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An Index of Community Vulnerability: Conceptual Framework and Application to Population and Employment Changes

1981 to 2001

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.	not available for any reference period
..	not available for a specific reference period
…	not applicable
0	true zero or a value rounded to zero
0^{s}	value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded
^{p}	preliminary
^{r}	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
A	excellent
B	very good
C	good
D	acceptable
^{E}	use with caution
F	too unreliable to be published

Executive summary

Over the last two decades, about one third of Canadian communities experienced continuous population decline. Even though it is unrealistic to expect to reverse declining trends for all rural communities, specific policies may help stabilize rural population levels, and reduce the level of vulnerability to population decline. The main goal of this research was to develop two indices of community vulnerability, one to population decline and one to employment decline, and to investigate the factors associated with the vulnerability for these processes of change.

The concept of vulnerability has been used in recent policy analysis to describe a specific dimension of socio-economic disadvantage. Unlike the notions of economic deprivation, or poverty, which focus the attention on present conditions, vulnerability is a forward-looking concept. In its general meaning, the idea of vulnerability relates to the way in which events impact on a certain system, and specifically on the likelihood of experiencing loss or negative outcomes in the future because of particular events or actions.

For the purpose of this research, vulnerability is defined as the likelihood of a worsening of socio-economic conditions for the community. The conceptual framework for vulnerability analysis at the community level includes three types of dimensions-indicators: stressors (e.g. exposure to global competition), assets (e.g. human capital), and outcomes (in this context, population decline).

Using the "stressor-asset-outcome" framework, a set of econometric models was estimated for the period 1981-2001. All the data used for the estimations were from the Census of Population 1981 and 2001, for 2,382 communities (Census Consolidated Subdivisions - CCS). The econometric models (probit models) estimate the probability of population and employment decline (1981-2001) as a function of stressor and asset indicators in 1981. A total of 29 community and regional indicators were used. The coefficients generated by the 1981-2001 estimations were then used to predict the long term probability of community decline based on the conditions of stressor and asset indicators observed in 2001. This probability represents the Index of Community Vulnerability (ICV), computed for population and employment decline.

The results of this research show that exposure to global restructuring trends increases community vulnerability to population and employment decline. Similarly, other conditions of community distress, such as high unemployment rates and low participation rates, increase the vulnerability to decline. Community assets, such as human capital, economic diversification, and proximity to agglomerations, reduce vulnerability to population and employment decline.

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1 Introduction

The concept of vulnerability has been used in recent policy analysis to describe a specific dimension of socio-economic disadvantage. Unlike the notions of economic deprivation, disadvantage, or poverty, which focus the attention on *present* conditions, vulnerability is a forward-looking concept. In its broader meaning, the idea of vulnerability relates to the way in which events impact on a certain system, and specifically on the likelihood of experiencing loss or negative outcomes in the future because of particular conditions, events or actions (Hoddinott and Quisumbing 2003). Despite its potential policy relevance, this concept has been rarely applied to the analysis of community trends in Canada, and even more rarely to the understanding of community socio-economic trends and concerns.

Over the last two decades, one of the most important factors of change for Canadian communities has been the process of global economic integration. While global market integration has opened up new economic opportunities for various economic sectors, it has at the same time increased economic exposure to global competition for more traditional sectors (namely, primary resource sectors and traditional and labour intensive manufacturing). As a result of this process, the economy of regions that were relying on these sectors has become more *vulnerable*, i.e. likely to experience loss or negative outcomes, specifically with regard to population and employment trends. These changes are ongoing: agriculture, forestry, and mining are expected to experience further restructuring; while other traditional manufacturing sectors, such as textile sectors, are also increasingly affected by the same global restructuring forces.

These trends justify an increasing attention to the notion of vulnerability, and its forward looking stance that emphasizes the potential exposure to risk, as an additional dimension to the analysis of current conditions of disadvantage. In this research, we present what to the authors' knowledge is the first application of a community socio-economic vulnerability analysis in a cross-Canadian perspective. Specifically, the objectives of this research are twofold. First, we outline a conceptual framework for the analysis of community vulnerability that is suitable for the analysis of rural and remote communities of Canada, given current data availability. This framework acknowledges that the concept of vulnerability is a complex construct, which encompasses various components: exposure to risks, capacity to respond, and contextual factors. These components are brought together in a coherent, albeit, preliminary framework. Second, we develop an operational framework and compute a set of community-level indices of vulnerability which are compatible with the territorial grid used in the Community Information Database (CID) of the Rural Secretariat.

This paper is organized in six major sections. Following this introduction, Section 2 surveys some of the key literature on vulnerability analysis and outlines the conceptual framework used in this study. Section 3 presents an application of this framework to specific processes of change: population and employment change. Section 4 presents the operational framework, estimation and computation methods used in the analysis. The results of this analysis are presented in Section 5, while Section 6 concludes the analysis with some final considerations.

2 Background and conceptual framework for vulnerability assessment

This section has two purposes. First, we present a concise review of the conceptual and applied literature concerning the notion of vulnerability. Second, we outline a general conceptual framework for the analysis of vulnerability, which can be applied to Canadian communities. The proposed framework combines elements of the current literature on vulnerability with previous research work of the authors and, in so doing, also accounts for the data availability for the particular problem at hand.

2.1 Insights from the existing literature

The concept of vulnerability has been used in recent policy analysis to describe a specific dimension of disadvantage, which relates to exposure to risk and risk management. Unlike the notions of disadvantage, such as economic deprivation, or poverty, which focus attention on *present* conditions, vulnerability is a forward-looking concept. In its broader meaning, the idea of vulnerability relates to the way in which events impact on a certain system, and specifically on the likelihood of experiencing loss or negative outcomes in the future because of particular events or actions (Alwang et al. 2001; Hoddinott and Quisumbing 2003).

This approach to the analysis of disadvantage brings the notion of risk and risk management at the core of the policy discourse (Alwang et al. 2001). In other words, it leads to a policy focus on how vulnerable entities – individuals, households, communities, or regions – exposed to certain risks, can be helped in managing and reducing risk, to become more resilient, adaptable and able to cope with changes. Although the concept of vulnerability has been applied in a variety of disciplines and contexts, it appears fair to say that the bulk of the literature on vulnerability focused on household vulnerability to poverty and vulnerability of geographic areas to environmental adversities or natural disasters (Cuna 2004). Relatively limited research has applied the concept of vulnerability to the analysis of socio-economic conditions of communities or regions.

The literature on household vulnerability has been generated primarily as an extension of the analysis on poverty (Alwang et al. 2001; Hoddinott and Quisumbing 2003; Cuna 2004). One of the key insights of this literature is the conceptual distinction between the current condition of a household (for instance: income status) and the likelihood that this given household will experience a deterioration of its condition in the future. Hence, vulnerability is not a measure of the current condition of the household, but a measure of the likelihood that these conditions (outcomes) will worsen in the future due to adverse events. In this context, it should be mentioned that this literature has linkages with the asset-based approach and sustainable livelihood literature (Alwang et al. 2001). All these streams of literature share a common element in what Alwang et al. (2001) define the “risk chain”, that is a conceptual decomposition of vulnerability into three main components: risk source, risk management, and risk outcome. As a result, the following general logical framework applies: households are vulnerable *from* exposure to a certain source of risk, and are vulnerable *to* suffering a certain outcome.

Hoddinott and Quisumbing (2003) further classify the research on household vulnerability to poverty into three main groups. According to these authors the first group defines vulnerability as expected poverty, i.e. vulnerability is defined as the likelihood that a household will fall into poverty. The second group see vulnerability as low expected utility, an approach that corrects some weakness of the first group but, at the same time, relies on economic concepts (utility changes) that have limited policy appeal. The third group defines vulnerability as uninsured exposure to risk, which contrary to the previous two groups, is backward looking and relies on an ex-post assessment of welfare loss caused by shocks or adverse events.

The research that focuses on vulnerability of geographic units (communities and regions as opposed to households or individuals) has been concerned primarily with vulnerability to environmental and natural events, such as climatic events, natural disasters, etc. (Dolan and Walker 2003; Parkins and MacKendrick 2007). These types of events are, to a large extent, exogenous to the socio-economic dynamics of a community. Moreover, a common characteristic of this vulnerability research is the focus on a single source risk (as opposed to household vulnerability to poverty in which the source or risk is complex and interlinked with a multitude of socio-economic determinants). Nonetheless, the conceptual framework developed within the context of this type of research offers several insights. Vulnerability research to natural disasters brought attention to: (1) the identification of the source of vulnerability, or hazard assessment (i.e., the likelihood that a natural disaster will hit the community); (2) the assessment of adverse effects on the community (i.e., how much is the community vulnerable?); and (3) the assessment of the community capacity to respond to the hazard.

Apart from natural disasters or environmental concerns, there are few examples of vulnerability analysis in which the unit of analysis is geographically defined. One of these is research by Ayadi et al. (2006) about the vulnerability to sector employment decline for regions that are particularly exposed to international competition and trade liberalization. These authors develop a Regional Vulnerability Index (RVI) for 63 regions of Europe with a focus on the impact of world trade liberalization on the employment in the fruit and vegetables sectors. The index is a weighted average of a large number of other indicators (approximately 40, combined in 4 main dimensions), where the weights are defined on the basis of a simulation process and expert judgment (Ayadi et al. 2006). The methodology applied for the computation of the index appears rudimentary, and the index is indicated as a "synthetic regional vulnerability index" by the authors (Ayadi et al. 2006:28). However, it provides a ranking of European regions according to the score of the index, and identifies those that are likely to be more exposed (vulnerable) to employment decline in specific agricultural sectors and as a consequence of trade policy changes.

Another example of vulnerability research that uses geographically defined entities as unit of analysis is the study by Atkins et al. (1998) that uses income (GDP) level and volatility as a measure of vulnerability for developing countries. This index has two main dimensions. The first refers to the impact of exogenous shocks, beyond the country's control. The second reflects the resilience of the country to withstand and recover from these shocks. The authors develop an index of output volatility by measuring the standard deviation of annual rates of growth of GDP per capita at constant price. The analysis used a sample of 111 developing countries. The authors tested about fifty variables, reflecting economic, environmental and geographic characteristics of the countries, and identified a restricted number of indicators that are highly significant in influencing volatility of GDP per capita. The most significant indicators were the lack of economic diversification, export dependence (the proportion of exports in GDP), remoteness and insularity and the impact of natural disasters. These elements were combined to form a composite index of the *impact of vulnerability* on developing countries. The resulting index was then weighted by GDP as a proxy for *resilience*, which is considered by the authors to be the second component of the vulnerability index. The impact results showed that small states were more vulnerable than larger ones, regardless of the income level. When impact was combined with resilience to form the vulnerability index, some country rankings changed dramatically, reflecting the intuitive notion that they should be able to manage their vulnerability through use of their own assets.

2.2 A conceptual framework for Canadian communities

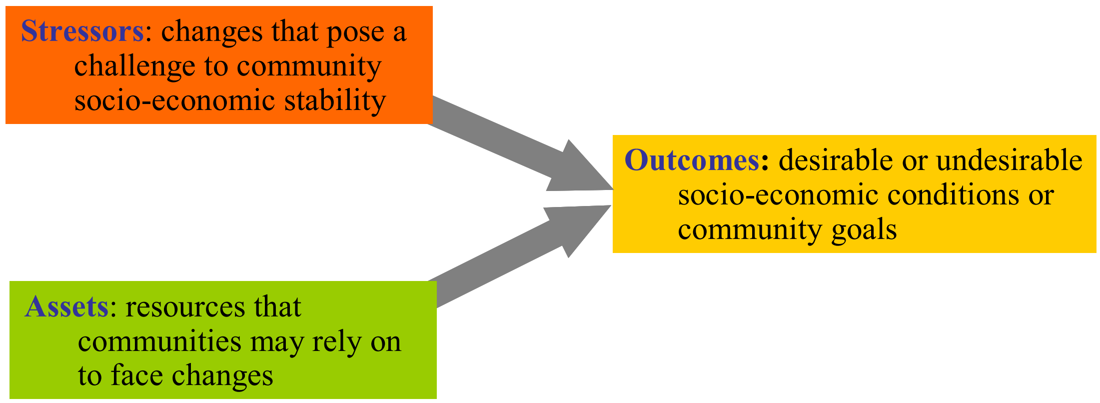
The review presented in the previous section reinforces the point that in most analytical approaches vulnerability is conceptualized as a dynamic concept, which requires the identification of a unit of analysis, the definition of a time dimension, and a consideration for the temporal dynamic of change. For the purpose of this research, vulnerability is defined as the likelihood of a worsening of socio-economic conditions for the community. The conceptual framework that we use to investigate and eventually measure community vulnerability is presented in Figure 1.

The key elements of this framework are: stressors, assets, and outcomes.[1] In broad terms, stressors identify input changes that pose a challenge to community socio-economic stability. Such changes in stability may be considered desirable or undesirable features of communities from an analytical or public perspective – with mixed evaluations being the most frequent assessment. Assets represent a variety of resources that communities may rely on to face changes. Although we use the term 'assets' they may be considered as liabilities under particular circumstances or at particular times. These might include natural assets, human or social capital, institutional capacity, or governance processes. Therefore, at this stage, we adopt a broad and inclusive definition of assets, which encompasses physical assets as well as "soft" assets and the capacity to use them. Finally, outcomes are used to represent specific desirable or undesirable socio-economic results or community goals/aspirations.

Using this framework, community vulnerability (i.e., adverse changes in community outcomes) is a function of two major elements. The first has to do with the stressors faced by the community (endogenous and exogenous). The second refers to the assets that the group or community has available to deal with the stressors. At this stage, we adopt a broad definition of assets that also entails the capacity of the group or community to make use of, or reorganize, those assets. This capacity in turn could be conceptualized as a function of at least two elements: local social organizations, networks, and relationships that enable collective behaviour and the more general entitlements and institutions that facilitate or inhibit such action. Vulnerability is the result of the inter-relationship between these two general elements. The most vulnerable communities are those that face significant stressors with few assets and little capacity to act (high vulnerability). It is expected that an increase in assets or capacity to act would decrease the vulnerability of a community. Communities with few resources may still have relatively low levels of vulnerability if the stressors on them are few or weak. Communities with high levels of stress but many assets could have relatively low levels of vulnerability, and so on.

1. Various terms have been used to identify these components, such as source of risk, exposure, stressor, condition, capacity (to adapt), resilience, and asset.

Figure 1 Community vulnerability: a conceptual framework



The distinction between the elements of this framework is largely conceptual. This framework implies a process that closely resembles cumulative causation (Myrdal 1971). Similarly, research on biological populations indicates that the history of decline is critical in explaining observed trends (Calhoun 1962; Holling 1973; Welberg and Seckl 2001). Thus, in the dynamic process of change, what in one time period could be identified as an asset or outcomes might in turn become a stressor in the following period of time, which is the typical structure of a process of cumulative causation. For instance, income level can be considered an outcome; yet an adverse change in income level can become a further element of stress for the community. These may be related to such processes as population, income, or asset decline, unemployment, suicides, or health problems. Similarly, declining trends in employment and population may become a further element of stress for the community. For small settlements, the downsizing of a single sector may have substantial multiplicative effects. An initial population downsizing makes it difficult to retain, let alone expand, basic services in the community and for the services that are retained delivery costs may increase to unbearable levels. In the long run, this pattern of decline may threaten the quality of life of the population residing in these areas.

In spite of these challenges, the conceptual distinction between stressors, assets and outcomes has a utility in structuring the analysis and developing an operational framework, as will be outlined in the next sections. In this first exploration of community socio-economic vulnerability, and first attempt to develop a community vulnerability index, we opted for a relatively clear-cut framework. We acknowledge that this can be further extended and articulated with the introduction of other conceptual elements or dimensions. For instance, a concept related to that of vulnerability is that of adaptability; this concept contributes to our understanding of how vulnerability can be reduced or mitigated within a natural or social system. Adaptability can be conceptualized as the capacity to adapt to a changing socio-economic or biophysical environment and to generate desirable outcomes despite initial adverse conditions. Put simply, a community is adaptable if it is able to avoid an adverse outcome despite being affected by a level of stress detrimental to other communities. A community is adaptable if it continues to grow across a range of factors to be determined and to do so despite the odds. Using our framework we can identify communities that had a high degree of adaptability, although we are not able to indicate the factors associated with this capacity to adapt.

3 Application of the framework to a process of change

The broad framework presented in the previous section can be applied to a variety of different contexts to assess community vulnerability to specific processes of change. In this research we apply this vulnerability framework to the process of population decline at the community level. Over the last two decades, about one third of Canadian communities experienced continuous demographic growth, while another third experienced continuous population decline (Mwansa and Bollman 2005). Even though it is unrealistic to expect to reverse declining trends for all rural communities, specific policies may help stabilize rural population levels, and reduce the level of vulnerability to population decline.

We operationally define a "vulnerable community" as a community that has a high probability of experiencing employment or population decline in the future. Since we cannot determine future outcomes, we will identify community characteristics that influenced employment or population decline in the past, then use them to estimate probabilities for the future. Hence, in order to turn our conceptual framework into an operational framework we need to identify three sets of indicators: (1) outcome indicators (2) indicators of stress (exposure to risk, etc.); and (3) indicators of the assets. The selection of the indicators was based on the insights derived from the literature, previous research experience of the authors, in particular Alasia (forthcoming) and Burns and Reimer (2004), and data availability for the specific problem at hand. Indicators that use income, industry group, occupation and employment are based ultimately on 1981, 1991 and 2001 census data. This information is derived from the "long-form" of the Census of Population and is therefore based on a 20% sample of Canada's population.

Three broad criteria were use to select the indicators for our model: (1) the indicators had to reflect one of the three sets above; (2) we favoured relatively simple and straightforward indicators as opposed to composite ones; (3) each indicator had to be used as predictors for future periods and its value needed to be recomputed for the current (2001) period; for this reason, we avoided using change indicators between census years (1981 and 2001), which would have made it impossible to recompute an appropriate dataset for 2001 (i.e. change between 2001 and 2021).

Before discussing each of the selected indicators selected in detail, some clarifications should be made with regard to the geographic scale of analysis and the time frame. As shown by the literature review, vulnerability considerations can be applied to individuals, households, communities or regions. In this report we focus on community-level vulnerability. We use the Census Consolidated Subdivision (CCS) as the operational definition of community, hence all the indicators used in this analysis are computed at the CCS level (in the remainder of the paper the term CCS and community are used as synonymous). A CCS is a grouping of adjacent census subdivisions (municipalities). Generally the smaller, more urban census subdivisions (towns, villages, etc.) are combined with the surrounding, larger, more rural census subdivision, in order to create a geographic level between the census subdivision and the census division.[2] All the indicators are from a community database generated by the Agriculture Division, in which CCS variables are tabulated for constant 1996 census geography. The total number of CCSs in 1996 was 2,607. For about 200 of these CCSs some of the indicators used in the model were not

2. For a detailed definition see the Statistics Canada web site at: http://geodepot.statcan.ca/Diss/Reference/COGG/Index_e.cfm

available for one or more of the census years considered.[3] As a result of these exclusions, the number of CCSs used in the analysis is 2,382.

Our analysis focuses on the vulnerability of individual communities but we introduce an important distinction between community and regional effect. Community vulnerability is likely to be affected both by local (community) characteristics as well as by the characteristics of the region in which the community is located. For instance, a community may have a relatively small pool of human capital, but at the same time it may be located in a region with high levels of human capital, which can facilitate the access to these resources for the community and ultimately determine its capacity to adapt and thus to reduce the vulnerability to changes (i.e. to reduce the probability of a negative outcome). Similarly, a community that has a relatively low share of employment in traditional sectors (for instance agriculture) may be located a region with a high share of employment in traditional sectors. Hence, its vulnerability to forces of global restructuring may be high due to employment multiplier effects that can affect the economy of the region. In other words, we postulate that a community's vulnerability is significantly determined by local as well as the regional stressors and assets available to it.

For this reason we give specific attention to this local/regional dimension by using a set of spatially-lagged indicators. For each community, a spatially-lagged variable is a distance-weighted average of the values recorded by neighbouring communities for the indicator of interest. For instance, the spatially-lagged share of employment in agriculture for community A is the distance-weighted average employment share in agriculture of the communities surrounding community A. Note that in this calculation the value of the indicator for the community itself is not taken into account. The distance-weighting is done using the inverse of the squared distance between community centroids (1/distance squared); thus the calculation follows a gravity principle with the values of the nearby communities having a greater bearing in determining the value of the spatial lag (see Section 4.1.1 for technical details).

Finally, the assessment of vulnerability requires taking into account a certain timeframe. The focus of our analysis is on long-term vulnerability and the availability of geographically consistent data allows us to consider the period 1981 to 2001. Hence, in the analysis we use three census years: 1981, 1991 and 2001. The core of the analysis is conducted for the period 1981 to 2001. However, we use the two sub-periods 1981 to 1991 and 1991 to 2001 to assess the robustness of the results and test the forecasting reliability of the model.

In the remainder of this section, we discuss the outcome, stressor and asset indicators. The exact definition of each variable used in the model is reported in Table 1, while the descriptive statistics for each of the census years are reported in Table 2 to Table 7, for alternative groupings of population and employment change conditions.

3.1 Outcome indicators

Vulnerability becomes visible through the failure of a system to adapt to changes in its environment. In the case of communities, such failures may be reflected in a large number of

3 Some census data are not released for CCSs with population less than 250 individuals due to data quality and confidentiality reasons; similarly, several variables are not released for CCSs corresponding to Indian Reserves. In this analysis we also excluded the Territories. For details on these issues see the following web page: http://www12.statcan.ca/english/Profil01/CP01/Help/Metadata/RandomRounding.cfm?Lang=E

undesirable outcomes – from economic decline to personal crises and social unrest. In this analysis we focus on population and employment decline as outcome indicators of vulnerability. We recognize that such declines should not always be considered as indications of system failure, but we choose them under the assumption that they are frequently considered negative outcomes by researchers, policy-makers, and citizens alike.

Two outcome indicators are used independently: population and employment change between 1981 and 2001. Both are expressed in a dichotomous form. Population is the total non-institutional population of the CCS in the two census years. The population indicator takes the value of 1 if the community experienced a decline between 1981 and 2001, and takes the value of 0 if the community experienced population growth. Employment is the total experienced labour force of the CCS in the two census years. The employment indicator takes the value of 1 if the community experienced employment decline between 1981 and 2001, and takes the value of 0 if the community experienced employment growth.

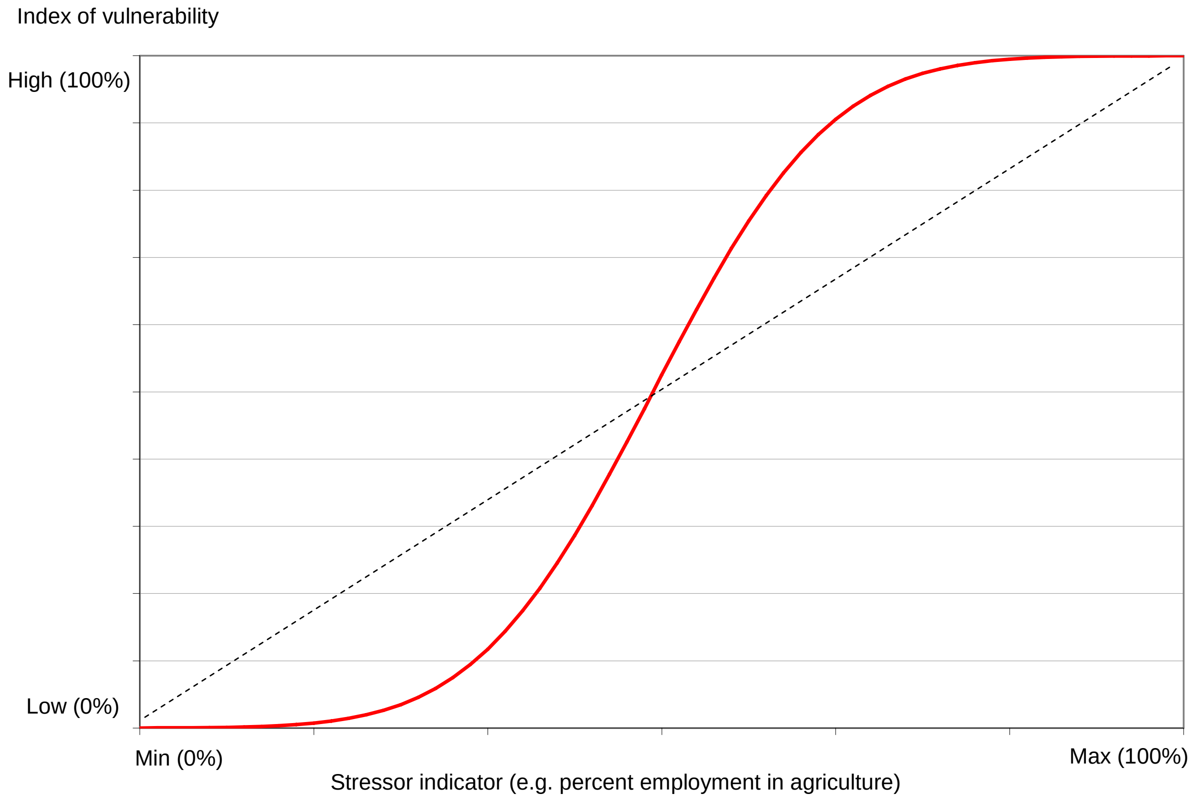
The choice of using these indicators in a dichotomous form should be further explained. This decision was driven by policy and methodological concerns. The policy question addressed by this research is "How vulnerable is a community to population (or employment) decline? Or in other words, what is the likelihood that the community will experience a population (or employment) decline? The concern is not with how much growth or decline this community will experience, although this is also a legitimate policy focus. There would be various methodological approaches to this question, given the continuous nature of the dependent variable. In our research, we follow an established practice in the household vulnerability and poverty literature in developing countries. It has become a standard practice to analyze the determinants of poverty through categorical regressions such as probits and logits (Cuna 2004; Hoddinott and Quisumbing 2003). Insights from this literature suggest also that standard regression methods provide better results in terms of inference, while quantitative dependent variable models have better performance in prediction. Hence, given our primary policy focus and research interest we opted for a qualitative dependent model.

3.2 Stressor indicators

Stressors are primarily, but not exclusively, external factors that place pressure on the organization and operation of communities. The specific choice of stressors is potentially vast, so we will limit our analysis by selecting those most likely to impact employment and population outcomes – and to do so among a wide variety of communities.

Regardless of its nature, however, the expected relationship between a stressor indicator and the vulnerability index is depicted in Figure 2. This figure illustrates one relevant aspect of our analytical framework. Since we are defining vulnerability in likelihood terms, we can anticipate that the value of the index needs to be in the range 0 to 1 (or 100%). If we consider an indicator that also has a natural minimum and maximum value (for instance percentage of labour force employed in agriculture, which can potentially range from 0 to 100%), it is unlikely that we will observe a linear relationship between the stressor indicator and the index of vulnerability. This linearity would imply a relationship as that indicated by the dashed line in Figure 2, which is unrealistic.[4]

Figure 2   Expected relationship between a stressor and the index of vulnerability



The red line of Figure 2 represents a more realistic and desirable representation of the relationship that we expect to find. The desirability of this pattern stems from two circumstances; first, this non-linearity ensures that the index will remain in the plausible range, regardless of the value that the indicators might take; second, and most important, this relationship is likely to reflect a plausible relationship between the stressor and the index. This implies that for very low values of the stressor (say community employment in agriculture equal to 0%), an increase of its value of a small amount (say 5%) it is unlikely to change the level of vulnerability of that community (which will remain close to the zero value). Similarly, for a community with 80% of employment in agriculture a further increase of 5% of the agricultural employment is unlikely to change substantially its vulnerability status (likelihood of experiencing a decline), which is probably already very close to 100%. In contrast, for certain ranges of the stressor small changes of its values are more likely to result in substantial variation of the vulnerability index. As we will further discuss in Section, 4.1 and 4.3 non-linearity and varying marginal effects are a typical, and relevant, feature of the econometric model that we use in the estimation.

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4. A linear regression line that crosses the horizontal axis at a positive value of the indicator would pose other methodological challenges in the computation of the indicators, as it would be difficult to bound the value of the index to the desired range (0 to 1).

We postulate that one of the main stressors on communities is sector restructuring due to changes in global trade relations and the relative prices of labour and capital. These changes have had particularly strong effects on the traditional sectors within developed countries. Agriculture and other primary sectors, such as forestry, have been forced to undergo significant restructuring. Similar challenges have been faced by traditional manufacturing (such as textiles), which have suffered from competition from countries with low labour costs. Communities that are dependent on commodities suffering from high competition, for example, are likely to experience employment and population declines.

There are two options for measuring exposure of communities to global pressures. The first can be captured in various measures of import-export linkages or export dependence between the local and global economy. Communities that have stronger linkages to the global economy are potentially more exposed to global fluctuations. The second approach to measuring global exposure-related stress would be to focus on the employment composition of the locality. Communities that have a higher share of employment in traditional sectors, which are highly exposed to global competition, are more likely to be vulnerable to global sector restructuring. Each approach is unlikely to be a perfect substitute for the other, but at this stage, given the availability of data and the challenge of measuring local linkages with the global economy, we opt for sector composition as a proxy of exposure to the forces of global restructuring. Following this second approach, the indicators used in the model are the share of employment in agriculture, share of employment in other primary sectors and share of employment in traditional manufacturing (Table 1). In all cases the figures refer to the experienced labour force. Each of these indicators is also entered as a spatially-lagged variable, measuring in this way, the sector composition of the region in which the community is located (regardless of the employment structure of the community itself).

The economic specialization of a locality and the surrounding region can also be conceptualized as a potential community stressor. A diversified economic base is likely to provide a wider variety of options for responding to the forces of global restructuring. The degree of economic specialization is measured by the Herfindahl index of concentration, which equals the sum of the squared shares of employment in each industrial sector for the given community (see Page and Beshiri 2003). The index is also entered in the model in a spatially-lagged form, to measure the degree of economic specialization of the region in which the community is located.

The unemployment rate is another indicator of stress for a community. In the model we use the local and spatially-lagged unemployment rate for individuals between 25 and 54 years of age. It is often argued that participation rates are a better indicator of the conditions of the local labour market, because the unemployment rate does not account for possible hidden unemployment which is not recorded by official statistics and which is reflected in low participation rates. Hence, we also include an indicator of participation in the labour market defined as the ratio between the experienced labour force, 15 years and over, and the total population 15 years and over (local and spatially lagged). A low level of this indicator is a potential sign of stress for communities.

A relatively high level of very young or very old people in the community can increase its stress. The extra resources and demands of these age populations tend to compete with the time available for economic production or labour recovery – thus reducing employment levels. In addition, the necessity for public services for these populations may increase pressure for people to move to locations offering such services – thus decreasing the population in smaller communities. We use the percentage of the population less than 15 years of age and the percentage 65 years of age and over to reflect these stressors.

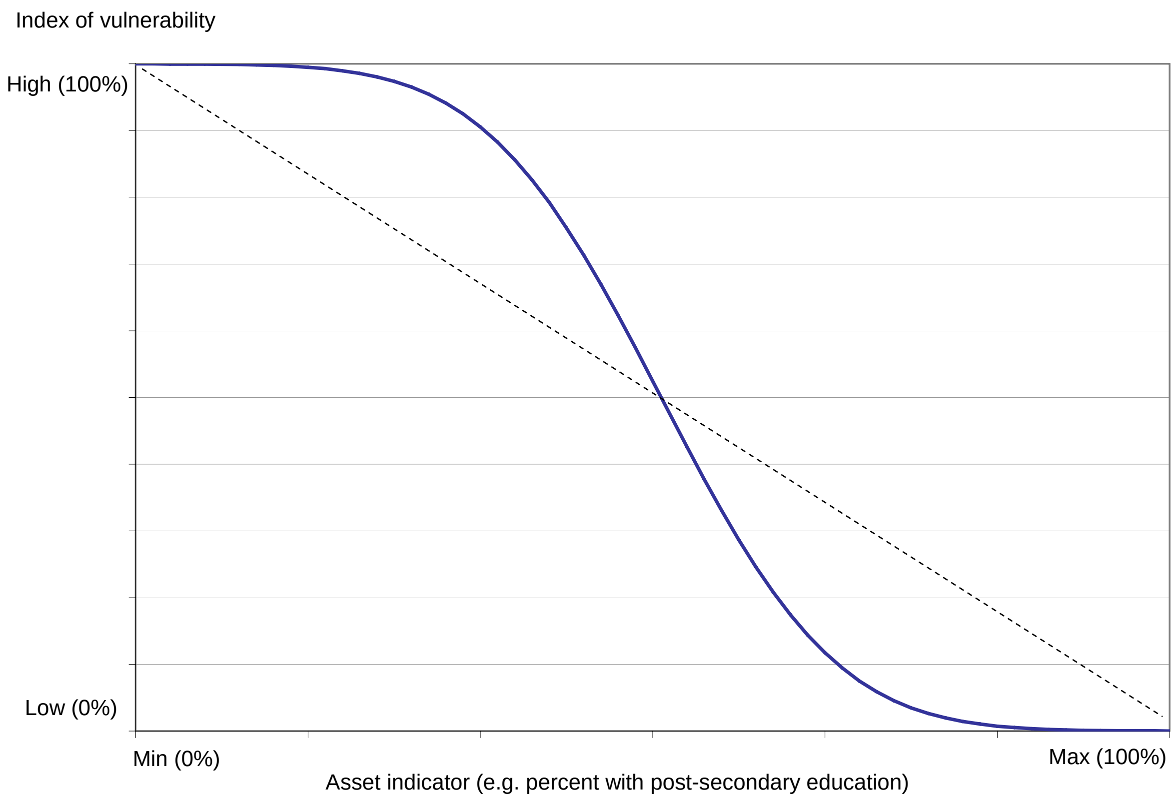
3.3 Asset indicators

The list of potential assets and resources available to communities is vast. They may include economic and financial assets, human capital, social and institutional resources, environmental assets, and natural resources. Under stress, these assets may be reorganized to adjust to changing conditions in the interest of reducing vulnerability. For our purposes we will focus on those that are most likely related to the population and employment outcomes of our study.

The expected relationship between an asset indicator and the vulnerability index is depicted in Figure 3. As we have discussed in the case of stressors, the characteristics of the vulnerability index that we are attempting to develop makes it difficult to observe a linear relationship between the indicator and the index (i.e., a line similar to the dashed line in Figure 3). A non linear relationship appears more plausible and desirable (blue line). For instance, if the asset indicator (e.g., the share of population with a post-secondary degree) is very low (e.g., 1%), it is plausible to assume that a small increase will have virtually no effect on the socio-economic dynamics of the community. Instead, once a minimum critical mass has been reached, the same additional increase is likely to have a large marginal effect on community vulnerability. Once the asset has reached a high value (e.g. the large majority of the population has a post-secondary degree), it is plausible to assume that the index of vulnerability will be very low (close to 0) and that a small increase of the asset indicator will have virtually no effect on the vulnerability index (which is already very low).

Human capital is considered to be one of the principal indicators of assets available to the community. Communities that are characterized by high educational attainments are more likely to retain and attract new economic activities. These communities are also more likely to have the skills to adapt to potential changes, understand the nature of stressors, identify appropriate assets, plan effective action, and motivate others to deal with the stressors. We use the percentage of individuals aged 25 to 54, with some post-secondary education as an indicator of human capital. The indicator is entered as a community indicator as well as in its spatially-lagged form to capture the spillover effect that the regional context may have on the community.

Figure 3 Expected relationship between an asset and the index of vulnerability



The presence of expanding economic sectors may represent a considerable advantage to the community. For this reason we use the percentage of employment in distributive services and percentage of employment in producer services. In both cases the indicators are based on experienced labour force figures, and are entered as local and spatially-lagged indicators. The share of employment in producer services is likely to be a better indicator than the share of employment in distributive services, because producer services are potentially exportable. The distributive services sectors (wholesale trade, retail trade, transportation) are not potentially exportable.

The availability of wealth (individual, enterprise, or group) can be an important asset for community adjustment in the face of stress. It may provide a buffer under conditions of change or the means by which personal or community adjustments may be made. In our analysis, variation in the level of wealth is measured by the average income for the population 15 years of age and over. It should be noted that this indicator was introduced in constant dollars to avoid capturing the effect of a variation due to nominal income variation, which was substantial between 1981 and 2001. In order to avoid over-representing the predicted probabilities due to nominal income change, we converted the average income value to constant 1980 dollars. We used the annual Consumer price index (CPI), 2001 basket content (CANSIM Table 326-0002).

Hence, all income values reported in the descriptive statistics tables are also in constant 1980 dollars.

Location characteristics, to some extent, can be considered an asset for the community. Communities that are close to large urban centres have the advantage of markets and labour pools that can be used to mitigate the negative effects of stressors. Urbanized areas may also enjoy the presence of institutions that can make a crucial difference in this process of change. These institutions may include various types of community and municipal associations, chambers of commerce, research and higher education facilities. The presence, proximity, or opportunity to access this type of institution may facilitate the process of adjustment and help cope with changes. The combined presence and effect of these assets is captured in two ways in our analysis: by using distance to urban centres and agglomeration measures. The former is measured using the geographic distance to the nearest large agglomeration (CMA of 500,000 inhabitants or more) and the geographic distance to the nearest medium or small CMA or CA (population between 10,000 and 500,000). In both cases, the geographic distance is computed as the distance between the CCS geographic centroid and the geographic centroid of the nearest CA or CMA. As a measure of agglomeration we use population and employment density. These are computed as total population and employment indicators (see Section 3.1) divided by the CCS area. Agglomeration indicators are also introduced in their spatially-lagged forms (i.e. distance weighted average of the population/employment density of surrounding communities).

Cultural groups provide networks and organizations that form potential assets (or liabilities) for communities when dealing with change. Although the census data does not provide extensive information regarding such groups, we have selected the presence of an Aboriginal population as one indicator related to this feature (it should be noted that this is the Aboriginal population outside the Territories and outside smaller settlements that were excluded from the analysis due to confidentiality and data quality concerns).

In the conceptual framework outlined in the previous sections we include the capacity to act as part of the assets available to a community. Indicators of capacity to act should reflect the extent to which a community or group takes action collectively. It is the difference between being a member and participating in a group, having businesses and actually shopping locally, having government and other services available and making use of them, having family and friends and actually interacting with them. In each case, the former part of the pair reflects the assets and the latter part reflects the use or capacity to use them. Although we acknowledge that there is a conceptual distinction between availability of assets and capacity to use them, we also came to the realization that the available data is not particularly suitable to capture this distinction. The census variables are very weak in reflecting this more active capacity characteristic. Given the indicators readily available for this study and the need to have comparable indicators for three census years (1981, 1991, and 2001), at this stage we limited our analysis to two indicators. We used the percent of individuals between 20 and 24 years of age who lived in a different CSD 5 years before the corresponding census year; and percent of individuals between 55 and 74 years of age who lived in a different CSD 5 years before the corresponding census year. In both cases we consider these individuals to be more capable to act on their own behalf – as demonstrated by their mobility.

4 Computation of the index of community vulnerability

The indicators presented above are brought together using a multivariate statistical framework. The computation of the vulnerability index, for both population and employment decline, is carried out in two steps. The first step of the analysis involves the estimation of a probit model for the period 1981-2001. We use the value of the indicators at the beginning of the period considered (i.e., in 1981) as a predictor for the nature of the change over the period considered (1981-2001). In the second step of the analysis, we use the parameters estimated with the 1981-2001 model to predict the likelihood of population and employment decline based on the community conditions observed in 2001. We also estimate the model for the two sub-periods 1981-1991 and 1991-2001 and test the predictive capacity of the model between these two sub-periods.

This section presents the computation of the indices in detail. The discussion is organized as follows: first, we present the characteristics of the econometric model (the first step of the index generation procedure), which also includes a detailed explanation of the computation of spatially-lagged variables (regional indicators). Then, we present the computation of the index (second step of our computation procedure). Finally, we provide detailed information on the interpretation of the probit coefficients, marginal and discrete changes effects.

4.1 Step 1: model estimation and rationale

The first step in the computation of the indices of vulnerability is the estimation of a qualitative dependent variable model (Long and Freese 2001; Aldrich 1984), for population and for employment decline. In both cases, we use probit specifications, in which the probability of population (or employment) decline between 1981 and 2001 is expressed as a function of stressor and asset indicators in 1981, hence Pr(y=Decline) = F(Stressors, Assets). In both cases, the dependent variables are dichotomous, thus variable y takes value 1 when the community records a population (or employment) decline between 1981 and 2001, and takes value of 0 otherwise. Dropping the observation subscript for sake of conciseness, we can write:

$$\Pr(y_{81-01} = 1) = \Phi(\beta_1 S_{81} + \beta_2 A_{81}) \qquad (1)$$

or using the extended form:

$$\Pr(y_{81-01} = 1) = \int_{-\infty}^{(\beta_1 S_{81} + \beta_2 A_{81})} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right) du \qquad (2)$$

where Φ(.) denotes the cumulative normal distribution function, β represents the set of parameters to be estimated, while S and A represent the sets of stressor and asset indicators in 1981, respectively. Equation (1) is estimated using maximum likelihood methods in STATA.

Probit models are often conceptualized as latent variables models, which imply that the dichotomous variable is the observable outcome of a continuous underlying model that is unobservable or non-measurable in practice (see Long and Freese (2001) for theoretical details, and Alasia et al. (2007) for an applied example). In our case, however, the choice of this specification is driven primarily by the nature of the non-linear probability model embedded in the vulnerability framework and graphically represented by Figure 2 and 3. Although this distinction is of little practical importance, it is conceptually relevant. We are not postulating an underlying continuous latent model; hence, the vulnerability of decline is substantially different from the rate of growth/decline. We are explicitly focusing on the *event of decline* (or non-decline) as a policy relevant variable. The probability of experiencing this decline is the key policy indicator of interest in our analysis (rather than the rate of growth/decline).

We are also postulating that there are certain value ranges where changes in one indicator have virtually no effect on community vulnerability to decline (see Figure 2 and 3). This assumption suggests it may be particularly interesting to investigate the existence of critical thresholds that trigger or prevent a process of population or employment decline. The non-linear nature of the probability model has another relevant feature: the marginal effect of each explanatory variable depends on the value of all other explanatory variables. Also in this case the model allows us to explore the effect of interactions between explanatory variables, as well as the effect of critical thresholds due to given variables on other explanatory variables. For instance, it is plausible to assume that remoteness is a critical stressor for rural communities. However, a marginal increase of human capital in a remote community may have virtually no effect on the probability of decline experienced by that community (due to the lack of a minimum critical mass). In contrast, the same change in human capital might have a substantially larger impact in a community that is located in closer proximity to an urban centre, because this community could be in a better position to exploit the benefits derived from a larger human capital stock. Non-linear probability models allow us to explore these interactions (as will be further illustrated in Section 4.3, on the interpretation of probit results).

In analytical terms, the adoption of a probability model requires using a model that has the following attributes:

$$\lim_{x\beta \to +\infty} \Pr\left[y=1\right]=1 \tag{3}$$

$$\lim_{x\beta \to -\infty} \Pr\left[y=1\right]=0 \tag{4}$$

This can be achieved by adopting a function that maps from the plausible values of $E(y|\mathbf{x})$ into the range 0 to 1. Cumulative probability distribution functions have this attribute and are a widely used option in applied research. As for the derivation of latent variable models, however, there is limited theoretical guidance for choosing the exact form of the cumulative probability distribution function. The most commonly used specifications are the normal (probit) and the logistic cumulative probability distribution function. In this research we use a probit specification.[5]

5. Applied research has typically adopted two alternatives: probit or logit distribution. The coefficients generated by the two models differ in magnitude, normally by a fixed proportion, but the differences in probability outcomes are generally marginal (Long and Freese 2001). Thus for practical purposes, the two specifications are equivalent and the choice among the two is driven by authors' preferences and practical computational reasons.

4.1.1 Specification of the spatially-lagged variables

As we discussed in Section 3, community vulnerability is likely to be affected by both local (community) characteristics as well as regional characteristics. Hence, we distinguish two components of the regional milieu effect: the local effect and the regional effect. Following Alasia et al. (2007), this distinction is introduced by means of community (CCS) indicators, to capture the effect of local characteristics, and their corresponding spatial lag, to capture the regional effect. A spatially-lagged variable is a weighted average of the neighboring CCSs' values for that given variable.

In general terms, the computation of spatial lags involves three steps. First, a spatial weight matrix **W** is computed using some proximity criteria between units of observation (CCS in our case). The elements w_{ij} of the squared matrix **W** defines the nature of the spatial relationships among the geographical units. The specification of the weight matrix **W** is of particular relevance in spatial analysis, since it defines the extent of the regional effects. There are alternative ways in which the matrix can be specified and relatively limited theoretical guidance is available for choosing among them. Typically, the choice rotates around alternative definitions of boundary proximity or geographic distance; it is then a common practice to assess the robustness of the analysis by testing the effects of alternative specifications of the weight matrix. Second, the spatial weight matrix is row standardized; the elements of each row are scaled so that the rows sum to one, resulting in a form of spatial smoothing. Third, the **W** matrix is used to compute spatially lagged variables (*x_lag*), by multiplying the (nxn) **W** matrix with the (nx1) vector of the indicator of interest.

For the problem at hand, a distance measure between territorial units appears more appropriate than any boundary criteria to define spatial relationships. Hence, the procedure used to compute the matrix is as follows:

$$\begin{cases} w_{i,j} = 1/d_{i,j}^{\alpha} & for\ i \neq j\ and\ d_{i,j} \leq D \\ w_{i,j} = 0 & otherwise \end{cases}$$
$$w_{i,j}^{s} = w_{i,j} \Big/ \sum_{j} w_{i,j} \qquad (5)$$
$$x\_lag_{i} = \sum_{j} w_{i,j}^{s} \cdot x_{j}$$

The element w_{ij} of the spatial weight matrix is set equal to the inverse of the linear distance (d) between each pair of CCS's geographic centroids (i≠j), while for i=j the element is equal to zero, implying that the diagonal of the matrix is 0. Hence, the value of each observation (local context) is not included in the computation of the corresponding spatial lag (regional context). The inverse-distance weight replicates a gravity model principle, with larger distance resulting in smaller value of the spatial weight, w_{ij}, which in turn implies a weaker spatial interaction. The gravity effect can be amplified or reduced by changing the parameter α, which is typically set equal to 1, 2 or 3. In this analysis we use the inverse of the squared distance as the basic specification. It is also common practice to set a threshold distance after which spatial interaction is supposed to disappear. In our analysis the bandwidth (D) of regional interaction is set equal to

1,000 km.[6]

4.2 Step 2: computation of the index of vulnerability

In the second step of the analysis we used the parameters estimated by the probit models (step 1) to compute the vulnerability indices. The index reflects the long-term probability of population (or employment) decline given the community characteristics in 2001 and the trends observed between 1981 and 2001. The methods used in computing the vulnerability index are described below.

Using the results of the model estimation for the period 1981-2001, in particular the vector of estimated coefficients $\overline{\beta}$, it is possible to compute the predicted probability of decline for each community. Dropping the observation subscript, we can write this predicted probability as follows:

$$\overline{\Pr}(Decline_{81-01}) = \Phi(\overline{\beta}_1 \, S_{81} + \overline{\beta}_2 \, A_{81}) \qquad (6)$$

where Φ(.) denotes always the cumulative normal distribution function, S and A are the vector of community characteristics in 1981 (including spatial lags) and the $\overline{\beta}$ are the corresponding coefficients estimated in step 1.

To compute the vulnerability index (predicted probability of decline) we use the parameters estimated for the period 1981-2001 $\overline{\beta}$, and the local and regional conditions observed in 2001. Hence in formal terms we compute the following:

$$\overline{\Pr}(Decline_{long-term}) = \Phi(\overline{\beta}_1 \, S_{01} + \overline{\beta}_2 \, A_{01}) \qquad (7)$$

Once again, this probability, computed for each individual community in the database, is taken as an index of vulnerability for population and employment, separately – that is the long-term probability of population or employment decline, based on trends observed over the period 1981 to 2001 and the community conditions observed in 2001.

4.3 Interpreting the results of a probit model

Probit models imply a non-linear relationship between the explanatory variables and the dichotomous dependent variables. This relationship is well captured by the typical "S" shaped profile of the normal cumulative distribution function. We have argued that, since the focus of the model is on estimating the conditional probability *Pr(y|x)* of experiencing a population/employment loss, non-linearity is a desirable property. This same feature, however, makes the interpretation of probit results more complex than for a standard regression model. Besides the fact that probit coefficients have no directly interpretable substantive meaning, the

6. The choice of this bandwidth is dictated primarily by a computational consideration; this value is slightly above the minimum distance that allows each observation to interact with at least one regional neighbour; in other words this avoids the presence of an unconnected "island", which would result in an entire row of zero values.

magnitude of change in the predicted probability associated with a given change in one of the explanatory variables depends on the values of all explanatory variables, and must be evaluated at a given value of **x**.

There is no single approach that can be used to summarize in a straightforward manner the complex relationship between dependent and independent variables in a probit model (Long and Freese 2001). Conventionally, the marginal effect is used to illustrate the effect of the change of an explanatory variable on the probability of a certain outcome. For continuous variables, the marginal effect (*m*) of the *k* explanatory variable represents the change in probability due to infinitesimal rate of change in x_k; that is the slope of the prediction function. This value can be derived from the equation (1-2), and is equal to the following:

$$m_k = \frac{\partial \Pr(y=1 \mid \mathbf{x})}{\partial x_k} = \frac{\partial \Phi(\mathbf{x}\beta)}{\partial x_k} \beta_k = \phi(\mathbf{x}\beta)\beta_k \qquad (8)$$

where $\phi(.)$ represents the standard normal probability density function and the rest is as previously defined. Equation (5) clearly shows that, unlike the standard regression which has constant marginal effects equal to the regression coefficients, the marginal effects in a probit model are non-linear and dependent on the level of all explanatory variables, **x**, at which they are evaluated. In practice, the marginal effects are usually evaluated holding other variables at their sample means, which is the procedure that we used for the values reported in Table 8, Table 10, Table 12, Table 14, Table 16, and Table 18.

As a result of non-linearity, the marginal effect is not always the best indicator of probability changes due to substantively meaningful variations of the explanatory variables. In several instances, the marginal change, m_k, is substantially different from the probability change that would result from a small discrete variation of x_k.[7] For this reason, it is important to pay attention to the effect of discrete changes of the independent variables on probability outcomes. We computed the probability associated with specific values of the explanatory variables and then compute the difference between the predicted probabilities of these “typical cases”. Thus, for a discrete change of x_k the associated probability change is given by the following,

$$\frac{\Delta \Pr(y=1 \mid \mathbf{x})}{\Delta x_k} = \Pr(y=1 \mid \mathbf{x},\ x_k + \delta) - \Pr(y=1 \mid \mathbf{x},\ x_k) \qquad (9)$$

where δ represents the discrete change of x_k and the rest is as previously defined. The computation is done by keeping all other explanatory variables at their sample means.

Using this approach, we evaluate the probability of population decline at minimum (x_{min}) and maximum (x_{max}) values for each explanatory variable, and the corresponding probability change between these two values.[8] We also computed the probability change associated with one

7. In fact, since m_k is the slope of the probability curve, its value can be greater than 1. Such values, although correct from a computational point of view, have no meaningful interpretation from a probabilistic point of view.
8. For dummy variables, $x_{min}=0$ and $x_{max}=1$, thus the change in probability from minimum to maximum value corresponds to the shift from absence to presence of the attribute represented by the dummy.

standard deviation (*sd*) change of the explanatory variable centered around its mean (μ). Since the variables that we used are approximately normally distributed (or not evidently skewed), we compute the value of the probability for 0.5 standard deviation below and above the variable mean, that is $x=\mu+/-(1/2 \cdot sd)$.

These computations are complemented with graphical analysis, which is particularly revealing for some of the variables. We plotted the predicted probability of population decline for plausible ranges of the values of selected explanatory variables, and alternative assumptions on the values of other independent variables.

5 Results and discussion

The presentation of the results is organized in six sections. First, we present the descriptive statistics for the variables used in the estimation and computation. Second, we discuss the results of probit models and the effect of discrete changes of the explanatory variables on the probability of decline between 1981 and 2001. Third, a discussion of sub-period estimates (1981 to 1991 and 1991 to 2001) and an assessment of the predictive capacity of the model are reported. Fourth, we outline some graphical results concerning the 1981-2001 estimates. This is followed by a discussion of the results on the indices of vulnerability. Finally, we present the spatial distribution of the predicted probabilities generated by the base models and the indices of community vulnerability to population and employment decline.

5.1 Descriptive statistics

The descriptive statistics for the variables used in the estimations and computation of the vulnerability indices are presented in Table 2, Table 3, Table 4, Table 5, Table 6, and Table 7, for population and employment change status and the three census years considered in this analysis (1981, 1991 and 2001). It should be emphasized that all the average values reported in these tables are computed from CCS level values; in other words, the displayed values are unweighted averages of CCS average values, and therefore are not to be confused with population statistics for Canada. The averages reported in these tables can be interpreted as the value of the "average community" of Canada.

Two points should be emphasized. First, the distribution of the dichotomous outcome is quite different for population and employment, regardless of the census period considered. The communities experiencing population decline over the long term period and between each census period are approximately half of all the communities in the sample (i.e. approximately 1,100 out of the 2,382 CCS). In contrast, the communities experiencing an employment decline tend to be a smaller number: 569 during the long period and between 400 and 900 for the two inter-census periods. The indication that emerges from these data is that growing participation rates must have compensated for these differences between population and employment decline.

Second, in most cases the descriptive tabulations anticipate the results of the multivariate analysis. It appears immediately evident that communities recording a population and employment decline over the 1981-2001 period had a higher share of labour force employed in primary sectors. For instance, in 1981, communities that were going to experience a population decline in the following two decades had, on average, almost 21% of their labour force in agricultural and over 7% employed in other primary sectors. In contrast, the communities that were going to experience a population growth had, on average, about 11% and 3% of their labour force employed in these two sectors respectively. On average, the growing communities had also a more diversified economy, more human capital, lower unemployment rates and higher participation rates than the average community that was going to experience a decline. A similar pattern is observed for the descriptive statistics by employment change status (Table 5, Table 6, and Table 7).

5.2 Long-term model results: 1981-2001 estimates

The results of the probit estimates for the period 1981-2001 are presented in Table 8 and Table 10, for the population and employment models respectively. Table 9 and Table 11 show the percentage of correct predictions generated by the two models. As discussed in Section 4.2, the coefficients of the probit models are difficult to interpret and have limited substantive meaning. Hence, we focus our discussion on the probability changes due to discrete changes of the explanatory variables, reported in Table 20 and Table 21, for the population and employment model respectively.

Three sets of results should be emphasized from the outset. First, the models generally show good measures of fit and, to a large extent, they predict correctly the observed outcomes. Second, in most cases the estimated coefficients have the anticipated sign and many of these coefficients are statistically significant; thus, the hypothesis that we formulated about the effects of stressors and assets are to a large extent supported by the results. Third, the results of the population and employment models are similar, although the population model fits the data better than the employment model. Also for this reason, we present the results for the two models separately, and give more emphasis to the population model results in the discussion.

5.2.1 Population model results

Overall, the measures of fit of the model, as well as the share of corrected predictions are good. As displayed in Table 8, the pseudo-R^2 values of the long-term model ranges from 0.40 (McFadden's R^2) to 0.68 (McKelvey and Zavoina's R^2). Using equation (6), we compared the population outcome predicted by the model with that actually observed in reality; the results, reported in Table 9, shows that the model prediction is correct for about 80% of the communities, which can be considered a good result for this type of model.

Employment by industry variables, which we used as a proxy for exposure to global restructuring (stressor), show the expected sign in most cases, although they are not always statistically significant (Table 8). Moreover, regional effects are usually reinforcing (i.e. working in the same direction as) community effects. As expected, the results show that a high percentage of *community* employment in agriculture and other primary sectors, in 1981, increased the probability of experiencing population decline over the following two decades.

Holding other variables constant at their sample means, a community that had about 24% of employment in agriculture experienced a probability of population decline 0.14 greater than a community with about 7% of employment in agriculture (Table 20).[9]

Compared to the *average community of Canada,*[10] that is, a community with about 5% employment in other primary sectors which experienced a probability of decline of 0.45, a community with only 1% employment in other primary sectors (about ½ standard deviation below the variable's average) had a probability of decline of 0.39. Table 20 shows also that a community with the highest value of employment share in other primary sectors had close to 100% probability of experiencing a population decline (Pr=0.99). However, the regional coefficient of this indicator is not statistically significant. The employment in traditional manufacturing has similar effects, although the magnitude of probability change due to discrete changes of the indicator appears more modest. For instance, compared to the average community of Canada (10% of traditional manufacturing employment in 1981), a community with about 15% of employment in traditional manufacturing (about ½ a standard deviation above the variable's average), had a probability of decline of 0.47.

The employment share in distributive and producer services has no significant effect on probability of decline, which suggests that the size of this sector is to a large extent proportional to the population base (Table 8). Similarly and contrary to expectation, the coefficients for employment in producer service sectors do not reach acceptable statistical significance levels, although the sign of these coefficients is positive, as we anticipated.

Community economic specialization, as measured by employment concentration in a small number of industries, is a statistically significant stressor for Canadian communities, but the coefficient for regional specialization is not statistically significant (and shows a negative sign, contrary to expectation). Thus, it appears that a high level of regional specialization does not represent a source of community stress, although a note of caution should be placed here: regional specialization and regional percentage of employment in agriculture tend to be highly correlated; hence the model might not be fully capable of disentangling the two effects. In any case, the effect of community specialization on probability of decline is limited. For the average community, a one standard deviation increase in the index of specialization centered around its mean would shift the probability of decline from 0.42 to 0.48 (Table 20).

Overall, it appears that weak local and regional labour market conditions are important stressors for a community, as we anticipated. Yet, a finding that contradicts our expectations is the sign of the income-related coefficient, which is positive instead of negative as we conjectured (Table 8). This result suggests that once the level of labour force engagement is controlled for, a higher income would increase the net outward mobility of the population and, therefore, increase the probability of population decline. In contrast, a low income level would reduce mobility and help

9. This difference in percentage of agriculture employment corresponds to a one standard deviation difference (17.30%, see Table 2), centred around the sample average of this same indicator (15.45%, see Table 2); that is, moving from a ½ standard deviation below the average community employment in agriculture (about 7%) to a ½ standard deviation above the average community employment in agriculture (about 24%).

10. In the rest of the paper we will use the term "average community of Canada" to indicate the predicted probability outcome for a community that presents average values for all the indicators used in the model (see Table 2 and Table 5). For the population model the predicted probability of decline for the average community of Canada was 0.45; for the employment model the probability of decline for the average community of Canada was 0.17.

to “retain” population. As shown in Table 20, changes in community participation rates have a large effect on the probability of population decline: a one standard deviation increase of this indicator is associated with a reduced probability of population decline of 0.11; while for the regional indicator an analogous change reduces the probability of decline by 0.13 (Table 20). Unemployment rates have a more complex effect: a high level of regional unemployment is associated with high probability of population decline, and the impact of this variable is quite substantial. However an excess supply of labour at the community level is not associated with higher probability of population decline; quite the contrary, there is a small but negative and significant effect of community unemployment rate on probability of decline (i.e. community high unemployment is associated with communities with low probability of population decline). A possible explanation for this result is that the community unemployment indicator in fact captures a residual effect of urbanization.

Human capital appears to be an important asset for the employment dynamics of a community, although the regional human capital coefficient is not statistically significant. Overall, these results confirm the expectation that human capital is an important asset for a community. Compared to the average Canadian community, that in 1981 had about 32% of the working age population with post-secondary degree (and probability of decline of 0.45), a community with only about 6% more educated individuals was facing a probability of decline of 0.43 (Table 20). Other conditions being the same, the differential in probability of decline between the least human-capital endowed and less human-capital endowed community is over 0.3 (Table 20).

Location factors are also crucial determinants of population change outcomes. Communities that are located in regions with high population density are more likely to see further population and employment growth; however, *local* population density is associated with a higher probability of population decline. Two forces seem to be at work in this case: agglomeration in high density regions as well as de-congestion from urban cores to the surrounding communities. Similarly, communities that are located in close proximity to large urban centres (above 500,000 inhabitants) are less likely to experience a population decline, but the effect of smaller urban centres is not statistically significant. Communities located in the regions with lowest values of population density had a probability of population decline of 0.53 (average community is 0.45) as opposed to a similar community located in the most densely populated region which was facing virtually zero probability of decline. Compared to the average community (located about 260 km from a major urban centre) a community located an additional 125 km further away from a large agglomeration has a probability of decline of 0.49.

Demographic indicators have, in general, less relevance in explaining the population outcome of the community. Only senior mobility had a statistically significant effect. A high percentage of in-coming senior residents is associated with a lower probability of population decline. Finally, the percentage of Aboriginal population is also associated with lower probability of population decline; it should be recalled that this variable is for the Aboriginal population residing outside the Territories and outside smaller settlements that were excluded from the analysis due to confidentiality and data quality concerns.

5.2.2 Employment model results

Overall, the results of the long-term employment model reflect those described for the population model, although the former does not fit the data as well as the latter. As shown in Table 10, the pseudo-R^2 values for the employment model ranges from 0.28 (McFadden's R^2) to 0.45 (McKelvey and Zavoina's R^2). Similarly, the percentage of communities whose predicted probability of employment decline between 1981 and 2001 correspond to the observed outcome is also lower than that computed for the population model (Table 11). Since the results concerning the effect of stressors and assets are similar to those discussed for the long-term population model, we present a more concise description with a specific emphasis on the differences between the two models.

Employment-related variables generate virtually identical results in terms of coefficient sign, but in this model traditional manufacturing and producer services indicators are not statistically significant, while distributive services are. Local economic specialization is also in this case a community stressor, while human capital has still a strong and statistically significant effect on the probability of decline. Holding other conditions at the sample average, the difference in probability of employment decline for communities with highest educational attainments in 1981 and those with lowest educational attainment is almost 30 percentage points (Table 21).

High distance to a large urban area is associated with a high probability of employment decline, but a surprising result is the positive sign of the regional employment density coefficient. Although the impact of this indicator on the probability outcome is small its sign indicates that, once other factors are controlled, higher regional employment density is associated with a higher probability of employment decline. The participation rate dynamics might help to explain this result. Although at this stage this explanation is conjectural and would need some further analysis to be substantiated, it seems plausible that communities have experienced a process of convergence in their participation rate levels across the two decades. Hence, communities with very low participation rates were relatively less likely to lose employment (although they might have lost population). Moreover, this community effect is countered by the regional effect of the labour force participation rate, which appear substantially larger than the community effect and has the expected sign. Finally, the effect of the unemployment rate is not statistically significant.

When considering the demographic variables, the employment model results are less straightforward. The presence of a high share of a junior population and in-coming senior residents are both associated with lower probability of experiencing an employment decline.

5.3 Assessment of stressor and assets effect: a graphical analysis

The non-linear relationship between stressors/assets and probability of decline can be further explored by using graphical analysis; this analysis generates a better understanding of the interactions between stressors and assets in determining socio-economic outcomes. For this purpose, we select some examples generated using the population model, which show some of the strong and significant relationships between community/regional indicators and predicted outcomes. These examples are presented in Figure 4 to Figure 9. It should be emphasized that the graphical analysis focuses on the base model results and is generated using equation (6).

Figure 4 displays the relationship between community employment in agriculture in 1981, and the probability of population decline between 1981 and 2001. The three probability lines that appear in this figure are drawn for alternative values of regional employment in the agricultural sector (see Section 4.1.1). In this and the following figures, the probabilities are evaluated at the sample mean of the other explanatory variables (see Section 4.3). Communities that had a high percentage of the labour force employed in agriculture also had a very high probability of population decline. However, the likelihood of population decline changes substantially depending on the regional context. For communities with an equivalent percentage of agricultural employment, the probability of decline is substantially lower (higher) if they are located in a region with a lower (higher) percentage of employment in agriculture. For instance, a community with 30% of agricultural employment, located in an agricultural region with 25% of agricultural employment, has a probability of population decline well over 0.7 (much above a probability of decline of about 0.3, for a similar community located in a region with only 5% of agricultural employment). Hence, this figure demonstrates that the regional context, not only the community characteristics, matters. An agricultural community in an agricultural region is significantly more likely to experience a population decline than an agricultural community in a region with a diversified economy.

The effect of other sector-related stressors on the probability of decline is displayed in Figure 5, for other primary sectors employment, and Figure 6, for traditional sector employment. In both cases, the upward sloping curves indicate that communities with a higher percentage of employment in these sectors, in 1981, were more likely to experience population decline between 1981 and 2001. The regional coefficient of other primary employment, however, is not significant and the negligibility of this regional effect is shown by the graph. The two curves plotted for alternative values of regional employment in other primary sectors are almost overlapping. This result is likely to reflect the regional distribution of other primary sector employment (mining, fishing, and forestry employment), which is concentrated in small towns rather than dispersed across regional spaces. Holding other variables at their sample means, communities with over 30% of their labour force in other primary sectors had a very high probability of population decline (over 0.8). Employment adjustment over this threshold (30%) appears to have relatively modest effect on the (already very high) probability of decline, while employment adjustments below this threshold had a substantially larger impact on the probability of decline.

Figure 7 shows the relationship between participation rates in 1981 and the probability of population decline between 1981 and 2001. As for the previous figure, the probability plots are computed holding all other variables at their sample means, except for alternative specifications of the regional participation rates. The three alternative values of regional participation rates are within the plausible range (for descriptive statistics see Table 2). Among the plots included in this paper, this figure is the one that more than any other resembles the "s" shaped curve that we anticipated for assets (see Section 3.3). Both community and regional participation rates had a large effect on the probability of population decline. Communities with low participation rates (below an indicative value of 40%) had an almost steady and high probability of population decline (over 0.9) if they were located in a region with a similarly low level of participation rate of 45% (it should be recalled that in 1981, the minimum value for community and regional participation rate was about 16% and 43%, respectively. See Table 2). At the opposite end, it is possible to identify an indicative threshold for participation rates above which a community experiences virtually no-risk of population decline: communities with a participation rate above 75% (highest value recorded in 1981 was 86%) and located in regions with a participation rate of 65% (maximum in 1981 was 69%) had a probability of decline of 0.1 or less.

The effect of community and regional human capital on the probability of population decline is presented in Figure 8. The downward sloping curves reflect the negative sign of the community coefficient. A community with low human capital endowment (about 30% of its population with a post-secondary degree) is likely to face a population decline (probability slightly above 0.5) if it is located in a human-capital poor region (regional share of post-secondary education of 20%). In contrast, the same community is significantly less likely to face a population decline (probability of about 0.4) if it is located in human-capital rich region (regional post-secondary education of 50%). Once again, it is evident that the regional context matters: communities that have a low asset endowment could access regional assets, if located in an asset-rich region.

Finally, Figure 9 and Figure 10 display two examples of interaction between stressors and assets. Figure 9 shows the probability of decline for the entire range of community employment in agriculture and selected values of community and regional endowments of human capital. The non-linear interaction between the two variables is evidenced by the shape of the probability plots. For example, a community that had about 30% of employment in agriculture in 1981 had a high probability of decline (close to 0.7) if the community and regional human capital were low (20%); but this probability is reduced to less than 0.4 for a similar community located in a human-capital rich community and region. However, as the percentage of agricultural employment increases above the threshold of 60%, the variation in the probability of decline due to different community and regional human-capital endowment also tends to diminish (as evidenced by a reduced distance between the probability curves).

Figure 10 shows the effect of the labour force participation rate given alternative urbanization characteristics of the community and the region. It appears evident that communities with urban attributes (high population density and proximity to major agglomerations) have a low probability of decline, regardless of the participation rate of the community. In contrast, communities with remote attributes (low population density and distance from major urban cores) have a high probability of decline even with an average level participation rate (57% was the community average participation rate in 1981).

In sum, the graphical results demonstrate the non-linearity between stressors/assets indicators and the probability of decline. Keeping in mind that the bivariate plots are generated maintaining all other variables at their sample means, in several cases it is possible to show lower and upper indicative thresholds below and above which further variation of a given indicator might have only minimal effect on changing the outcome probability. In a similar manner, it becomes evident that beyond certain thresholds, a variation in other community or regional conditions may have very little impact on probability outcomes. This suggests that some of these thresholds may in fact define binding conditions for the community, which can limit the potential effect of other factors.

5.4 Sub-period estimations and forecasting

The probit model results for population and employment decline and sub-periods 1981-1991 and 1991-2001 are presented in Table 12 to Table 19. Although the magnitude of the coefficients varies between the two decades, the signs and significance levels remain to a large extent unchanged. This suggests that the effect and significance of what we conceptualized as community stressors and assets remained substantially unaltered across the two decades.

The model statistics suggest that the 1991-2001 models have generally a better fit than the 1981-1991 models, both in the case of population and employment. For the population models, the pseudo-R^2 values range from 0.33 to 0.63 for the 1991-2001 model, and from 0.29 to 0.56 for the 1981-1991 model. As observed for the long-term and the sub-period estimates, the employment models generally have a lower fit than the population models: ranging from 0.25 to 0.47 in 1991-2001 to 0.21 to 0.37 in 1981-1991. For each of the sub-period models, we compared the predicted probability of decline with observed outcome at the end of the corresponding period. The results confirm that the sub-period estimates also have rather accurate predictive power (see Table 13, Table 15, Table 17 and Table 19).

For the population model estimates, the most remarkable stability, in terms of coefficient sign and statistical significance, is observed for some of the key employment indicators (agriculture and other primary sector in particular) and participation rates. Moreover, except for the community average income coefficient in the 1991-2001 model (with negative results in this estimate), none of the variables that present changing signs across the three estimates are statistically significant.

For the employment model estimates, the variable signs appear less stable than for the population model estimates, but also in this case, most of the switching signs are found on variables that do not have a statistically significant effect. Overall, the sub-period estimates confirm the trends observed in the long period estimate: employment in agriculture and primary sectors are plausible indicators of community distress, as well as community economic specialization. Human capital is an asset, as well as proximity to more urbanized areas, demographic indicators have a less clear and relevant role in defining the probability of employment decline.

In order to further assess the forecasting capacity of the models, we used results from the 1981-1991 estimates to compute the expected probability of population decline given the condition observed in 1991. In other words, we applied the computation methods described by equation (7) to the 1981 and 1991 census years. We compared these predicted probabilities with the observed outcome in 2001. The results of this exercise are reported in Table 22 and Table 23, for population and employment respectively. These results indicate that the models track rather closely the observed outcomes. Using the parameters from the 1981-1991 estimate and the community conditions in 1991, it shows that between 63% and 85% of the predicted outcomes coincide with the observed outcomes in 2001. The population model appears to perform better than the employment model. But generally, it appears that, using this sub-period, both models under-predicted the number of communities that experienced a decline. However, for both models, more than 80% of communities that were predicted to decline did in fact experience that trend between 1991 and 2001.

5.5 Results and distribution of the ICV indices

The results presented in the previous section refer primarily to the 1981-2001 estimates or to sub-period estimates; that is, the first step of our analysis. The remaining discussion is focused mainly on the results generated in the second step of our analysis: the computation of the indices of community vulnerability. Figure 11 and Figure 12 show the distribution of the two indices across the 2,382 communities included in this analysis. In both figures, all communities have been ranked by the value of the index, from lowest to highest. The blue line shows the distribution of the index of vulnerability. Using the same community ranking, the orange dots indicate the predicted probability of decline according to the 1981-2001 model. Hence, the vertical distance between each dot and the blue line shows the change between predicted probability (1981 conditions) and index of community vulnerability (2001 conditions).

Overall the number of communities that are expected to experience population or employment decline in the future is relatively limited. The computation of the ICVs, based on the 1981-2001 parameter estimates and the community conditions observed in 2001, indicate that there are 415 communities (CCS) that are vulnerable to population decline over the long-run ($Pr \geq 0.5$), and 107 communities (CCS) that are vulnerable to employment decline over the long run ($Pr \geq 0.5$). See the communities represented by the blue line above the 0.5 in Figure 11. If the predictive capacity of the long term model mimics that of the sub-period estimate, these two numbers are more likely to under-estimate rather than over-estimate future long-term outcomes. In other words, assuming stable relationships between stressors-assets and outcomes, most of these communities are expected to follow the predicted trends, while others that were not predicted to decline might also experience a declining trend.

The distribution of the two indices is likely to reflect the different population and employment dynamics that were observed between 1981 and 2001. Over this period of time, while population counts have declined, employment change has been much more stable, because the negative effects of demographic decline have been compensated, in many cases, by increasing participation rates. A relevant insight coming from this analysis is that the relationship between changes in demographic structure and participation rate should be further explored. However, a conjecture that can be formulated at this stage is that, if the community differentials in participation rates have converged over the past two decades, it is likely that future employment outcomes will parallel demographic outcomes more closely than in the past. In other words, since the process of "catching up" with participation in the labour market is exhausted, community demographic decline will be more similar to community employment decline than before. Also for this reason, the index of vulnerability to employment decline might under-estimate (rather than over-estimate) future changes.

In this regard, it is important to observe the relationship between observed population and employment outcomes between 1981 and 2001, which is reported in Table 24. At the community level, population growth was almost certainly accompanied by employment growth, but employment growth was also recorded in a slight majority of communities that experienced population decline. As shown in Table 24, only 2% of the communities that experienced population growth between 1981 and 2001 recorded employment decline over the same period. This is in net contrast with the result for communities with a population decline: slightly more than 50% of these communities recorded some employment growth. This finding calls for further analysis into the relationship between these two trends and their linkages.

In general, however, these results suggest also that most communities have moved toward a population size that is more sustainable given their structural and socio-economic conditions, which has in turn reduced the vulnerability to further population decline. This is demonstrated by the fact that in Figure 11 and Figure 12 most of the orange dots lie above the blue line; that is, the socio-economic conditions observed in 2001 have adjusted in a direction that reduces the probability of further decline. This adjustment came at a cost for many communities: a decline of the vulnerability index resulting from large regional depopulation (or, in the extreme, from total depopulation) is unlikely to be a desirable way to address these vulnerability issues or an acceptable outcome to many policy-makers or stakeholders. Nonetheless, what the model suggests is that for many communities this "demographic transition" has occurred over the past two decades and these areas may now face a relatively greater demographic stability in the future (or more precisely a lower probability of population decline). Nonetheless a sizable number of communities are still likely to experience population downsizing. Therefore, it remains important to gain an understanding of the geographic distribution of community vulnerability to population and employment decline. This is the last undertaking of this analysis and is presented in the following section.

5.6 Spatial distribution of the vulnerability indices

The final stage of the analysis involved the mapping of the vulnerability indices. For the sake of completeness and comparability we also include two maps showing the spatial distribution of the predicted probabilities generated by the 1981-2001 estimates and calculated using equation (6). Overall, the results of these mapping exercises do not come as a surprise: the broad spatial patterns are those that could be conjectured based on well known long-term trends (see Mwansa and Bollman 2005). However, the maps provide detailed information at a small geographic scale and show that even within typically declining regions, various communities are unlikely to experience demographic or employment decline in the future, or the other way around.

The communities that remain most vulnerable to population decline are those located in regions characterized by steady and constant population outflows over the past two decades, suggesting that several of these areas have not completed the demographic shift experienced over this period (Map 1 and Map 3). Specifically, these communities are concentrated in the Prairies, in northern Ontario and Quebec, and the most remote regions of Atlantic Canada. In each of these vulnerable regions, however, there are communities that do not face a high probability of decline (i.e., will likely stabilize their population or experience some growth). The only exception is Newfoundland and Labrador, where its remote location (distance from major agglomeration) and resource dependence are probably the key drivers of this result. In 2001, the socio-demographic conditions of Newfoundland and Labrador communities were still indicating that sizable demographic adjustments might occur in the future (assuming other conditions and trends will persist over the next few decades).

Fewer regions experience a high degree of vulnerability to employment decline than those predicted to experience population decline (Map 2 and Map 4). Once again, these results should be interpreted carefully, keeping in mind two points already discussed in the previous section. First, the adjustment in labour force participation that occurred in the past (i.e. growing participation rates in areas that had typically lower level of participation to the formal labour market) may no longer be observed in the future. Hence declining population should accompany declining employment in a closer way than in the previous decades. Second, as noted in the sub-period estimation and prediction results, the model is more likely to under-estimate than to over-estimate the number of communities that experience a decline. The communities that are predicted to decline will likely experience this trend, but some of those that were not predicted to do so will in fact experience some employment decline (see in particular Table 23).

The communities with a high probability of employment decline are located primarily in peripheral regions or in the Prairies: in particular they are located in Saskatchewan, Newfoundland and Labrador, and in Eastern Quebec and New Brunswick. The bulk of the other communities appear to have a greater likelihood of stabilizing their employment in the long term or to experience employment growth. As might be expected, the lowest values of the index form a virtually continuous area surrounding all the main urban agglomerations of the country.

6 Conclusions

In this paper we develop a conceptual and an operational framework for the analysis of community socio-economic vulnerability, which we apply to the analysis of population and employment changes. We define vulnerability as the likelihood of adverse socio-economic outcomes at the community level. The conceptual and operational framework that we develop for this analysis uses three major elements of a specific community process of change: stressors, assets and outcomes.

Using this framework we develop two Indices of Community Vulnerability (ICV): one for population and the other for employment decline. In the paper we provide details about the econometric and computational methods: we conduct sub-period estimates and test the predictive power of the model. We assess the econometric model (probit) by looking at the magnitude of predicted probability changes due to discrete variations in the stressor/asset indicators, as well as by using graphical and mapping analysis. The results of our model show that exposure to global restructuring trends, as measured by incidence of employment in traditional sectors, increases community vulnerability to population decline. Similarly, other conditions of community distress, such as high unemployment rates and low participation rates, increase the vulnerability of population decline. Community assets, such as human capital, economic diversification, and proximity to agglomerations, reduce vulnerability to population decline.

Overall, the results suggest that the population model performs better than the employment model; consequently, it appears fair to say that the index of vulnerability to population decline is likely to be stronger than the index of vulnerability to employment decline. Nonetheless, it should be emphasized that both models are more likely to under-estimate community vulnerability than over-estimate it; thus communities that are indicated as vulnerable are indeed likely to experience a decline (holding constant current conditions and trends), while some communities that are not predicted to be vulnerable may still face decline in the future.

It is the authors' hope and expectation that this framework will be further refined and extended to the analysis of other processes of community change, or to assess community vulnerability to specific sources of risk. This analysis is a first step toward a more articulated conceptualization of community vulnerability. At this stage, we acknowledge that the dynamic of changes were addressed only in a preliminary manner. The dynamic nature of community changes makes it difficult to separate 'outcomes' from the stressors or even factors of resiliency. Resiliency assets can become stressors, especially where they are on the decline. Although a more dynamic framework may be compelling from a conceptual point of view, it is challenging at the operational level since it is dynamic and recursive. At this stage, there is still a degree of discrepancy between the conceptual framework and its operational specification. At the same time it might be risky to make strong assumptions, which are generalized for all types of communities and economic activities. A promising area of research could also be a better integration of vulnerability concepts with concepts and methodologies of asset-based approaches and sustainable livelihood analysis (Alwang et al. 2001). We also note that indicators of social capital and local governance processes are absent from the model – largely due to the dearth of information relating to them. Both are likely to serve as significant assets to communities, potentially changing the outcomes observed (Reimer 2006). In all these instances, it is the authors' belief that a deeper understanding of the processes and determinants of community vulnerability may help communities to manage risks and develop adaptation and resilience strategies.

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Table 1 Definition of the indicators

Name	Definition (census year 1981, 1991 and 2001)
Population decline	Dichotomous variable, takes value of 1 if total non-institutional population is declining between the two census years considered, 0 if population is growing; the variable is computed for the following census years: from 1981 to 2001 (base model), from 1981 to 1991, and from 1991 to 2001 (sub-period models).
Employment decline	Dichotomous variable, takes value of 1 if total experienced labour force is declining between the two census years considered, 0 if total experienced labour force is growing; the variable is computed for the following census years: from 1981 to 2001 (base model), from 1981 to 1991, and from 1991 to 2001 (sub-period models).
Agriculture – C	Percentage of experienced labour force in agriculture. "C" denotes a "community" indicator.
Agriculture – R	Spatial lag of percentage of experienced labour force in agriculture. "R" denotes a regional indicator (spatially lagged variable).
Other primary – C	Percentage of experienced labour force in other primary sectors.
Other primary – R	Spatial lag of percentage of experienced labour force in other primary sectors.
Traditional manufacturing – C	Percentage of experienced labour force in traditional manufacturing sectors.
Traditional manufacturing – R	Spatial lag of percentage of experienced labour force in traditional manufacturing sectors.
Distributive services – C	Percentage of experienced labour force in distributive services.
Distributive services – R	Spatial lag of percentage of experienced labour force in distributive services.
Producer services – C	Percentage of experienced labour force in producer services.
Producer services – R	Spatial lag of percentage of experienced labour force in producer services.
Specialization – C	Herfindahl Index; this index is the sum of the squared employment shares in each major industry in a given community. Nine major industries are used in the computation, which include: agriculture, other primary sectors, traditional manufacturing, complex manufacturing, construction, distributive, business, consumer, and public services.
Specialization – R	Spatial lag of Herfindahl Index.
Human capital – C	Percentage of population 25-54 years of age with some post secondary education.
Human capital – R	Spatial lag of percentage of population 25-54 years of age with some post secondary education.
Unemployment – C	Unemployment rate for individuals age 25 to 54.
Unemployment – R	Spatial lag of unemployment for individuals age 25 to 54.
Participation rate – C	Computed as total experienced labour force 15 years and over divided by total population 15 years and over.
Participation rate – R	Spatial lag of Participation rate.
Average income – C	Average total income for population 15 years and over in constant 1980 dollars.
Average income – R	Spatial lag of Average total income for population 15 years and over in constant 1980 dollars.
Population density – C	Total non-institutional population of a census consolidated subdivision (CCS) divided by the total area of the CCS. This variable is used in the population models.
Population density – R	Spatial lag of population density. This variable is used in the population models
Employment density – C	Total experienced labour force 15 years and over divided by total area of the CCS. This variable is used in the employment model.
Employment density – R	Spatial lag of Employment density. This variable is used in the employment model.
Distance to large CMA	Distance between CCS centroid and centroid of the closest or census metropolitan area (CMA) of more than 500,000 people.
Distance to small CMA/CA	Distance between CCS centroid and centroid of the closest or census agglomeration (CA)/CMA of less than 500,000 people.
Junior population	Percentage of total population that is below 15 years of age.
Senior population	Percentage of total population that is between 55 and 74 years of age.
Junior mobility	Percentage of population 20-24 who lived in a different census subdivision (CSD) 5 years before the corresponding census year; computed as percent of the corresponding age cohort.
Senior mobility	Percentage of population 55-74 who lived in a different CSD 5 years before the corresponding census year; computed as percent of the corresponding age cohort.
Aboriginal	Percentage of total population that is reporting Aboriginal ethnicity.

Note: "C" denotes a "community" indicator. "R" denotes a "regional" indicator (spatially lagged variable). Except for the two variables measuring distance to urban areas, each variable is computed for the three census yeas considered in this analysis: 1981, 1991, and 2001.

Table 2 Descriptive statistics by population growing/declining status, 1981

Indicator	CCSs with growing population (y=0)		CCSs with declining population (y=1)		All CCSs in the sample			
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Minimum	Maximum
Population decline 1981-2001 (share)	…	…	…	…	0.48	0.50	0.00	1.00
Agriculture – C (%)	10.66	11.32	20.65	20.81	15.45	17.30	0.00	86.36
Agriculture – R (%)	12.66	8.58	19.94	16.08	16.15	13.25	0.06	60.07
Other Primary – C (%)	2.88	5.16	7.37	10.29	5.04	8.35	0.00	71.61
Other primary – R (%)	3.21	3.47	5.77	4.90	4.44	4.41	0.30	34.67
Traditional manufacturing – C (%)	10.18	8.40	10.95	11.72	10.55	10.14	0.00	72.62
Traditional manufacturing – R (%)	10.45	4.86	10.30	7.23	10.38	6.11	0.27	33.94
Distributive services – C (%)	21.20	6.39	18.18	7.05	19.75	6.88	0.00	62.80
Distributive services – R (%)	20.72	2.53	18.87	2.55	19.83	2.70	11.88	32.35
Producer services – C (%)	5.90	3.75	3.79	3.39	4.89	3.73	0.00	41.69
Producer services – R (%)	5.64	1.70	4.25	1.16	4.97	1.62	0.66	14.02
Specialization – C (index)	0.17	0.04	0.22	0.09	0.20	0.08	0.10	0.75
Specialization – R (index)	0.18	0.03	0.21	0.06	0.20	0.05	0.14	0.45
Human capital – C (%)	35.39	10.94	28.60	10.73	32.13	11.36	0.00	74.47
Human capital – R (%)	34.50	6.37	30.45	6.18	32.55	6.59	16.01	59.69
Unemployment – C (%)	7.47	6.13	9.90	9.30	8.64	7.91	0.00	66.67
Unemployment – R (%)	7.36	3.61	9.44	6.34	8.36	5.21	0.98	30.45
Participation rate – C (%)	59.07	8.25	54.55	8.07	56.90	8.47	15.49	86.34
Participation rate – R (%)	58.75	4.56	55.55	4.83	57.21	4.96	42.76	69.49
Average income – C (1980$)	9172.05	2021.20	8127.92	2017.08	8670.59	2085.13	3444.00	17543.00
Average income – R (1980$)	9093.78	1310.13	8292.87	1319.01	8709.12	1373.72	5951.06	14010.63
Population density – C (people/km^2)	99.13	404.89	16.61	53.81	59.50	297.08	0.01	6095.99
Population density – R (people/km^2)	109.71	215.06	28.09	25.82	70.51	161.28	0.06	2947.78
Distance to larger urban centre (km)	181.48	186.63	353.12	279.32	263.91	250.81	4.47	1335.98
Distance to smaller urban centre (km)	44.55	51.87	63.44	45.73	53.62	49.91	0.00	860.02
Junior population (%)	24.73	4.62	25.46	4.54	25.08	4.60	6.25	47.50
Senior population (%)	15.73	5.63	16.43	5.19	16.06	5.43	2.18	44.25
Junior mobility (%)	31.36	14.36	25.72	15.64	28.65	15.25	0.00	100.00
Senior mobility (%)	14.51	9.21	7.67	6.61	11.23	8.76	0.00	60.00
Aboriginal (%)	2.93	10.80	1.82	6.33	2.40	8.95	0.00	97.50
Number of observations (CCS)	1,238	…	1,144	…	2,382	…	…	…

Note: Averages are computed as un-weighted averages of CCS level values; hence they are not to be interpreted as population averages. The growth/declining status is based on changes between 1981 and 2001. See Table 1 for the definition of indicators.
Source: Authors' computation based on Census of Population 1981 and 2001 data.

Table 3 Descriptive statistics by population growing/declining status, 1991

Indicator	CCSs with growing population (y=0)		CCSs with declining population (y=1)		All CCSs in the sample			
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Minimum	Maximum
Population decline 1981-1991 (share)	…	…	…	…	0.46	0.50	0.00	1.00
Agriculture – C (%)	8.79	10.44	20.13	19.92	13.97	16.51	0.00	80.77
Agriculture – R (%)	10.77	8.46	19.16	15.49	14.61	12.89	0.03	55.62
Other Primary – C (%)	2.92	5.45	5.21	7.48	3.97	6.56	0.00	60.25
Other primary – R (%)	2.90	3.31	4.24	3.82	3.51	3.61	0.31	19.49
Traditional manufacturing – C (%)	8.04	7.38	8.29	9.31	8.16	8.32	0.00	57.23
Traditional manufacturing – R (%)	8.05	4.17	8.06	5.89	8.05	5.03	0.35	32.65
Distributive services – C (%)	21.72	5.68	18.45	6.93	20.23	6.49	0.00	48.38
Distributive services – R (%)	21.34	2.38	19.13	2.82	20.33	2.81	11.92	30.29
Producer services – C (%)	7.32	3.84	5.18	3.96	6.34	4.04	0.00	42.39
Producer services– R (%)	7.08	1.98	5.61	1.42	6.41	1.89	2.02	17.26
Specialization – C (index)	0.17	0.04	0.21	0.09	0.19	0.07	0.10	0.66
Specialization – R (index)	0.18	0.03	0.21	0.06	0.19	0.05	0.14	0.39
Human capital – C (%)	40.78	12.45	34.03	12.53	37.69	12.93	0.00	82.61
Human capital – R (%)	39.79	7.97	35.95	7.65	38.04	8.06	17.04	67.43
Unemployment – C (%)	10.84	7.46	13.47	11.73	12.04	9.73	0.00	67.03
Unemployment – R (%)	10.97	5.50	12.25	8.07	11.55	6.82	2.56	48.05
Participation rate – C (%)	64.34	8.57	61.55	10.43	63.07	9.57	29.37	96.25
Participation rate – R (%)	63.78	5.56	62.24	6.66	71.34	21.46	43.46	77.87
Average income – C (1980$)	10607.15	2172.20	8929.91	1677.69	9840.35	2131.89	4277.93	18982.59
Average income – R (1980$)	10460.72	1423.49	9227.18	1008.98	9896.77	1393.74	6775.56	15698.50
Population density – C (people/km^2)	111.72	425.35	14.59	61.25	67.31	319.74	0.01	6462.53
Population density – R (people/km^2)	119.63	233.40	32.57	37.93	79.83	179.16	0.05	3174.09
Distance to larger urban centre (km)	208.38	232.48	329.85	255.86	263.91	250.81	4.47	1335.98
Distance to smaller urban centre (km)	45.28	50.06	63.52	47.91	53.62	49.91	0.00	860.02
Junior population (%)	23.35	4.13	22.84	4.05	23.11	4.10	4.05	41.63
Senior population (%)	16.42	5.48	18.43	5.58	17.34	5.62	0.00	88.18
Junior mobility (%)	18.54	11.83	12.23	12.13	15.65	12.37	0.00	100.00
Senior mobility (%)	15.39	9.63	8.23	7.13	12.11	9.29	0.00	66.67
Aboriginal (%)	4.45	9.97	3.89	9.90	4.20	9.94	0.00	100.00
Number of observations (CCS)	1,293	…	1,089	…	2,382	…	…	…

Note: Averages are computed as un-weighted averages of CCS level values; hence they are not to be interpreted as population averages. The growth/declining status is based on changes between 1981 and 1991. See Table 1 for the definition of indicators.
Source: Authors' computation based on Census of Population 1981 and 1991 data.

Table 4 Descriptive statistics by population growing/declining status, 2001

Indicator	CCSs with growing population (y=0)		CCSs with declining population (y=1)		All CCSs in the sample			
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Minimum	Maximum
Population decline 1991-2001 (share)	…	…	…	…	0.49	0.50	0.00	1.00
Agriculture – C (%)	7.99	9.50	16.10	17.61	11.96	14.64	0.00	91.18
Agriculture – R (%)	9.65	7.63	15.35	13.17	12.44	11.08	0.04	53.01
Other Primary – C (%)	2.55	4.18	5.77	7.69	4.13	6.36	0.00	61.70
Other primary – R (%)	2.67	2.68	4.79	4.16	3.71	3.64	0.30	22.73
Traditional manufacturing – C (%)	8.43	7.63	9.81	9.56	9.10	8.65	0.00	64.29
Traditional manufacturing – R (%)	8.67	4.87	9.37	5.99	9.01	5.46	0.63	28.95
Distributive services – C (%)	23.04	5.84	20.74	6.75	21.92	6.40	0.00	51.72
Distributive services – R (%)	22.75	2.60	21.24	2.84	22.01	2.82	12.28	32.87
Producer services – C (%)	9.06	4.39	7.06	4.23	8.08	4.42	0.00	35.90
Producer services – R (%)	9.00	2.26	7.36	1.56	8.20	2.12	2.54	21.70
Specialization – C (index)	0.18	0.04	0.21	0.07	0.20	0.06	0.12	0.84
Specialization – R (index)	0.19	0.02	0.20	0.04	0.19	0.03	0.16	0.39
Human capital – C (%)	55.83	11.73	49.05	11.72	52.51	12.20	7.41	90.20
Human capital – R (%)	55.13	6.39	50.77	5.38	53.00	6.31	33.28	79.41
Unemployment – C (%)	7.24	5.81	11.22	10.83	9.19	8.86	0.00	65.22
Unemployment – R (%)	7.15	3.83	10.40	7.89	8.74	6.37	1.36	44.85
Participation rate – C (%)	63.71	8.94	60.62	10.36	62.20	9.78	27.54	95.65
Participation rate – R (%)	63.67	4.85	61.66	6.93	62.68	6.04	38.61	76.23
Average income – C (1980$)	11348.41	2513.74	9525.27	1807.22	10455.22	2377.44	4732.42	23569.54
Average income – R (1980$)	11187.69	1536.38	9793.40	1159.70	10505.18	1532.51	7055.93	17407.29
Population density – C (people/km^2)	119.85	466.95	26.31	131.71	74.06	349.20	0.01	6869.02
Population density – R (people/km^2)	137.67	268.47	36.16	46.24	87.98	201.00	0.05	3437.11
Distance to larger urban centre (km)	182.18	184.57	349.15	280.70	263.91	250.81	4.47	1335.98
Distance to smaller urban centre (km)	45.63	52.69	61.96	45.37	53.62	49.91	0.00	860.02
Junior population (%)	20.47	4.40	18.59	3.73	19.55	4.19	1.79	42.42
Senior population (%)	18.73	5.91	20.21	4.65	19.45	5.38	4.55	49.14
Junior mobility (%)	25.59	18.34	22.67	21.85	24.16	20.19	0.00	100.00
Senior mobility (%)	12.71	7.68	7.91	6.80	10.36	7.65	0.00	56.41
Aboriginal (%)	6.35	13.66	4.53	8.27	5.46	11.38	0.00	98.64
Number of observations (CCS)	1,216	…	1,166	…	2,382	…	…	…

Note: Averages are computed as un-weighted averages of CCS level values; hence they are not to be interpreted as population averages. The growth/declining status is based on changes between 1991 and 2001. See Table 1 for the definition of indicators.
Source: Authors' computation based on Census of Population 1991 and 2001 data.

Table 5 Descriptive statistics by employment growing/declining status, 1981

Indicator	CCSs with growing population (y=0)		CCSs with declining population (y=1)		All CCSs in the sample			
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Minimum	Maximum
Employment decline 1981-2001 (share)	…	…	…	…	0.24	0.43	0	1
Agriculture – C (%)	13.07	14.00	23.05	23.52	15.45	17.30	0.00	86.36
Agriculture – R (%)	14.44	11.07	21.60	17.49	16.15	13.25	0.06	60.07
Other Primary – C (%)	4.26	7.23	7.52	10.83	5.04	8.35	0.00	71.61
Other primary – R (%)	3.98	4.00	5.91	5.24	4.44	4.41	0.30	34.67
Traditional manufacturing – C (%)	10.67	9.26	10.16	12.54	10.55	10.14	0.00	72.62
Traditional manufacturing – R (%)	10.70	5.55	9.35	7.54	10.38	6.11	0.27	33.94
Distributive services – C (%)	20.42	6.67	17.61	7.12	19.75	6.88	0.00	62.80
Distributive services – R (%)	20.13	2.68	18.88	2.55	19.83	2.70	11.88	32.35
Producer services – C (%)	5.27	3.72	3.67	3.52	4.89	3.73	0.00	41.69
Producer services – R (%)	5.23	1.66	4.17	1.19	4.97	1.62	0.66	14.02
Specialization – C (index)	0.18	0.06	0.24	0.11	0.20	0.08	0.10	0.75
Specialization – R (index)	0.19	0.04	0.22	0.06	0.20	0.05	0.14	0.45
Human capital – C (%)	33.13	11.18	28.94	11.34	32.13	11.36	0.00	74.47
Human capital – R (%)	33.15	6.49	30.66	6.58	32.55	6.59	16.01	59.69
Unemployment – C (%)	8.38	7.34	9.45	9.45	8.64	7.91	0.00	66.67
Unemployment – R (%)	8.10	4.54	9.18	6.86	8.36	5.21	0.98	30.45
Participation rate – C (%)	57.11	8.56	56.26	8.15	56.90	8.47	15.49	86.34
Participation rate – R (%)	57.75	4.82	55.48	4.98	57.21	4.96	42.76	69.49
Average income – C (1980$)	8771.13	2021.37	8350.24	2248.47	8670.59	2085.13	3444.00	17543.00
Average income – R (1980$)	8810.58	1341.48	8385.86	1425.53	8709.12	1373.72	5951.06	14010.63
Employment density – C (people/km^2)	34.43	176.12	14.40	98.92	29.65	161.28	0.00	3507.82
Employment density – R (people/km^2)	41.19	89.47	16.92	82.37	35.39	88.42	0.02	1677.26
Distance to larger urban centre (km)	223.73	220.88	391.94	294.09	263.91	250.81	4.47	1335.98
Distance to smaller urban centre (km)	48.48	49.43	70.02	47.88	53.62	49.91	0.00	860.02
Junior population (%)	25.15	4.54	24.87	4.78	25.08	4.60	6.25	47.50
Senior population (%)	15.83	5.39	16.82	5.49	16.06	5.43	2.18	44.25
Junior mobility (%)	29.34	14.67	26.46	16.80	28.65	15.25	0.00	100.00
Senior mobility (%)	12.40	8.95	7.49	6.91	11.23	8.76	0.00	60.00
Aboriginal (%)	2.54	9.47	1.96	7.02	2.40	8.95	0.00	97.50
Number of observations (CCS)	1,813	…	569	…	2,382	…	…	…

Note: Averages are computed as un-weighted averages of CCS level values; hence they are not to be interpreted as population averages. The growth/declining status is based on changes between 1981 and 2001. See Table 1 for the definition of indicators.
Source: Authors' computation based on Census of Population 1981 and 2001 data.

Table 6 Descriptive statistics by employment growing/declining status, 1991

Indicator	CCSs with growing population (y=0)		CCSs with declining population (y=1)		All CCSs in the sample			
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Minimum	Maximum
Employment decline 1981-1991 (share)	…	…	…	…	0.19	0.39	0	1
Agriculture – C (%)	12.54	15.05	19.98	20.53	13.97	16.51	0.00	80.77
Agriculture – R (%)	13.54	11.97	19.08	15.39	14.61	12.89	0.03	55.62
Other Primary – C (%)	3.57	5.94	5.61	8.47	3.97	6.56	0.00	60.25
Other primary – R (%)	3.36	3.56	4.15	3.77	3.51	3.61	0.31	19.49
Traditional manufacturing – C (%)	8.16	8.04	8.12	9.41	8.16	8.32	0.00	57.23
Traditional manufacturing – R (%)	8.07	4.87	7.99	5.66	8.05	5.03	0.35	32.65
Distributive services – C (%)	20.72	6.10	18.15	7.57	20.23	6.49	0.00	48.38
Distributive services – R (%)	20.64	2.74	19.04	2.72	20.33	2.81	11.92	30.29
Producer services – C (%)	6.66	3.81	5.00	4.67	6.34	4.04	0.00	42.39
Producer services – R (%)	6.56	1.92	5.79	1.66	6.41	1.89	2.02	17.26
Specialization – C (index)	0.18	0.06	0.21	0.09	0.19	0.07	0.10	0.66
Specialization – R (index)	0.19	0.04	0.20	0.06	0.19	0.05	0.14	0.39
Human capital – C (%)	39.01	12.49	32.17	13.29	37.69	12.93	0.00	82.61
Human capital – R (%)	38.75	7.87	35.06	8.17	38.04	8.06	17.04	67.43
Unemployment – C (%)	11.62	9.16	13.81	11.69	12.04	9.73	0.00	67.03
Unemployment – R (%)	11.43	6.70	12.06	7.32	11.55	6.82	2.56	48.05
Participation rate – C (%)	64.27	8.84	58.05	10.81	63.07	9.57	29.37	96.25
Participation rate – R (%)	73.29	21.37	63.18	19.86	71.34	21.46	43.46	77.87
Average income – C (1980$)	10073.01	2132.11	8865.63	1836.13	9840.35	2131.89	4277.93	18982.59
Average income – R (1980$)	10055.86	1421.30	9230.26	1034.24	9896.77	1393.74	6775.56	15698.50
Employment density – C (people/km^2)	39.72	179.84	19.00	162.78	35.72	176.84	0.00	3822.13
Employment density – R (people/km^2)	46.09	90.68	27.58	129.80	42.52	99.65	0.02	1836.43
Distance to larger urban centre (km)	255.94	258.11	297.34	214.65	263.91	250.81	4.47	1335.98
Distance to smaller urban centre (km)	50.98	49.40	64.70	50.57	53.62	49.91	0.00	860.02
Junior population (%)	23.17	3.95	22.88	4.67	23.11	4.10	4.05	41.63
Senior population (%)	16.80	5.22	19.63	6.58	17.34	5.62	0.00	88.18
Junior mobility (%)	16.28	11.94	13.04	13.76	15.65	12.37	0.00	100.00
Senior mobility (%)	12.92	9.40	8.73	7.95	12.11	9.29	0.00	66.67
Aboriginal (%)	4.12	9.61	4.51	11.25	4.20	9.94	0.00	100.00
Number of observations (CCS)	1,923	…	459	…	2,382	…	…	…

Note: Averages are computed as un-weighted averages of CCS level values; hence they are not to be interpreted as population averages. The growth/declining status is based on changes between 1981 and 1991. See Table 1 for the definition of indicators.
Source: Authors' computation based on Census of Population 1981 and 1991 data.

Table 7 Descriptive statistics by employment growing/declining status, 2001

Indicator	CCSs with growing population (y=0)		CCSs with declining population (y=1)		All CCSs in the sample			
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Minimum	Maximum
Employment decline 1991-2001 (share)	…	…	…	…	0.39	0.49	0	1
Agriculture – C (%)	8.87	9.91	16.71	18.86	11.96	14.64	0.00	91.18
Agriculture – R (%)	10.47	8.33	15.46	13.78	12.44	11.08	0.04	53.01
Other Primary – C (%)	3.19	4.99	5.57	7.80	4.13	6.36	0.00	61.70
Other primary – R (%)	3.04	3.00	4.73	4.25	3.71	3.64	0.30	22.73
Traditional manufacturing – C (%)	9.50	8.45	8.50	8.92	9.10	8.65	0.00	64.29
Traditional manufacturing – R (%)	9.43	5.35	8.36	5.55	9.01	5.46	0.63	28.95
Distributive services – C (%)	22.58	6.00	20.89	6.85	21.92	6.40	0.00	51.72
Distributive services – R (%)	22.37	2.72	21.44	2.88	22.01	2.82	12.28	32.87
Producer services – C (%)	8.63	4.35	7.24	4.41	8.08	4.42	0.00	35.90
Producer services– R (%)	8.65	2.22	7.50	1.73	8.20	2.12	2.54	21.70
Specialization – C (index)	0.18	0.04	0.21	0.08	0.20	0.06	0.12	0.84
Specialization – R (index)	0.19	0.02	0.21	0.04	0.19	0.03	0.16	0.39
Human capital – C (%)	54.21	12.23	49.90	11.69	52.51	12.20	7.41	90.20
Human capital – R (%)	53.96	6.51	51.52	5.67	53.00	6.31	33.28	79.41
Unemployment – C (%)	7.75	6.64	11.40	11.12	9.19	8.86	0.00	65.22
Unemployment – R (%)	7.72	4.57	10.30	8.19	8.74	6.37	1.36	44.85
Participation rate – C (%)	64.24	8.34	59.06	10.94	62.20	9.78	27.54	95.65
Participation rate – R (%)	63.32	5.20	61.71	7.05	62.68	6.04	38.61	76.23
Average income – C (1980$)	11021.56	2489.10	9586.12	1890.82	10455.22	2377.44	4732.42	23569.54
Average income – R (1980$)	10876.92	1575.51	9933.91	1267.39	10505.18	1532.51	7055.93	17407.29
Employment density – C (people/km^2)	50.29	218.44	21.88	124.89	39.09	187.71	0.00	4049.67
Employment density – R (people/km^2)	62.19	128.72	22.57	57.84	46.57	108.29	0.02	1943.57
Distance to larger urban centre (km)	197.20	189.20	366.44	295.43	263.91	250.81	4.47	1335.98
Distance to smaller urban centre (km)	46.59	49.89	64.42	48.00	53.62	49.91	0.00	860.02
Junior population (%)	19.96	4.27	18.92	3.98	19.55	4.19	1.79	42.42
Senior population (%)	18.56	5.40	20.83	5.05	19.45	5.38	4.55	49.14
Junior mobility (%)	23.86	17.56	24.62	23.67	24.16	20.19	0.00	100.00
Senior mobility (%)	11.51	7.57	8.60	7.43	10.36	7.65	0.00	56.41
Aboriginal (%)	5.66	12.48	5.16	9.44	5.46	11.38	0.00	98.64
Number of observations (CCS)	1,443	…	939	…	2,382	…	…	…

Note: Averages are computed as un-weighted averages of CCS level values; hence they are not to be interpreted as population averages. The growth/declining status is based on changes between 1991 and 2001. See Table 1 for the definition of indicators.
Source: Authors' computation based on Census of Population 1991 and 2001 data.

Table 8 Probit model results: population model, 1981-2001 (base model)

Indicator	Coefficient	Robust standard error	Z	Probability >|z|	Marginal effect	Robust standard error
Constant	2.3202	1.2939	1.79	0.07	…	…
Agriculture – C	0.0207	0.0050	4.14	0.00	0.0082	0.0020
Agriculture – R	0.0558	0.0126	4.44	0.00	0.0221	0.0050
Other primary – C	0.0372	0.0066	5.65	0.00	0.0147	0.0026
Other primary – R	0.0271	0.0172	1.57	0.12	0.0107	0.0068
Traditional manufacturing – C	0.0092	0.0052	1.76	0.08	0.0037	0.0021
Traditional manufacturing – R	0.0274	0.0136	2.02	0.04	0.0109	0.0054
Distributive services – C	0.0041	0.0062	0.66	0.51	0.0016	0.0025
Distributive services – R	0.0293	0.0218	1.34	0.18	0.0116	0.0086
Producer services – C	-0.0116	0.0118	-0.99	0.32	-0.0046	0.0047
Producer services – R	-0.0333	0.0367	-0.91	0.36	-0.0132	0.0145
Specialization – C	2.0720	0.9350	2.22	0.03	0.8205	0.3715
Specialization – R	-2.2982	2.2864	-1.01	0.32	-0.9100	0.9050
Human capital – C	-0.0114	0.0052	-2.20	0.03	-0.0045	0.0021
Human capital – R	-0.0098	0.0126	-0.77	0.44	-0.0039	0.0050
Unemployment – C	-0.0121	0.0066	-1.85	0.07	-0.0048	0.0026
Unemployment – R	0.0447	0.0180	2.49	0.01	0.0177	0.0071
Participation rate – C	-0.0343	0.0074	-4.64	0.00	-0.0136	0.0029
Participation rate – R	-0.0663	0.0194	-3.41	0.00	-0.0262	0.0077
Average income – C	0.0001	0.0000	2.63	0.01	0.0000	0.0000
Average income – R	0.0002	0.0001	2.12	0.03	0.0001	0.0000
Population density – C	0.0002	0.0002	0.80	0.43	0.0001	0.0001
Population density – R	-0.0030	0.0013	-2.27	0.02	-0.0012	0.0005
Distance to large CMA	0.0008	0.0003	3.07	0.00	0.0003	0.0001
Distance to small CMA/CA	0.0006	0.0009	0.66	0.51	0.0002	0.0003
Junior population	-0.0121	0.0121	-1.00	0.32	-0.0048	0.0048
Senior population	-0.0034	0.0107	-0.31	0.75	-0.0013	0.0042
Junior mobility	-0.0023	0.0026	-0.87	0.38	-0.0009	0.0010
Senior mobility	-0.0349	0.0047	-7.39	0.00	-0.0138	0.0019
Aboriginal	-0.0159	0.0071	-2.25	0.03	-0.0063	0.0028
Measures of fit						
Log-likelihood full model	-985.734					
Log-likelihood intercept	-1649.221					
McFadden's R^2	0.402					
Maximum Likelihood R^2	0.427					
McKelvey and Zavoina's R^2	0.679					
Number of observations	2,382					

Note: See Table 1 for a description of the indicators and unit of measures.
Source: Authors' estimation based on Census of Population 1981 and 2001 data.

Table 9 Probit model results: correct predictions, population , 1981-2001

Observed	Predicted growing (Probability<0.5)	Predicted declining (Probability>0.5)	Total
	Number of CCSs (percentage of column total)		
Growing	1,001 (81%)	237 (21%)	1,238 (52%)
Declining	235 (19%)	909 (79%)	1,144 (48%)
Total	1,236 (100%)	1,146 (100%)	2,382 (100%)

Source: Authors' computation based on Census of Population 1981 and 2001 data.

Table 10 Probit model results: employment model, 1981-2001 (base model)

Indicator	Coefficient	Robust standard error	Z	Probability >|z|	Marginal effect	Robust standard error
Constant	3.2488	1.2889	2.52	0.01	…	…
Agriculture – C	0.0086	0.0049	1.75	0.08	0.0022	0.0012
Agriculture – R	0.0300	0.0128	2.34	0.02	0.0076	0.0033
Other primary – C	0.0225	0.0058	3.91	0.00	0.0057	0.0015
Other primary – R	0.0219	0.0164	1.33	0.18	0.0056	0.0042
Traditional manufacturing – C	0.0059	0.0052	1.13	0.26	0.0015	0.0013
Traditional manufacturing – R	0.0021	0.0145	0.14	0.89	0.0005	0.0037
Distributive services – C	-0.0019	0.0065	-0.30	0.77	-0.0005	0.0017
Distributive services – R	0.0399	0.0230	1.73	0.08	0.0101	0.0058
Producer services – C	-0.0048	0.0130	-0.37	0.72	-0.0012	0.0033
Producer services – R	-0.0534	0.0396	-1.35	0.18	-0.0135	0.0100
Specialization – C	2.0253	0.6884	2.94	0.00	0.5135	0.1769
Specialization – R	0.0685	2.2278	0.03	0.98	0.0174	0.5649
Human capital – C	-0.0162	0.0051	-3.20	0.00	-0.0041	0.0013
Human capital – R	-0.0292	0.0140	-2.09	0.04	-0.0074	0.0035
Unemployment – C	0.0023	0.0060	0.38	0.71	0.0006	0.0015
Unemployment – R	-0.0054	0.0167	-0.33	0.75	-0.0014	0.0042
Participation rate – C	0.0492	0.0075	6.56	0.00	0.0125	0.0019
Participation rate – R	-0.1327	0.0201	-6.59	0.00	-0.0336	0.0051
Average income – C	0.0000	0.0000	0.77	0.44	0.0000	0.0000
Average income – R	0.0002	0.0001	2.52	0.01	0.0000	0.0000
Employment density – C	0.0000	0.0003	0.11	0.91	0.0000	0.0001
Employment density – R	0.0013	0.0007	2.02	0.04	0.0003	0.0002
Distance to large CMA	0.0012	0.0003	4.48	0.00	0.0003	0.0001
Distance to small CMA/CA	0.0005	0.0009	0.58	0.56	0.0001	0.0002
Junior population	-0.0711	0.0116	-6.11	0.00	-0.0180	0.0029
Senior population	0.0074	0.0101	0.73	0.47	0.0019	0.0026
Junior mobility	-0.0020	0.0027	-0.76	0.45	-0.0005	0.0007
Senior mobility	-0.0173	0.0050	-3.46	0.00	-0.0044	0.0013
Aboriginal	0.0106	0.0071	1.49	0.14	0.0027	0.0018
Measures of fit						
Log-likelihood full model	-940.743					
Log-likelihood intercept	-1309.575					
McFadden's R^2	0.282					
Maximum Likelihood R^2	0.266					
McKelvey and Zavoina's R^2	0.458					
Number of observations	2,382					

Note: See Table 1 for a description of the indicators and unit of measures.
Source: Authors' estimation based on Census of Population 1981 and 2001 data.

Table 11 Probit model results: correct predictions, employment, 1981-2001

Observed	Predicted growing (Probability<0.5)	Predicted declining (Probability>0.5)	Total
	Number of CCSs (percentage of column total)		
Growing	1,699 (84%)	114 (31%)	1,813 (76%)
Declining	315 (16%)	254 (69%)	569 (24%)
Total	2,014 (100%)	368 (100%)	2,382 (100%)

Source: Authors' computation based on Census of Population 1981 and 2001 data.

Table 12 Probit model results: population model, 1981-1991

Indicator	Coefficient	Robust standard error	Z	Probability >|z|	Marginal effect	Robust standard error
Constant	2.8288	1.1948	2.37	0.02	…	…
Agriculture – C	0.0186	0.0047	3.96	0.00	0.0073	0.0018
Agriculture – R	0.0382	0.0117	3.25	0.00	0.0149	0.0046
Other primary – C	0.0218	0.0057	3.80	0.00	0.0085	0.0022
Other primary – R	0.0333	0.0156	2.14	0.03	0.0130	0.0061
Traditional manufacturing – C	0.0045	0.0047	0.94	0.35	0.0017	0.0019
Traditional manufacturing – R	0.0218	0.0124	1.75	0.08	0.0085	0.0049
Distributive services – C	0.0043	0.0058	0.74	0.46	0.0017	0.0023
Distributive services – R	-0.0167	0.0202	-0.83	0.41	-0.0066	0.0079
Producer services – C	-0.0083	0.0110	-0.76	0.45	-0.0033	0.0043
Producer services – R	-0.0135	0.0344	-0.39	0.70	-0.0053	0.0135
Specialization – C	1.1688	0.8062	1.45	0.15	0.4575	0.3163
Specialization – R	0.0601	2.0882	0.03	0.98	0.0235	0.8175
Human capital – C	-0.0061	0.0048	-1.27	0.21	-0.0024	0.0019
Human capital – R	0.0099	0.0119	0.84	0.40	0.0039	0.0046
Unemployment – C	-0.0023	0.0058	-0.40	0.69	-0.0009	0.0023
Unemployment – R	0.0264	0.0160	1.65	0.10	0.0103	0.0063
Participation rate – C	-0.0289	0.0068	-4.24	0.00	-0.0113	0.0027
Participation rate – R	-0.0471	0.0176	-2.68	0.01	-0.0184	0.0069
Average income – C	0.0000	0.0000	0.87	0.38	0.0000	0.0000
Average income – R	0.0001	0.0001	1.47	0.14	0.0000	0.0000
Population density – C	-0.0001	0.0003	-0.40	0.69	-0.0001	0.0001
Population density – R	-0.0025	0.0013	-1.90	0.06	-0.0010	0.0005
Distance to large CMA	0.0000	0.0002	0.19	0.85	0.0000	0.0001
Distance to small CMA/CA	0.0007	0.0008	0.93	0.35	0.0003	0.0003
Junior population	-0.0282	0.0108	-2.61	0.01	-0.0110	0.0042
Senior population	-0.0204	0.0099	-2.06	0.04	-0.0080	0.0039
Junior mobility	-0.0017	0.0025	-0.66	0.51	-0.0006	0.0010
Senior mobility	-0.0237	0.0043	-5.53	0.00	-0.0093	0.0017
Aboriginal	-0.0012	0.0048	-0.25	0.80	-0.0005	0.0019
Measures of fit						
Log-likelihood full model	-1163.702					
Log-likelihood intercept	-1642.330					
McFadden's R^2	0.291					
Maximum Likelihood R^2	0.331					
McKelvey and Zavoina's R^2	0.561					
Number of observations	2,382					

Note: See Table 1 for a description of the indicators and unit of measures.
Source: Authors' estimation based on Census of Population 1981 and 1991 data.

Table 13 Probit model results: correct predictions, population , 1981-1991

Observed	Predicted growing (Probability<0.5)	Predicted declining (Probability>0.5)	Total
	Number of CCSs (percentage of column total)		
Growing	1,016 (77%)	277 (26%)	1,293 (54%)
Declining	308 (23%)	781 (74%)	1,089 (46%)
Total	1,324 (100%)	1,058 (100%)	2,382 (100%)

Source: Authors' computation based on Census of Population 1981 and 2001 data.

Table 14 Probit model results: population model, 1991-2001

Indicator	Coefficient	Robust standard error	Z	Probability >|z|	Marginal effect	Robust standard error
Constant	2.5882	1.2360	2.09	0.036	…	…
Agriculture – C	0.0093	0.0050	1.85	0.06	0.0037	0.0020
Agriculture – R	0.0719	0.0127	5.68	0.00	0.0287	0.0051
Other primary – C	0.0372	0.0082	4.52	0.00	0.0148	0.0033
Other primary – R	0.0242	0.0198	1.22	0.22	0.0096	0.0079
Traditional manufacturing – C	0.0080	0.0058	1.37	0.17	0.0032	0.0023
Traditional manufacturing – R	0.0049	0.0154	0.32	0.75	0.0020	0.0061
Distributive services – C	0.0007	0.0066	0.11	0.91	0.0003	0.0026
Distributive services – R	0.0451	0.0224	2.01	0.04	0.0180	0.0089
Producer services – C	-0.0024	0.0102	-0.24	0.81	-0.0010	0.0041
Producer services – R	-0.0866	0.0346	-2.50	0.01	-0.0345	0.0138
Specialization – C	2.4856	0.9116	2.73	0.01	0.9904	0.3635
Specialization – R	-4.7698	2.1404	-2.23	0.03	-1.9005	0.8529
Human capital – C	0.0068	0.0046	1.49	0.14	0.0027	0.0018
Human capital – R	-0.0335	0.0095	-3.52	0.00	-0.0134	0.0038
Unemployment – C	0.0026	0.0062	0.41	0.68	0.0010	0.0025
Unemployment – R	0.0105	0.0175	0.60	0.55	0.0042	0.0070
Participation rate – C	-0.0123	0.0070	-1.76	0.08	-0.0049	0.0028
Participation rate – R	-0.0781	0.0169	-4.61	0.00	-0.0311	0.0068
Average income – C	-0.0001	0.0000	-1.76	0.08	0.0000	0.0000
Average income – R	0.0004	0.0001	4.61	0.00	0.0002	0.0000
Population density – C	0.0004	0.0002	2.22	0.03	0.0002	0.0001
Population density – R	-0.0014	0.0007	-2.07	0.04	-0.0006	0.0003
Distance to large CMA	0.0013	0.0003	4.69	0.00	0.0005	0.0001
Distance to small CMA/CA	0.0014	0.0009	1.61	0.11	0.0006	0.0003
Junior population	-0.0248	0.0120	-2.07	0.04	-0.0099	0.0048
Senior population	0.0053	0.0098	0.54	0.59	0.0021	0.0039
Junior mobility	-0.0113	0.0029	-3.89	0.00	-0.0045	0.0012
Senior mobility	-0.0248	0.0042	-5.84	0.00	-0.0099	0.0017
Aboriginal	-0.0232	0.0060	-3.84	0.00	-0.0092	0.0024
Measures of fit						
Log-likelihood full model	-1127.324					
Log-likelihood intercept	-1650.552					
McFadden's R^2	0.317					
Maximum Likelihood R^2	0.356					
McKelvey and Zavoina's R^2	0.552					
Number of observations	2,382					

Note: See Table 1 for a description of the indicators and unit of measures.
Source: Authors' estimation based on Census of Population 1991 and 2001 data.

Table 15 Probit model results: correct predictions, population , 1991-2001

Observed	Predicted growing (Probability<0.5)	Predicted declining (Probability>0.5)	Total
	Number of CCSs (percentage of column total)		
Growing	945 (78%)	271 (23%)	1,216 (51%)
Declining	264 (22%)	902 (77%)	1,166 (49%)
Total	1,209 (100%)	1,173 (100%)	2,382 (100%)

Source: Authors' computation based on Census of Population 1981 and 2001 data.

Table 16 Probit model results: employment model, 1981-1991

Indicator	Coefficient	Robust standard error	Z	Probability >|z|	Marginal effect	Robust standard error
Constant	2.7303	1.2957	2.11	0.04	…	…
Agriculture – C	0.0022	0.0052	0.43	0.67	0.0005	0.0011
Agriculture – R	0.0493	0.0130	3.78	0.00	0.0109	0.0029
Other primary – C	0.0320	0.0061	5.26	0.00	0.0071	0.0013
Other primary – R	0.0406	0.0171	2.38	0.02	0.0089	0.0037
Traditional manufacturing – C	0.0090	0.0056	1.61	0.11	0.0020	0.0012
Traditional manufacturing– R	0.0119	0.0145	0.82	0.41	0.0026	0.0032
Distributive services – C	0.0030	0.0072	0.42	0.67	0.0007	0.0016
Distributive services– R	-0.0304	0.0246	-1.24	0.22	-0.0067	0.0054
Producer services – C	-0.0126	0.0150	-0.84	0.40	-0.0028	0.0033
Producer services – R	0.0223	0.0394	0.57	0.57	0.0049	0.0087
Specialization – C	0.8573	0.6918	1.24	0.22	0.1889	0.1534
Specialization – R	-4.2049	2.2203	-1.89	0.06	-0.9265	0.4886
Human capital – C	-0.0058	0.0055	-1.06	0.29	-0.0013	0.0012
Human capital – R	-0.0377	0.0142	-2.65	0.01	-0.0083	0.0031
Unemployment – C	0.0037	0.0064	0.57	0.57	0.0008	0.0014
Unemployment – R	0.0120	0.0178	0.67	0.50	0.0026	0.0039
Participation rate – C	0.0627	0.0077	8.10	0.00	0.0138	0.0017
Participation rate – R	-0.1134	0.0198	-5.74	0.00	-0.0250	0.0043
Average income – C	-0.0001	0.0000	-1.72	0.09	0.0000	0.0000
Average income – R	0.0003	0.0001	3.84	0.00	0.0001	0.0000
Employment density – C	-0.0004	0.0002	-1.64	0.10	-0.0001	0.0001
Employment density – R	0.0018	0.0005	3.36	0.00	0.0004	0.0001
Distance to large CMA	0.0000	0.0003	0.14	0.89	0.0000	0.0001
Distance to small CMA/CA	0.0008	0.0008	1.06	0.29	0.0002	0.0002
Junior population	-0.0845	0.0118	-7.17	0.00	-0.0186	0.0026
Senior population	0.0216	0.0107	2.02	0.04	0.0048	0.0023
Junior mobility	-0.0026	0.0028	-0.94	0.35	-0.0006	0.0006
Senior mobility	-0.0110	0.0054	-2.06	0.04	-0.0024	0.0012
Aboriginal	0.0268	0.0048	5.53	0.00	0.0059	0.0011
Measures of fit						
Log-likelihood full model	-918.087					
Log-likelihood intercept	-1167.436					
McFadden's R^2	0.214					
Maximum Likelihood R^2	0.189					
McKelvey and Zavoina's R^2	0.369					
Number of observations	2,382					

Note: See Table 1 for a description of the indicators and unit of measures.
Source: Authors' estimation based on Census of Population 1981 and 1991 data.

Table 17 Probit model results: correct predictions, employment , 1981-1991

Observed	Predicted growing (Probability<0.5)	Predicted declining (Probability>0.5)	Total
	Number of CCSs (percentage of column total)		
Growing	1,858 (84%)	65 (36%)	1,923 (81%)
Declining	342 (16%)	117 (64%)	459 (19%)
Total	2,200 (100%)	182 (100%)	2,382 (100%)

Source: Authors' computation based on Census of Population 1981 and 2001 data.

Table 18 Probit model results: employment model, 1991-2001

Indicator	Coefficient	Robust standard error	Z	Probability >|z|	Marginal effect	Robust standard error
Constant	2.1085	1.2167	1.73	0.08	…	…
Agriculture – C	0.0217	0.0048	4.50	0.00	0.0082	0.0018
Agriculture – R	0.0273	0.0120	2.27	0.02	0.0104	0.0046
Other primary – C	0.0385	0.0075	5.14	0.00	0.0146	0.0029
Other primary – R	-0.0085	0.0187	-0.46	0.65	-0.0032	0.0071
Traditional manufacturing – C	0.0137	0.0056	2.43	0.02	0.0052	0.0021
Traditional manufacturing – R	-0.0313	0.0148	-2.12	0.03	-0.0119	0.0056
Distributive services – C	0.0093	0.0065	1.43	0.15	0.0035	0.0025
Distributive services – R	0.0312	0.0211	1.48	0.14	0.0118	0.0080
Producer services – C	0.0121	0.0100	1.21	0.23	0.0046	0.0038
Producer services – R	-0.0791	0.0315	-2.51	0.01	-0.0300	0.0120
Specialization – C	1.9222	0.8835	2.18	0.03	0.7292	0.3365
Specialization – R	1.1491	2.0526	0.56	0.58	0.4359	0.7784
Human capital – C	0.0060	0.0045	1.35	0.18	0.0023	0.0017
Human capital – R	-0.0315	0.0094	-3.33	0.00	-0.0119	0.0036
Unemployment – C	0.0106	0.0059	1.80	0.07	0.0040	0.0022
Unemployment – R	0.0088	0.0157	0.56	0.58	0.0033	0.0060
Participation rate – C	0.0594	0.0073	8.18	0.00	0.0225	0.0028
Participation rate – R	-0.1222	0.0166	-7.35	0.00	-0.0464	0.0063
Average income – C	-0.0001	0.0000	-2.94	0.00	0.0000	0.0000
Average income – R	0.0004	0.0001	4.61	0.00	0.0001	0.0000
Employment density – C	0.0009	0.0003	2.97	0.00	0.0003	0.0001
Employment density – R	-0.0019	0.0012	-1.67	0.10	-0.0007	0.0004
Distance to large CMA	0.0015	0.0003	5.66	0.00	0.0006	0.0001
Distance to small CMA/CA	0.0003	0.0008	0.39	0.70	0.0001	0.0003
Junior population	-0.1015	0.0130	-7.79	0.00	-0.0385	0.0050
Senior population	0.0084	0.0126	0.67	0.50	0.0032	0.0048
Junior mobility	-0.0035	0.0029	-1.20	0.23	-0.0013	0.0011
Senior mobility	-0.0137	0.0044	-3.15	0.00	-0.0052	0.0017
Aboriginal	0.0062	0.0045	1.37	0.17	0.0024	0.0017
Measures of fit						
Log-likelihood full model	-1174.734					
Log-likelihood intercept	-1597.352					
McFadden's R^2	0.265					
Maximum Likelihood R^2	0.299					
McKelvey and Zavoina's R^2	0.480					
Number of observations	2,382					

Note: See Table 1 for a description of the indicators and unit of measures.
Source: Authors' estimation based on Census of Population 1991 and 2001 data.

Table 19 Probit model results: correct predictions, employment , 1991-2001

Observed	Predicted growing (Probability<0.5)	Predicted declining (Probability>0.5)	Total
	Number of CCSs (percentage of column total)		
Growing	1,255 (76%)	188 (26%)	1,443 (61%)
Declining	394 (24%)	545 (74%)	939 (39%)
Total	1,649 (100%)	733 (100%)	2,382 (100%)

Source: Authors' computation based on Census of Population 1981 and 2001 data.

Table 20 Changes in predicted probability of population decline, 1981-2001

Indicator	Predicted probability for x=min	x=max	Minto max change (1)	Predicted probability for μ -1/2 standard deviation	μ +1/2 standard deviation	One standard deviation change (2)	Marginal effect (3)
Agriculture – C	**0.329**	**0.911**	**0.581**	**0.382**	**0.523**	**0.141**	**0.008**
Agriculture – R	**0.154**	**0.990**	**0.836**	**0.311**	**0.598**	**0.287**	**0.022**
Other primary – C	**0.378**	**0.991**	**0.612**	**0.391**	**0.513**	**0.123**	**0.015**
Other primary – R	0.407	0.757	0.350	0.428	0.475	0.047	0.011
Traditional manufacturing – C	**0.413**	**0.674**	**0.261**	**0.433**	**0.470**	**0.037**	**0.004**
Traditional manufacturing – R	**0.345**	**0.700**	**0.355**	**0.418**	**0.485**	**0.066**	**0.011**
Distributive services – C	0.420	0.522	0.102	0.446	0.457	0.011	0.002
Distributive services – R	0.361	0.597	0.236	0.436	0.467	0.031	0.012
Producer services – C	0.474	0.291	-0.183	0.460	0.443	-0.017	-0.005
Producer services – R	0.509	0.336	-0.173	0.462	0.441	-0.021	-0.013
Specialization – C	**0.376**	**0.848**	**0.472**	**0.420**	**0.483**	**0.063**	**0.821**
Specialization – R	0.504	0.239	-0.265	0.474	0.429	-0.045	-0.910
Human capital – C	**0.597**	**0.272**	**-0.324**	**0.477**	**0.426**	**-0.051**	**-0.005**
Human capital – R	0.516	0.349	-0.167	0.464	0.439	-0.026	-0.004
Unemployment – C	**0.493**	**0.205**	**-0.288**	**0.470**	**0.433**	**-0.038**	**-0.005**
Unemployment – R	**0.326**	**0.807**	**0.481**	**0.406**	**0.498**	**0.092**	**0.018**
Participation rate – C	**0.903**	**0.129**	**-0.775**	**0.509**	**0.395**	**-0.115**	**-0.014**
Participation rate – R	**0.798**	**0.175**	**-0.624**	**0.517**	**0.387**	**-0.130**	**-0.026**
Average income – C	**0.260**	**0.777**	**0.517**	**0.411**	**0.493**	**0.082**	**0.000**
Average income – R	**0.291**	**0.758**	**0.466**	**0.410**	**0.494**	**0.084**	**0.000**
Population density – C	0.447	0.847	0.400	0.440	0.463	0.022	0.000
Population density – R	**0.535**	**0.000**	**-0.535**	**0.547**	**0.359**	**-0.188**	**-0.001**
Distance to large CMA	**0.369**	**0.777**	**0.408**	**0.411**	**0.493**	**0.082**	**0.000**
Distance to small CMA/CA	0.439	0.634	0.195	0.446	0.457	0.011	0.000
Junior population	0.542	0.347	-0.195	0.462	0.440	-0.022	-0.005
Senior population	0.470	0.414	-0.056	0.455	0.448	-0.007	-0.001
Junior mobility	0.478	0.387	-0.090	0.458	0.444	-0.014	-0.001
Senior mobility	**0.606**	**0.034**	**-0.572**	**0.512**	**0.392**	**-0.121**	**-0.014**
Aboriginal	**0.467**	**0.051**	**-0.416**	**0.480**	**0.423**	**-0.056**	**-0.006**

Note: Figures reported in bold correspond to coefficients that are statistically significant at 10% or less. (1) Change in predicted probability as the corresponding independent variable (*x*) changes from its minimum to its maximum value. (2) Change in predicted probability as the corresponding independent variable (*x*) changes from 1/2 standard deviation below its sample mean to 1/2 standard deviation above its sample mean. (3) Marginal effect is the partial derivative of the predicted probability with respect to the corresponding independent variable. All other variables are held at their sample means in all of these computations.
Source: Authors' estimation based on Census of Population 1981 and 2001 data.

Table 21 Changes in predicted probability of employment decline, 1981-2001

Indicator	Predicted probability for x=min	x=max	Min to max change (1)	Predicted probability for µ -1/2 standard deviation	µ +1/2 standard deviation	One standard deviation change (2)	Marginal effect (3)
Agriculture – C	**0.139**	**0.366**	**0.227**	**0.152**	**0.190**	**0.038**	**0.002**
Agriculture – R	**0.076**	**0.643**	**0.567**	**0.125**	**0.226**	**0.101**	**0.008**
Other primary – C	**0.143**	**0.707**	**0.564**	**0.148**	**0.195**	**0.048**	**0.006**
Other primary – R	0.149	0.386	0.237	0.159	0.183	0.025	0.006
Traditional manufacturing– C	0.155	0.279	0.124	0.163	0.178	0.015	0.002
Traditional manufacturing– R	0.165	0.183	0.018	0.169	0.172	0.003	0.001
Distributive services – C	0.180	0.150	-0.030	0.172	0.169	-0.003	-0.001
Distributive services – R	**0.102**	**0.325**	**0.223**	**0.157**	**0.185**	**0.027**	**0.010**
Producer services – C	0.177	0.130	-0.047	0.173	0.168	-0.005	-0.001
Producer services – R	0.235	0.076	-0.160	0.182	0.160	-0.022	-0.014
Specialization – C	**0.127**	**0.568**	**0.441**	**0.152**	**0.191**	**0.039**	**0.514**
Specialization – R	0.170	0.175	0.006	0.170	0.171	0.001	0.017
Human capital – C	**0.333**	**0.051**	**-0.283**	**0.195**	**0.148**	**-0.047**	**-0.004**
Human capital – R	**0.320**	**0.041**	**-0.279**	**0.196**	**0.147**	**-0.049**	**-0.007**
Unemployment – C	0.166	0.206	0.040	0.168	0.173	0.005	0.001
Unemployment – R	0.181	0.142	-0.039	0.174	0.167	-0.007	-0.001
Participation rate – C	**0.001**	**0.690**	**0.689**	**0.123**	**0.229**	**0.106**	**0.013**
Participation rate – R	**0.833**	**0.005**	**-0.828**	**0.267**	**0.100**	**-0.166**	**-0.034**
Average income – C	0.137	0.238	0.100	0.164	0.178	0.014	0.000
Average income – R	**0.073**	**0.504**	**0.431**	**0.141**	**0.204**	**0.063**	**0.000**
Employment density – C	0.170	0.199	0.028	0.170	0.171	0.001	0.000
Employment density – R	**0.159**	**0.894**	**0.736**	**0.156**	**0.186**	**0.030**	**0.000**
Distance to large CMA	**0.105**	**0.614**	**0.509**	**0.136**	**0.210**	**0.074**	**0.000**
Distance to small CMA/CA	0.164	0.290	0.126	0.167	0.174	0.006	0.000
Junior population	**0.651**	**0.005**	**-0.645**	**0.215**	**0.132**	**-0.083**	**-0.018**
Senior population	0.146	0.229	0.083	0.166	0.176	0.010	0.002
Junior mobility	0.186	0.136	-0.049	0.175	0.167	-0.008	-0.001
Senior mobility	**0.224**	**0.036**	**-0.188**	**0.191**	**0.152**	**-0.039**	**-0.004**
Aboriginal	0.164	0.522	0.358	0.159	0.183	0.024	0.003

Note: Figures reported in bold correspond to coefficients that are statistically significant at 10% or less. (1) Change in predicted probability as the corresponding independent variable (*x*) changes from its minimum to its maximum value. (2) Change in predicted probability as the corresponding independent variable (*x*) changes from 1/2 standard deviation below its sample mean to 1/2 standard deviation above its sample mean. (3) Marginal effect is the partial derivative of the predicted probability with respect to the corresponding independent variable. All other variables are held at their sample means in all of these computations.

Source: Authors' estimation based on Census of Population 1981 and 2001 data.

Table 22 Sub-period estimation 1981-1991: predicted versus observed population outcomes in 2001

Observed outcome 2001	Predicted growing (Probability<0.5)	Predicted declining (Probability>0.5)	Total
	Number of CCSs (percentage of column total)		
Growing	1,119 (64%)	97 (15%)	1,216 (51%)
Declining	625 (36%)	541 (85%)	1,166 (49%)
Total	1,744 (100%)	638 (1005)	2,382 (100%)

Source: Authors' computation based on Census of Population 1981 and 2001 data.

Table 23 Sub-period estimation 1981-1991: predicted versus observed employment outcomes in 2001

Observed outcome 2001	Predicted growing (Probability<0.5)	Predicted declining (Probability>0.5)	Total
	Number of CCSs (percentage of column total)		
Growing	1,418 (63%)	25 (19%)	1,443 (61%)
Declining	831 (37%)	108 (81%)	939 (39%)
Total	2,249 (100%)	133 (100%)	2,382 (100%)

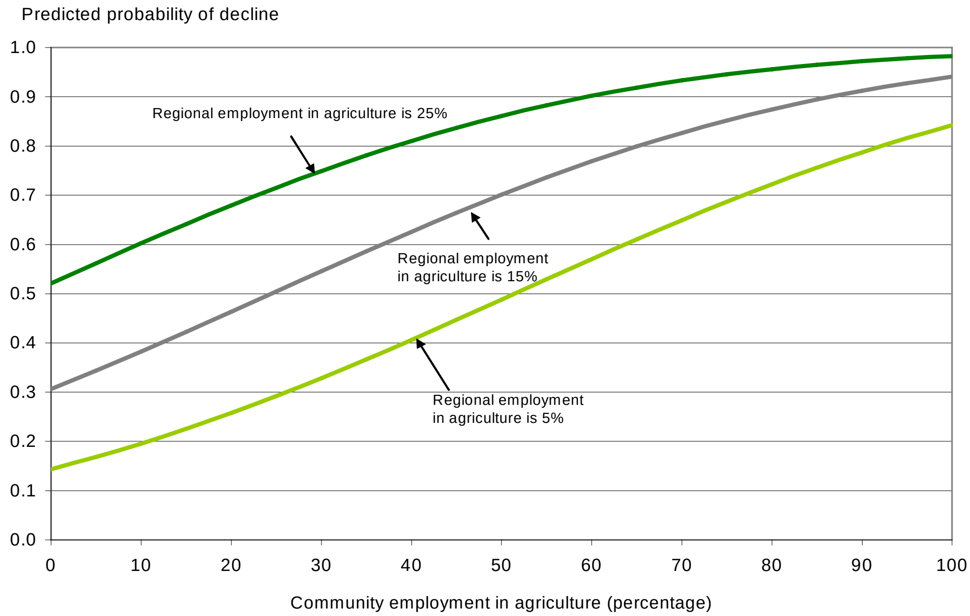
Source: Authors' computation based on Census of Population 1981 and 2001 data.

Table 24 Observed relationship between population and employment outcomes in 1981-2001

Employment is:	Population is:		
	Growing	Declining	Total
	Number of CCSs (percentage of column total)		
Growing	1,218 (98%)	595 (52%)	1,813 (76%)
Declining	20 (2%)	549 (48%)	569 (24%)
Total	1,238 (100%)	1,144 (100%)	2,382 (100%)

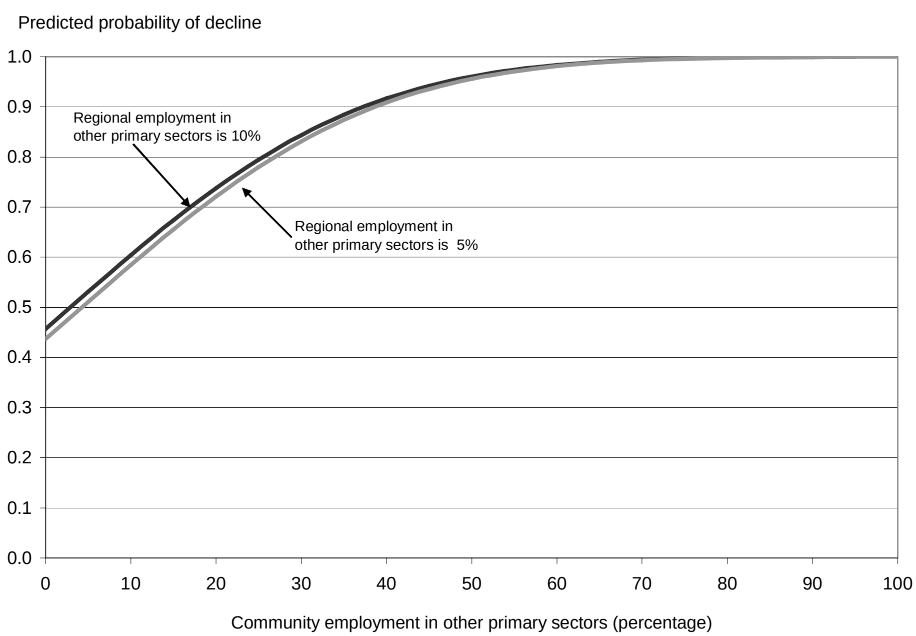
Source: Authors' computation based on Census of Population 1981 and 2001 data.

Figure 4 Predicted probability of population decline and employment in agriculture, 1981-2001



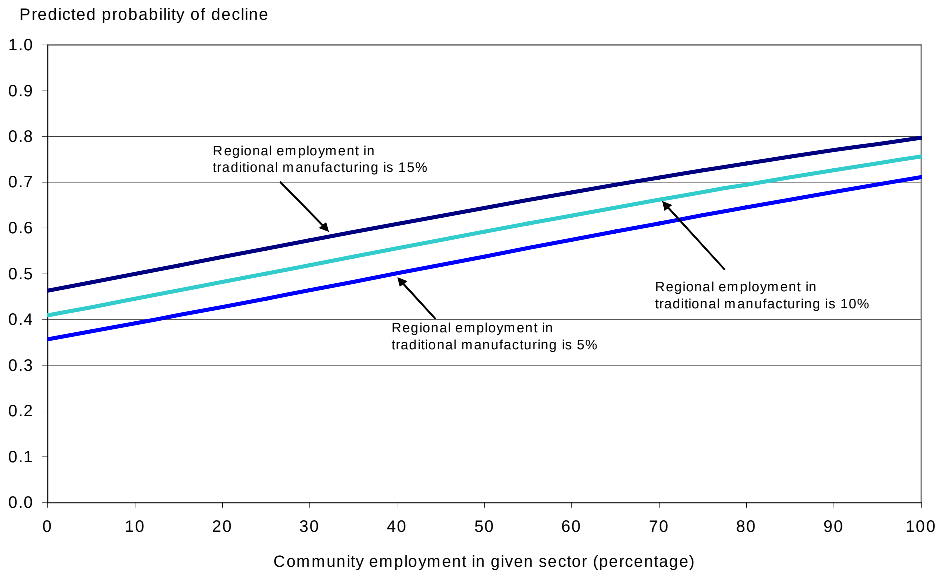
Note: Probabilities are valuated at the sample means of other explanatory variables.
Source: Authors' computation based on estimation results.

Figure 5 Predicted probability of population decline and employment in other primary sectors, 1981-2001



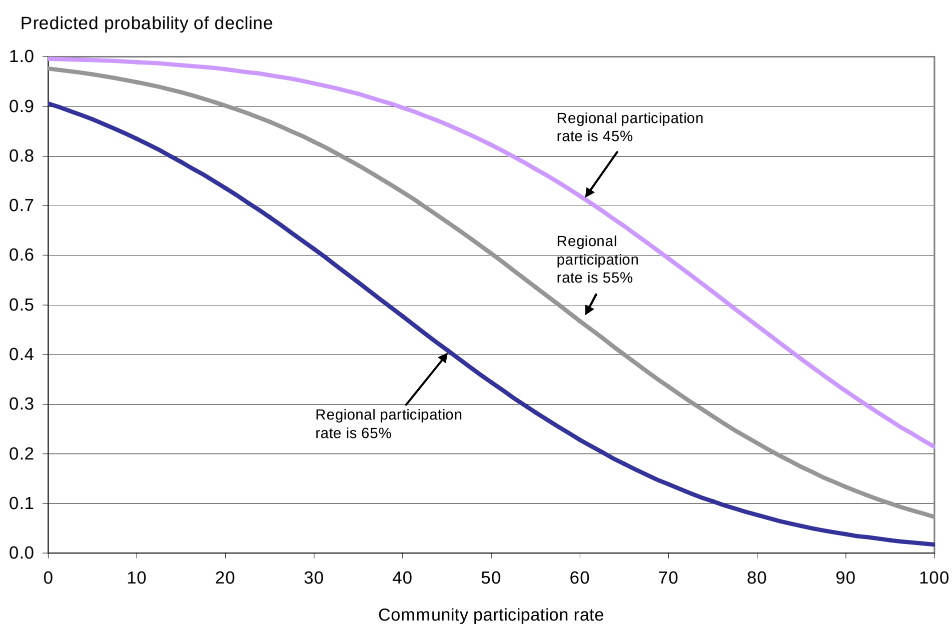
Note: Probabilities are valuated at the sample means of other explanatory variables.
Source: Authors' computation based on estimation results.

Figure 6 Predicted probability of population decline and employment in traditional manufacturing sectors, 1981-2001



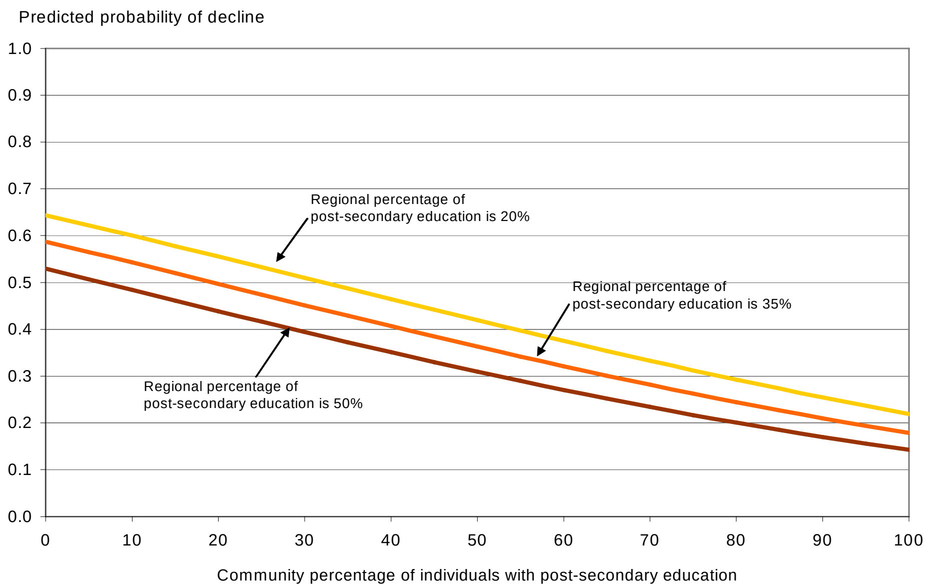
Note: Probabilities are valuated at the sample means of other explanatory variables.
Source: Authors' computation based on estimation results.

Figure 7 Predicted probability of population decline and labour force participation rates, 1981-2001



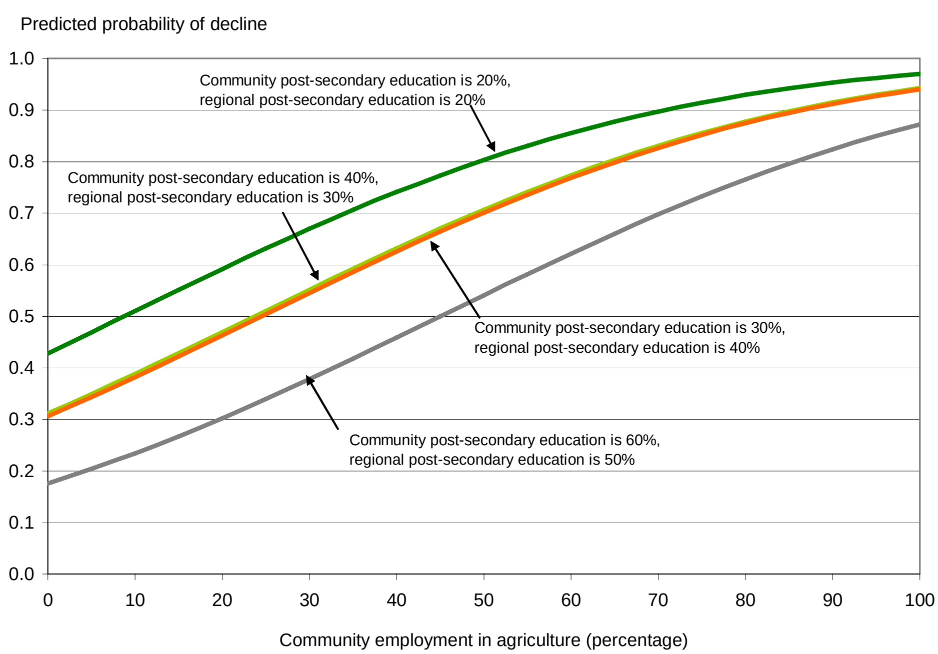
Note: Probabilities are valuated at the sample means of other explanatory variables.
Source: Authors' computation based on estimation results.

Figure 8 Predicted probability of population decline and human capital, 1981-2001



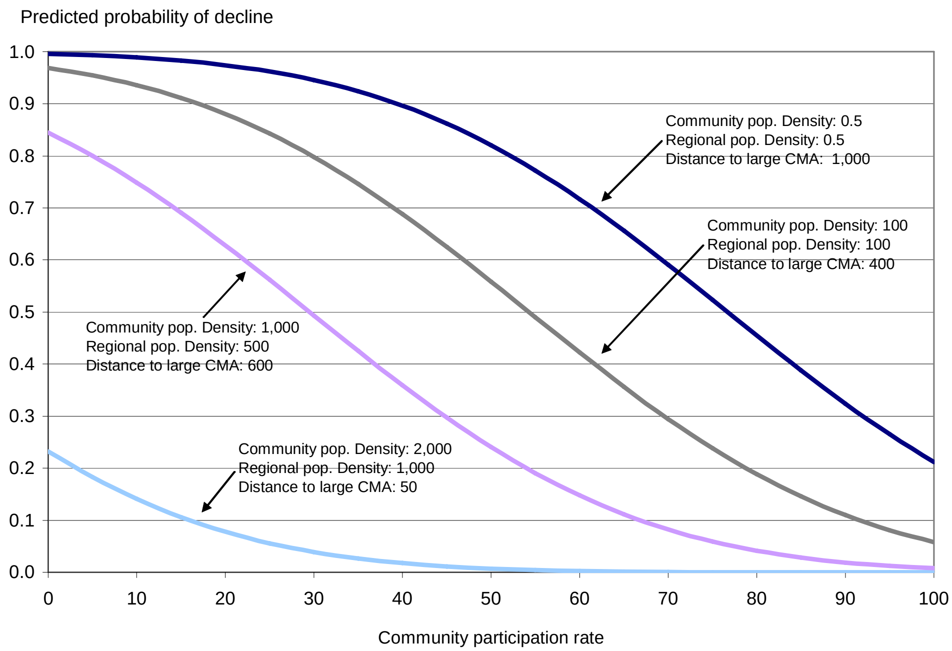
Note: Probabilities are valuated at the sample means of other explanatory variables.
Source: Authors' computation based on estimation results.

Figure 9 Stressors and assets interaction: agriculture employment and human capital effect on predicted probability to population decline, 1981-2001



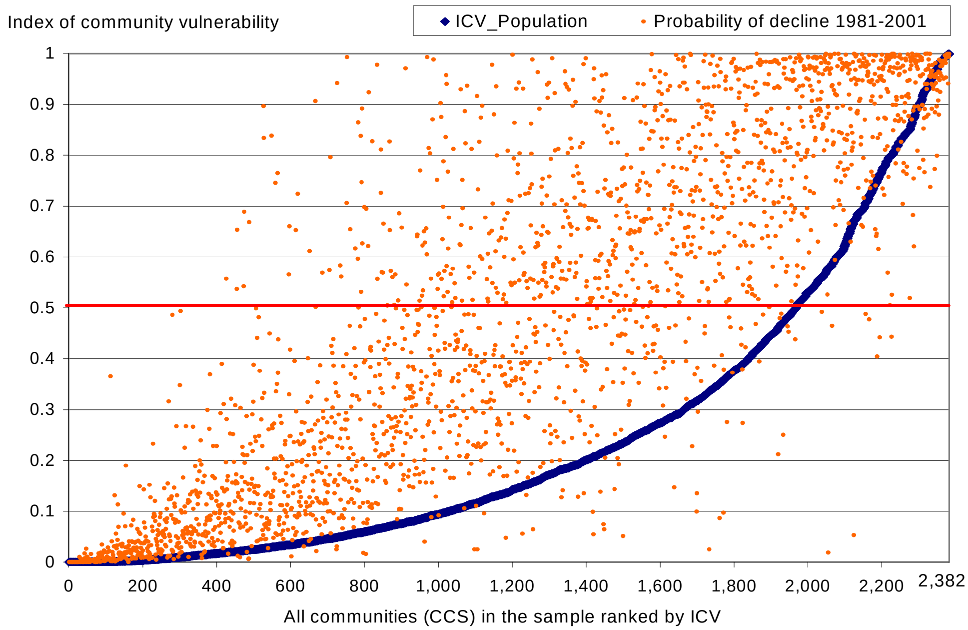
Note: Probabilities are valuated at the sample means of other explanatory variables.
Source: Authors' computation based on estimation results.

Figure 10 Assets interaction: urbanization and participation rates, 1981-2001



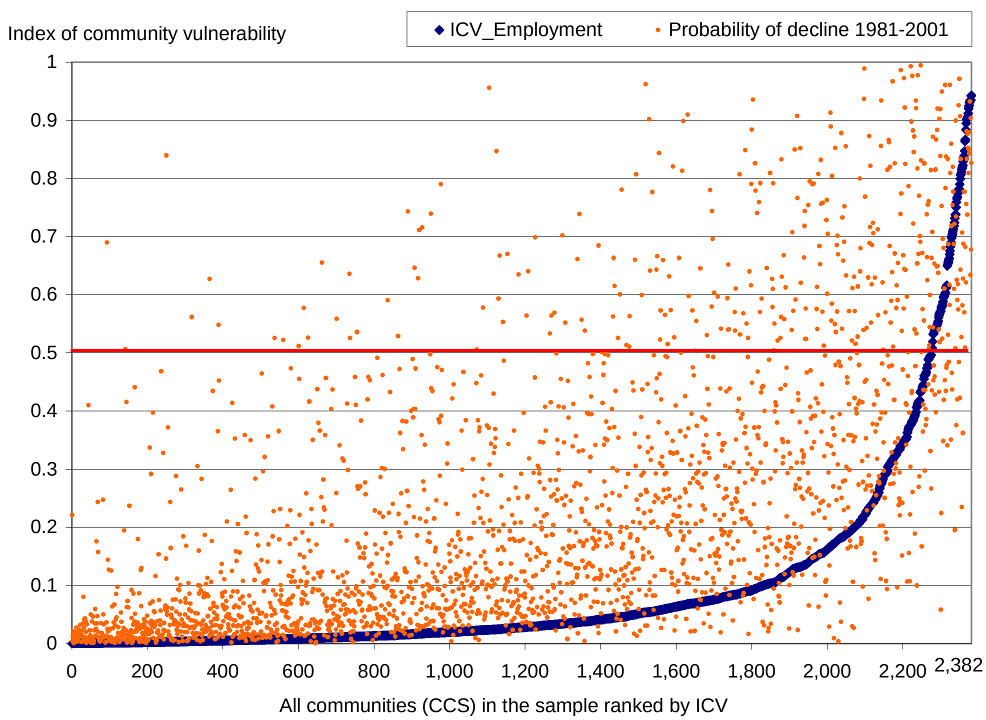
Note: Probabilities are valuated at the sample means of other explanatory variables.
Source: Authors' computation based on estimation results.

Figure 11 Distribution of the ICV to population decline and predicted probability, 1981-2001



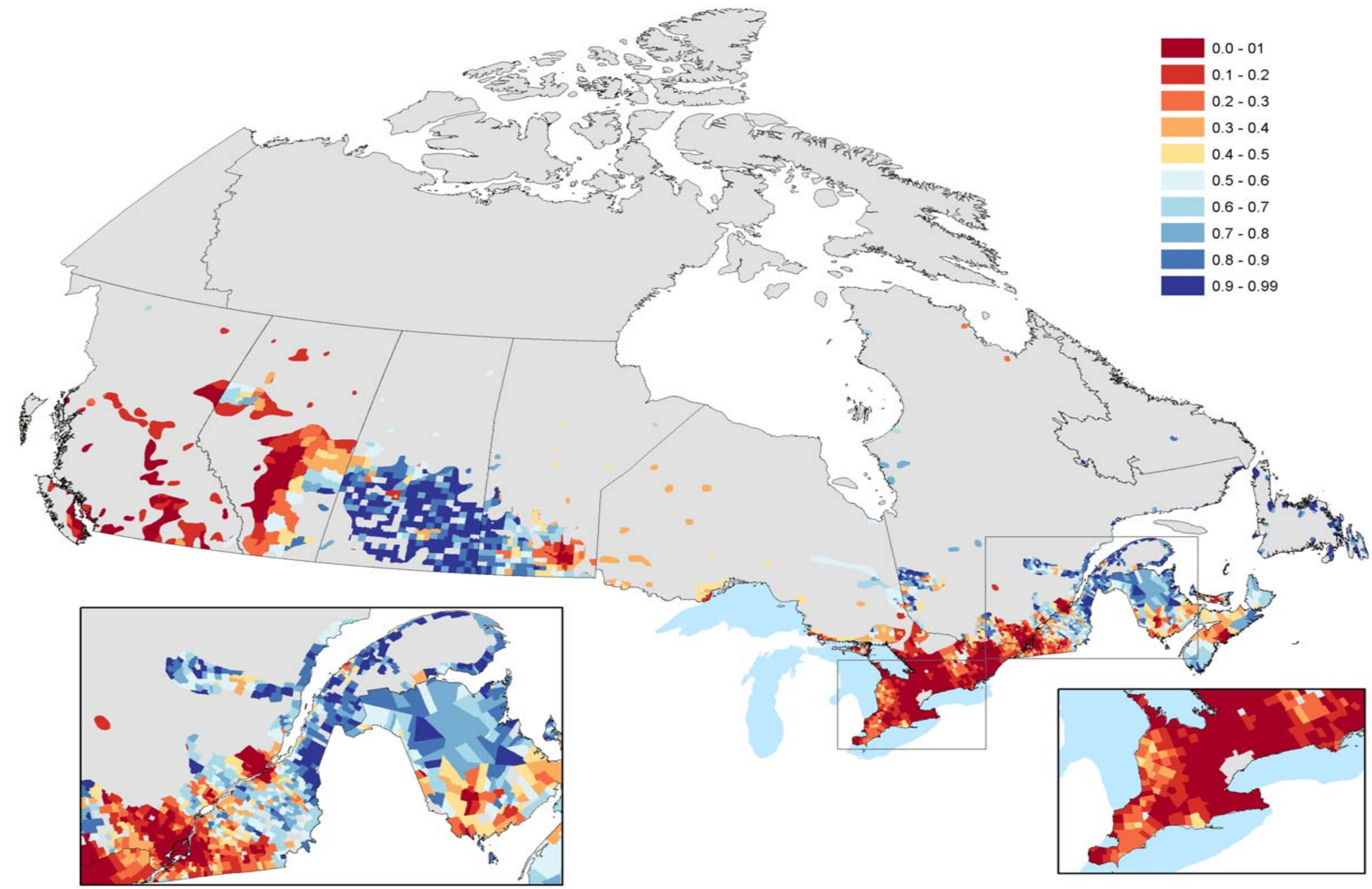
Source: Authors' computation based on estimation results.

Figure 12 Distribution of the ICV to employment decline and predicted probability, 1981- 2001

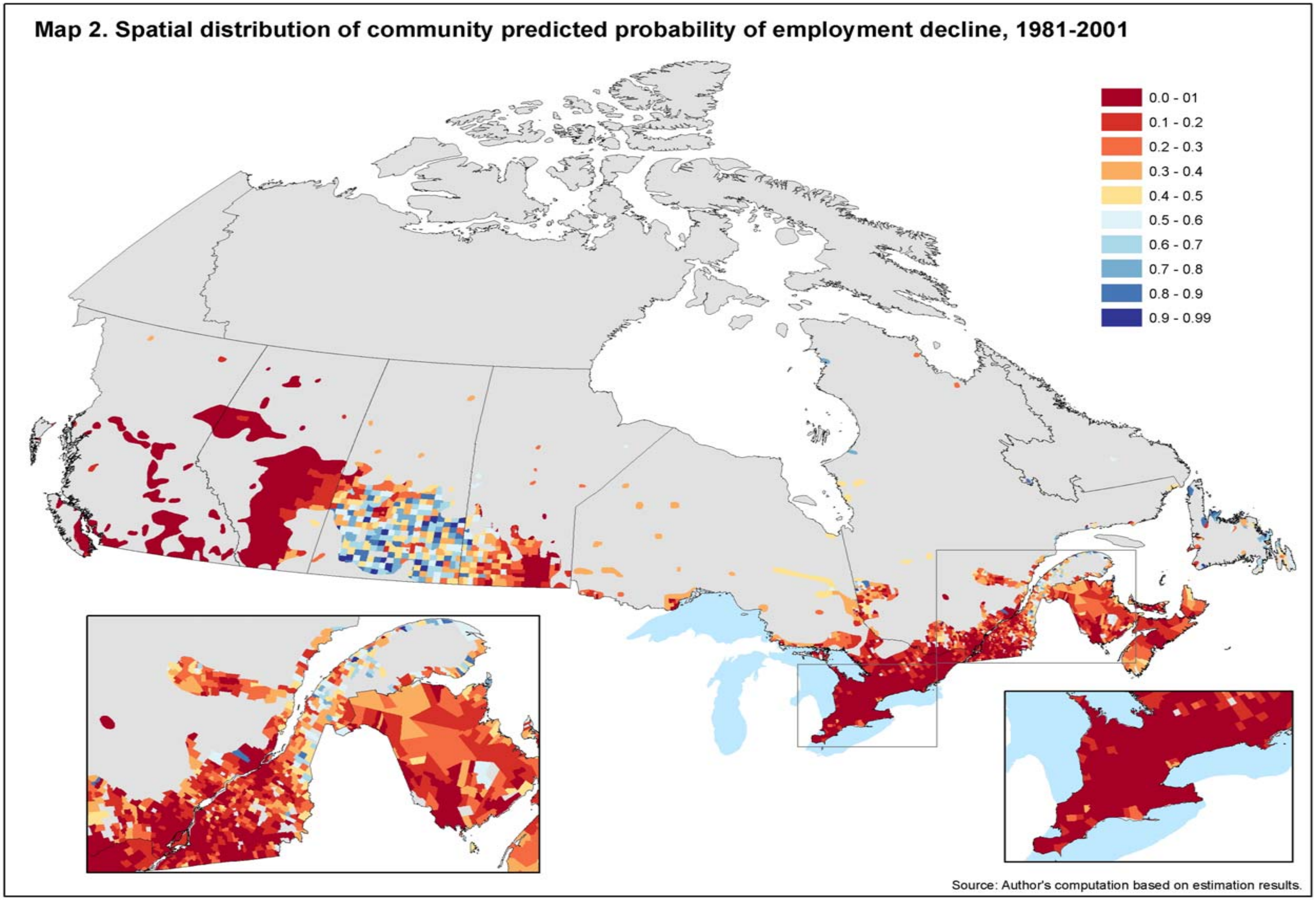


Source: Authors' computation based on estimation results.

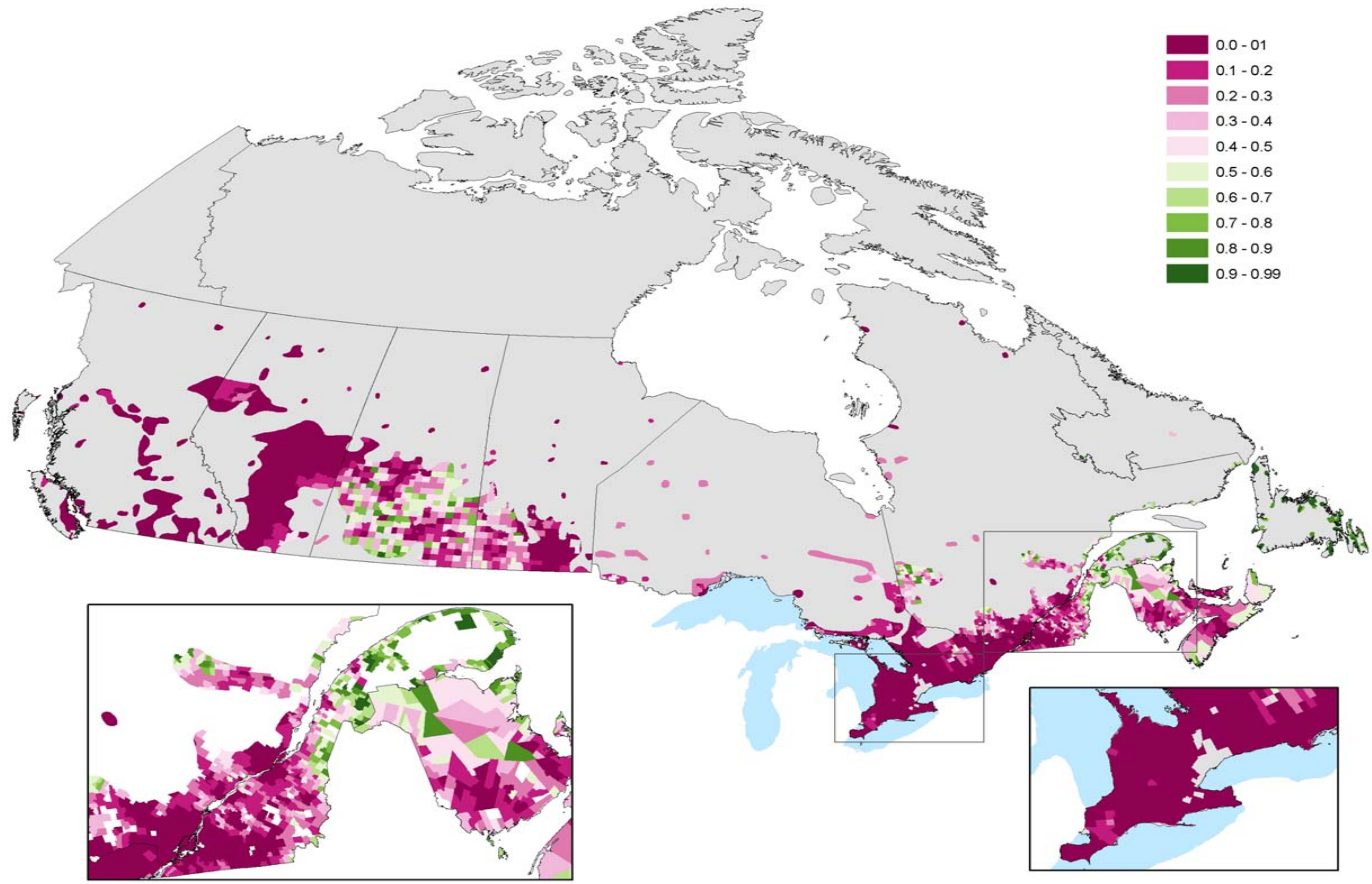
Map 1. Spatial distribution of community predicted probability of population decline, 1981-2001



Source: Author's computation based on estimation results.

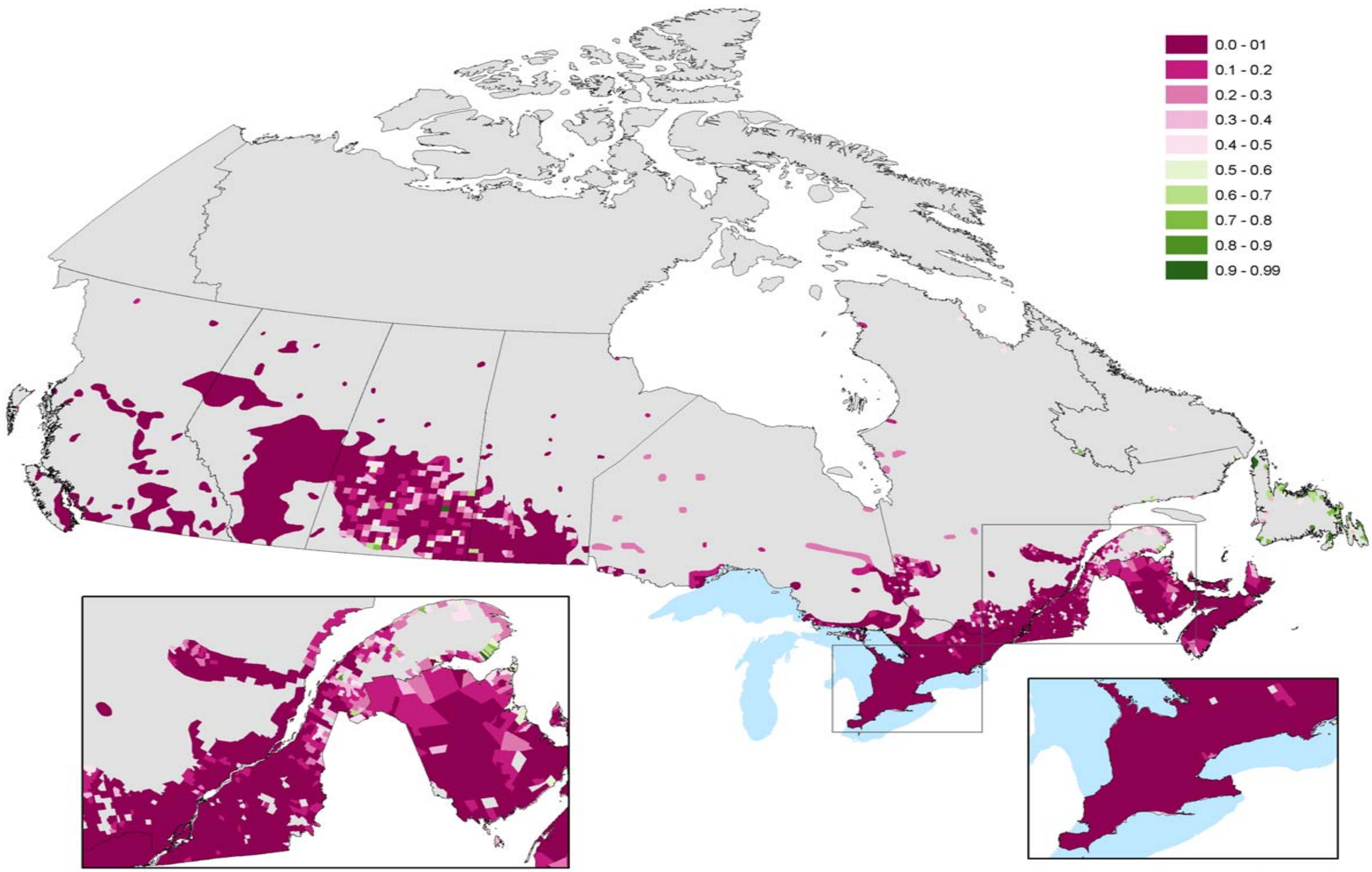

Map 2. Spatial distribution of community predicted probability of employment decline, 1981-2001
0.0 - 01
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 0.99
Source: Author's computation based on estimation results.

Map 3. Index of community vulnerability to population decline, 2001



Source: Author's computation based on estimation results.

Map 4. Index of community vulnerability to employment decline, 2001



Source: Author's computation based on estimation results.

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