (INEGI, 2000).

Migrants from Michoacán establish on different states in the United States. For example, between 1998 and 2000, 165,000 migrants from Michoacán lived in Chicago, and 261,000 lived in California (Bada, 2004). Michoacán is ranked as the second province in Mexico receiving remittances. However, remittances are the main source of income for many families with migrants. Most of the resources received as remittances by these families are used to meet basic needs, purchase durable goods, as well as housing improvements. Nevertheless, only a small proportion of these remittances are used to renovate and improve public schools, water wells, paving, construction of roads and highways, sports facilities, as well as other infrastructure (Bada, 2004).

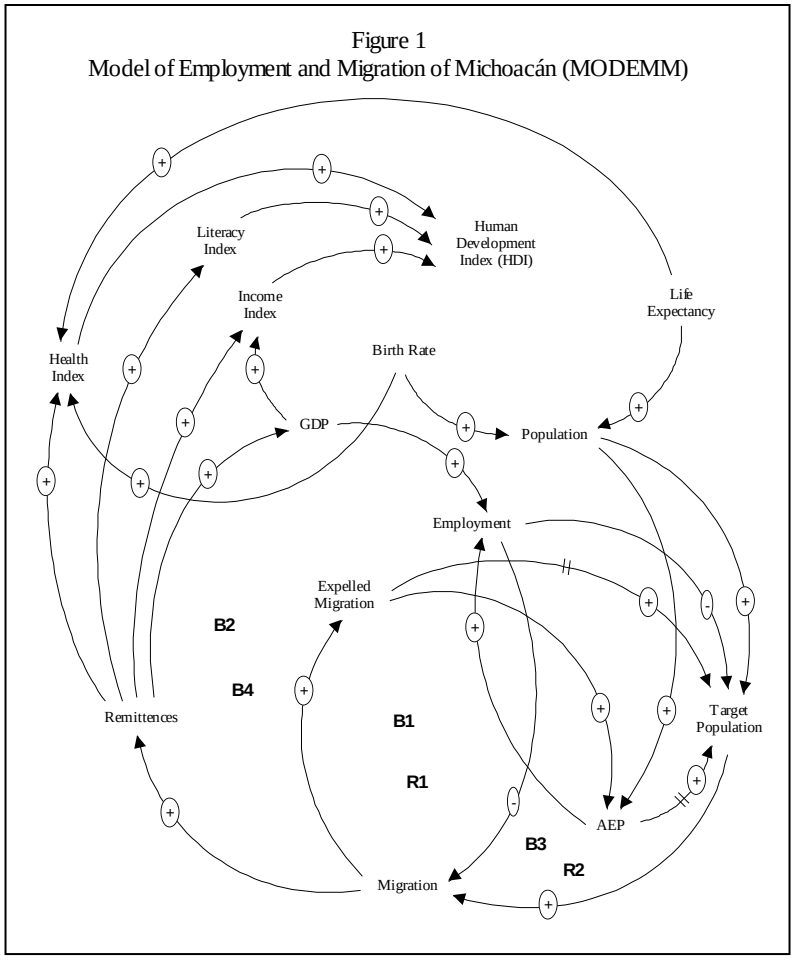
It is worth saying that among the positive effects that bring the inflow of remittances and migration is that people in some communities have decreased the effects of unemployment,

poverty and poor productivity in agriculture and livestock. Another major positive effect arising from migration is that during the period when migrants temporally return to their communities, they demand a large amount of goods and services, increasing the consumption in their communities (Bada , 2004). However, there are many other negative effects drawn from migration as it is the abandonment of agricultural land belonging to migrants, since in most cases they refuse to sell these properties with the hope that their descendants will be returning some day to these communities to work or build their homes (Bada, 2004), even if the land has bold ruined by cumulative erosion since colonial times.

4. MODEL OF EMPLOYMENT AND MIGRATON OF MICHOACÁN

This section describes the CLD characterizing MODEMM (Figure 1). The main question arising from the dynamic hypothesis discussed in this section concerns to what are the effects of migration flows from Michoacán to the United States on the economic and social welfare on migrant families in this province? The CLD allows defining the reinforcing and balancing loops that make up the model. Recall that a reinforcing or positive loop can be expressed as a change in time generating and reinforcing major changes, while a negative or balancing loop searches to achieve a target value (Kirkwood, 1998). The CLD of the migration phenomenon analyzed in this paper identified two positive or reinforcing loops, and four negative or balancing loops.

Figure 1
Model of Employment and Migration of Michoacán (MODEMM)



Loop R1: *Migration → Expelled Migration → Target Migrant Population → Migration*. As expected, this loop generates a great number of migrant people because if they fail settling in the United States, and thus being expelled, the number of people in the target migrant population increases, willing to immigrate to the United States. The target migrant population is the number of people willing to settle in the United States because they are not formally part of the labor market in Mexico, or they are in the informal economy. The loop R1 reflects the pressure exerted on the migration flows through the economic conditions that eventually allow (or not) people to settle in their places of origin. Additionally, it must be emphasized that this loop is characterized by a time delay which influences the number of migration expelled from the United States that in turn would join the target migrant population, either directly or indirectly through AEP.

Loop R2: *Migration → Expelled Migration → EAP → Target Population → Migration*. This loop reflects a similar behavior like in loop R1. Nevertheless, this loop explains how the expelled population may join the *EAP* that would be incorporated into the target population with a time delay. However, the loops R1 and R2 taken together explain the

forward-backward dynamics followed by the flow of migrants from Michoacán to the United States, and vice versa.

Loop B1: *Migration → Expelled Migration → Employment → EAP → Migration*. This loop explains how expelled migration exerts pressure on the labor market through increasing the *EAP*. However, when the expelled migration does not locate in the labor market, they eventually decide to migrate once again to the United States. This loop explains thus the behavior of the flow of migrants between the United States and Michoacán in Mexico.

Loop B2: *Migration → Expelled Migration → Employment → EAP → Target Population → Migration*. This loop is similar to the loop B1 but incorporating the variable target population. In this sense, the loop B2 explains how migration can be rejected increasing the target population that it is likely to emigrate.

Loop B3: *Migration → Remittances → Gross Domestic Product (GDP) → Employment → Migration*. The loop B3 along with the loop B4 are of great impact on the economic dynamics of the model. Particularly, the loop B3 accounts for a cyclical impact of remittances on GDP, employment and migration. Indeed, when remittances increase by migration, in turn there is a positive impact on GDP and employment that eventually reduce the migration flows.

Loop B4: *Migration → Remittances → GDP → Employment → Target Population → Migration*. As in the loop B3, the loop B4 shows how employment and Gross Domestic Product is influenced by migration but taking into account the target population. In this case, the target population affects the migration that is likely to migrate to the United States. To the extent that employment and GDP exhibit a positive behavior, the variable migration shows a downward trend, and vice versa. While generally all loops influence the social welfare, the loops B3 and B4 particularly affect the Human Development Index (HDI) among the migrant families by means of health, education, and incomes.

5. SIMULATION RESULTS

MODEMM was built on the basis of four subsystems: (1) the demographic subsystem, (2) the macroeconomic subsystem, (3) the immigration subsystem, and (4) the social subsystem. However, from the SD approach, it is possible to perform a more comprehensive analysis on the migration problem from the province of Michoacán to the United States (see Appendix A). MODEMM is composed by 5 stocks or level variables, 60 flow variables, and 20 parameters. Although all variables and equations are transcendental

in the model, this paper discusses specifically the variables Migration, Remittances, Migrants Total Incomes, and HDI Migrant Families.

Migration = (Initial Migration) + ∫(Migration)*dt - ∫(Migration Employment)*dt - ∫(Migration Unemployment USA)*dt - ∫(Expelled Migration)*dt (1)

Remittances = (Migration Total Incomes)*(Remittances Factor) (2)

Migration Total Incomes = ∫(Migration Income)*dt - ∫(Remittances)*dt - ∫(Migration Spending Income)*dt - ∫(Migration Associations Contributions)*dt (3)

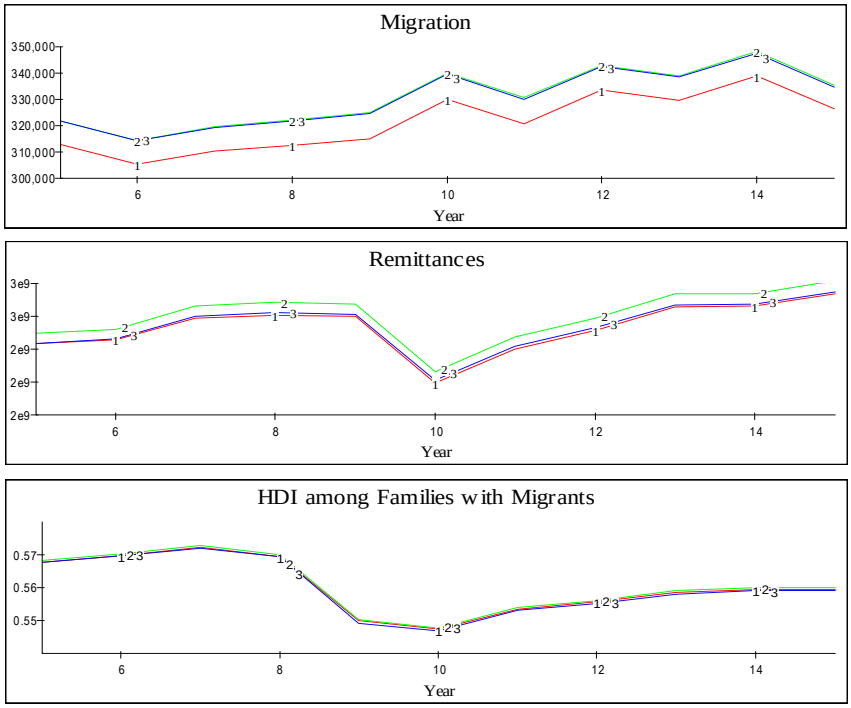
HDI Migration Families = (Income Index + Literacy Index + Health Index)/3 (4)

The specification of these equations is crucial to explain the simulation results from MODEMM in relation to a baseline scenario, and two other alternative scenarios. Equation 1 is computed through the flow of migrants crossing the border between Mexico and the United States. This equation includes migrants crossing the border for the first time plus the people that have been expelled from the United States trying to cross that border once again. Equation 2 is computed through the total remittances sent to Mexico by migrants as an average percentage of the total incomes earned by migrants in the United States. Equation 3 measures the total income earned by migrants in the United States minus remittances sent to their families in Mexico, the income available for personal consumption, and the contributions made to migrant associations. Finally, equation 4 is an average of the three indexes determining the HDI.

The behavior of the baseline scenario (Line -1-), the optimistic scenario (Line -2-) and the pessimistic scenario (Line -3-) are shown in the panels of Figure 2. The simulation results of the baseline scenario were simulated taking into account the actual values of the corresponding parameters. Indeed, the values of these parameters were taken from different databases sources such as BANXICO, CONAPO and INEGI. These values were also used to calibrate the model.

To simulate the optimistic and pessimistic scenarios, the values of the parameters were modified. The optimistic scenario assumes a less restrictive immigration policy in the United States in a way that it implies a smaller number of migrants expelled from the United States to Mexico. At the same time, the optimistic scenario assumes that the economic conditions in Mexico are more favorable, so there are a smaller number of people willing to migrate to the United States.

Figure 2
Migration, Remittances and Social Welfare in Michoacán: Baseline, Optimistic and Pessimistic Scenarios, 2005 - 2015



Baseline Scenario: -1-
Optimistic Scenario: -2-
Pessimistic Scenario: -3-
HDI: Human Development Index

Under the pessimistic scenario, it is assumed that the migration policy in the United States is much more restrictive than in the case of the optimistic scenario, leading to a greater number of migrants expelled from the United States to Mexico. This scenario assumes that the economic conditions in Mexico are worsening than it is the case in the optimistic scenario, so a greater proportion of the income earned migrants in the United States is sent to Mexico.

The results obtained suggest that although migration flows during the study period show a cyclical and growing trend, the number of migrants increase in 2009 and 2010. This behavior can be explained due to the world economic conditions and their impact on the national and regional economies. Moreover, according to the scenarios simulated in this research, the behavior of the migration variable would continue rising in the next years. However, in the case of two alternative scenarios, the optimistic scenario and the pessimistic scenario show a growing trend in the flow of migrants that would be increasing even more due to the recession in the world economy.

The behavior of remittance is characterized by a slightly growing trend in the long term. However, the remittances sent by migrants have become an important source of income for their families in the province of Michoacán. It is important to say that during the period of crisis and under the baseline scenario, there is a slowdown in remittances during the period of crisis. However, the behavior of this variable in the long run turns to a growing trend behavior. On the other hand, under the optimistic and pessimistic scenarios there is a slightly increase in remittances sent by migrants from the United States to Michoacán. This means that under the pessimistic scenario, a greater number of migrants are expulsed from the United States to Mexico. By contrast, under the pessimistic scenario, we assume that migration serves as a buffer for the less favorable economic conditions in Mexico. Also, under the pessimistic scenario, when economic conditions are less favorable, the larger number of migrants from Mexico to the United States does not allow to increase the amount of remittances, since this only increases the flow of migrants across the border.

The welfare among the families of migrant is explained through the Human Development Index (HDI). An important fact has to do with the simulated values generated by this model in the case of the three scenarios, and thus has to do with the behavior of the HDI. Indeed, the three scenarios show the behavior of remittances, suggesting the importance of this variable to the level of welfare among the families with migrants. This finding suggests the importance of the remittances to the families with migrants. On the other hand, it is possible to see the consequences of the economic crisis in 2009 that adversely affected the welfare in these families, realizing the social deterioration and the cost of the global economic crisis for the families with migrants and for the entire population.

6. CONCLUSIONS

SD models can be highly relevant as a methodological approach to study the phenomenon of migration. In fact, this approach can integrate in the same analysis a set of variables, both quantitative and qualitative within a systemic framework. In this sense, MODEMM is constituted by four subsystems: (1) a macroeconomic subsystem, (2) a demographic subsystem, (3) a migration subsystem, and (4) a social subsystem. The four subsystems can be integrated into a single analysis, which affect the behavior of the migration flows.

Through SD models, it is possible to simulate and evaluate alternative policies under different scenarios. In this sense, this approach allows studying migration as a systemic phenomenon. In the case of the province of Michoacán, remittances drawn from migration have become the second source of revenues to migrant families in recent years. However, this approach implies the possibility to simultaneously study social and economic development in relation to migration, requiring a comprehensive and global research approach.

On the other hand and from a general perspective, the results from MODEMM suggest that migration and remittances have had a positive growth in Michoacán in recent years. However, throughout the crisis economic years, migration and remittances have become more volatile. In this sense, a baseline and two other alternative scenarios were simulated in this research. Moreover, the SD approach opens up further research opportunities in relation to the migration phenomenon. In addition, this approach contributes to the analysis of migration from a multidisciplinary perspective.

Finally, this paper discussed the importance of SD models when evaluating alternative policies under different scenarios. Particularly, the baseline scenario demonstrates the value of remittances for the welfare of migrant families. This scenario also demonstrates the effects of the economic crisis in the Mexican economy on migration, remittances, and welfare. The optimistic and pessimistic scenarios showed the effects on these variables derived from the economic conditions in Mexico and the United States. Thus, the ability to evaluate scenarios from the perspective of SD methods is an important contribution to scientific research.

Appendix A

The most widely recognized social development index is the United Nations' Human Development Index (HDI) (*Human Development Report*, 1990). In this research, the HDI was used as the basis to demonstrate how economic, social, and demographic conditions systemically influence welfare levels among families with migrants. Actually, families with migrants receive remittances as an important source of incomes. This fact allows the HDI Families variable capturing this phenomenon.

Ray (2008) points out that the HDI provides a composite measure of three dimensions of human development: living a long and healthy life (life expectancy), being educated (adult literacy and enrolment at the primary, secondary, and tertiary level), and having a decent standard of living (purchasing power parity income). However, since the years this index has been published, several methodological changes have been made, making more difficult the comparison of the index throughout these years. Accordingly, two important limitations on this index are imposed (Ray, 2008): (1) there is only a short historical series, (2) there is a lack of comparability between the reports created to compare HDI series, and (3) there is a lack of regional aggregates for historical comparison. Thus, there is still a debate on the nature of this index in order to properly measure social and economic conditions among people.

In the case of Michoacán, the HDI was developed for the years 1990, 1995, 2000 and 2005 (UNDP, 2008). The development of HDI for Michoacán was made by **José César Lenin Navarro Chávez** under the supervision of the United Nations Development Program and the Economic and Business Research Institute (*Instituto de Investigaciones Económicas y Empresariales*). However, more research must be made to estimate this index within the state of Michoacán.

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