DEFINING SCENARIOS THROUGH SHIFT-SHARE MODELS. AN APPLICATION TO THE REGIONAL EMPLOYMENT

Matías Mayor Fernández **mmayorf@uniovi.es**
Ana Jesús López Menéndez **anaj@uniovi.es**
Rigoberto Pérez Suárez **rigo@uniovi.es**

Abstract
The analysis of different economic situations and risk factors is necessary in order to properly define forecasting scenarios.
In this paper we focus on the shift-share model as a useful tool in the definition of economic scenarios, based on the different components that contribute to the change of a given economic magnitude (the so called national, sectoral and competitive effects).
Although the most commonly used methodology is based on the "constant shift" and the "constant share" hypotheses, additional options can be considered based on the expected behaviour of the competitive effect, thus leading to more realistic scenarios.
Once these new options are developed, this approach is applied to the definition of scenarios for the future evolution of the regional employment.

Key words: forecasting, shift-share, competitive effect, EPA.

1. Introduction

The prospective analysis based on statistical and econometric models must be understood as conditioned forecasts, based on some hypothetical values of the exogenous variables. The determination of those future values requires an outstanding effort and has a great impact in the final results. Therefore it is essential to guarantee the coherence among the hypotheses assumed for different variables.

As Huss (1988) points out, the development of scenarios can play an important role since it links the planning and forecasting processes. The definition of these scenarios requires a good knowledge of the economic magnitude to be forecasted, including its historical evolution and also its relationship with some other magnitudes.

From a historic perspective, the use of scenarios started at the decade of 1970 with the empirical investigations carried out by General Electric in 1971 (published with the title “Four alternative World/U. S. Scenarios”) and by Royal Dutch Shell, in order to face the crisis of 1973-74 and 1979.

The scenarios have been defined as “visionary forecasts” since they are supported in subjective methods, based on the imagination and the extrapolation carried out by experts. Some authors also critisized this methodology due to its lack of accuracy and its limitations in the turning points identification.

Nevertheless, as Georgoff and Murdick (1986) point out, the definition of scenarios has some important advantages such its little mathematical demand, its flexibility and its easy adaptation to the changes. Although three different methodological options can be considered in the definition of scenarios, including intuitive logic, cross-section analysis and trend analysis, the present work is focused on this last category.

More specifically, in this paper we propose the consideration of scenarios based on the shift-share models, assuming hypotheses related to the national, sectoral and regional estimated components.

With this aim, in the next section we briefly describe the shift-share model and their components. Next, in section three we focus on the dynamic shift-share formulation studying the evolution of its effects.

The empirical application of these methods is collected in section four, which summarizes the scenarios of regional employment based on the information provided by the Spanish Economically Active Population Survey (EPA).

2. Forecasting and shift-share models

The shift-share analysis was first developed by Dunn (1960) as a method for the determination of the components explaining the variations in economic magnitudes, mainly the employment. According with this author, the essential component of this statistical technique is the computation of the geographical changes in the economic evolution.

If we denote by E_{ij} the employment of sector i $\left(i=1,\ldots,s\right)$ in the spatial unit j $\left(j=1,\ldots,r\right)$ at the initial moment and by $E^{'}_{ij}$ the final value of this employment, the change of this magnitude can be expressed as:

$$E^{'}_{ij} - E_{ij} = \Delta E_{ij} = E_{ij}r + E_{ij}\left(r_i - r\right) + E_{ij}\left(r_{ij} - r_i\right) \qquad (1.1)$$

where:

$$r = \frac{\sum_{i=1}^{s}\sum_{j=1}^{r}(E'_{ij} - E_{ij})}{\sum_{i=1}^{s}\sum_{j=1}^{r}E_{ij}} \qquad r_i = \frac{\sum_{j=1}^{r}\left(E'_{ij} - E_{ij}\right)}{\sum_{j=1}^{r}E_{ij}} \qquad r_{ij} = \frac{E'_{ij} - E_{ij}}{E_{ij}}$$

According to this identity, three different components can be identified:

$$\begin{array}{ll} \text{National Effect} & EN_{ij} = E_{ij}r \\ \text{Sectorial Effect or Industry} - \text{mix effect} & ESC_{ij} = E_{ij}\left(r_i - r\right) \quad (1.2) \\ \text{Regional Effect or Competitive Effect} & ERC_{ij} = E_{ij}\left(r_{ij} - r_i\right) \end{array}$$

The national effect represents the change of the regional employment that would take place if the employment had changed at the same rate as the national economy.

The sectoral effect or "industry-mix" collects the differential contribution introduced by each economic activity (that is, the positive or negative influence of the specialization in sectors with rates of growth over or under the national average, respectively). Following Loveridge and Selting (1998), this component "is the amount of change attributable to differences in the sectoral make-up of the region versus that of the nation".

Finally, the competitive effect measures the special dynamism of the regional economic sectors in comparison with their evolution at the national level.

The classic shifty-share identity can also be expressed as:

$$r_{ij} = r + (r_i - r) + (r_{ij} - r_i) \qquad (1.3)$$

and also, following Moore y Rodhes (1973) and Buck and Atkins (1976) as:

$$r_j = r + \sum_{i=1}^{s}\left(W_{ij}r_i - r\right) + \sum_{i=1}^{s}\left(r_j - W_{ij}r_i\right) \qquad (1.4)$$

The shift-share analysis computes the deviations experimented by the regional sectoral employment with respect to the expected value based on the national evolution. The knowledge of this differential growth allows the forecasting of its future values.

Once the national forecast are available, different alternatives can be considered to obtain regional forecasts of the employment. In this sense, the easiest models are based on trend extrapolation with the expressions:

$$E_{ij}^{t+n} = \left(\overline{r}_{ij}\right)^n E_{ij}^t \tag{1.5}$$

$$E_{ij}^{t+n} = n\left(\overline{r}_{ij}\right) E_{ij}^t \tag{1.6}$$

Another option named by Hewings (1975) “share models” is based on shift-share decomposition. More specifically, the available national predictions are assumed in order to calculate the future values of national and industry-mix effects, remaining the competitive effect as the main forecasting problem. In this sense, two simple hypotheses are usually applied in the literature: constant share and constant shift.

The ***constant share hypothesis*** assumes that the regional industries show a behaviour which is analogous to the national one. According to this hypothesis, the sectors in a region grow at the same rate as their national counterpart, so the regional weight of the sectoral employment will remain constant. In this case, the competitive effect is zero because there is not different evolution between region and nation:

$$\frac{E_{ij}^t}{E_i^t} = cte \ \forall t \tag{1.7}$$

The described assumption leads to the following condition:

$$r_{ij} = \frac{E_{ij}^{t+1} - E_{ij}^t}{E_{ij}^t} = \frac{E_i^{t+1} - E_i^t}{E_i^t} = r_i \tag{1.8}$$

and the employment of sector i in region j would then be obtained by applying the national rate of growth of the same sector:

$$E_{ij}^{t+1} = (1 + r_i) E_{ij}^t \tag{1.9}$$

This is an easy method to obtain regional predictions although the assumption is quite unrealistic.

On the other hand, the ***constant shift hypothesis*** allows some differences between the national and the regional evolution. According to this assumption the competitive effect is not null but it is assumed to remain constant within the forecasting period.

This simplistic hypotheses is not congruent with the neoclassical theory since the competitive effect (positive or negative) is understood as a transition to the equilibrium state (with null expected value). Nevertheless, the cumulative causation growth theory justifies the constant shift assumption based on the existence of agglomeration economies, suggesting that the competitive component might be nonzero for long periods, or might even increase through time, as stated by Kurre y Weller (1989).

According to his hypothesis, the employment in each sector will be obtained as:

$$E_{ij}^{t+1} = \left(1 + r_i^{t+1} + s_i^{t+1}\right) E_{ij}^{t} \qquad s_i^{t+1} = r_{ij}^{t+1} - r_i^{t+1} \qquad (1.10)$$

where r_{ij}^{t+1} is an unknown value, which could be forecasted by studying his historic values.

This model is equivalent to the one developed by Hewings (1976) and is considered as a suitable method to anticipate the growth deviations between a spatial unit and its upper level. Given the rates of growth:

$$r_i = \frac{E_i^t}{E_i^{t-n}} \quad r_{ij} = \frac{E_{ij}^t}{E_{ij}^{t-n}} \quad r_i^* = \frac{E_i^{t+n}}{E_i^t} \qquad (1.11)$$

the employment in t+n could be obtained as:

$$E_{ij}^{t+n} = \left[r_i^* + \left(r_{ij} - r_i\right)\right] E_{ij}^t \qquad (1.12)$$

In adittion to the described basic hypotheses, some other models can be used to describe the competitive effect[1]. Brown (1969) proposes some forecasting models based on temporal translations of the equations:

$$\begin{aligned} e_i^t - e_i^{t-1} &= NS_i + IM_i + RS_i \\ e_i^{t+1} - e_i^t &= NS_i^* + IM_i^* + RS_i^* \end{aligned} \qquad (1.13)$$

Brown also develops some variations of the constant share hypothesis, leading to the so-called Ingrow and Super Ingrow models. The first of them is based on the historical information while the second one assumes the available national forecasts for the value E_i^{t+1}.

$$E_{ij}^{t+1} - E_{ij}^t = E_{ij}^t \left[\left(\frac{E_i^t}{E_i^{t-1}}\right) - 1\right] \qquad (1.14)$$

$$E_{ij}^{t+1} - E_{ij}^t = E_{ij}^t \left[\left(\frac{E_i^{t+1}}{E_i^t}\right) - 1\right] \qquad (1.15)$$

The main problem of these models is their lack of stability, as shown by Brown (1969) and Gerking y Barrington (1981).

An alternative model to local forecast through shif-share analysis was developed by James y Hughes (1973):

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[1] A review of the different alternatives to obtain local forecast by means of shift-share decomposition can be found in Stevens y Moore (1980).

$$\log\left(\frac{E_{ij}^{t}}{E_{i}^{t}}\right) = \log(a_{i}) + b_{i}t + u \qquad (1.16)$$

where the parameters can be interpreted as the initial weight of the region in each sector (a_i) and the competitive effect (b_i)[2].

If high values of b_i are obtained the results of expression (1.16) could be unrealistic, and therefore the use of the model should be limited to short term forecasts.

Hellman (1974) developed four models based on the expression summarized in table 1, where P denotes the total population and C_i is an agglomeration indicator for each of the considered sectors:

Table 1. Hellman´s Models

Hypotheses	Model
Constant weight of national population	$E_{ij}^{t+1} = E_{i}^{t+1}\left(\frac{E_{ij}^{t}}{E_{i}^{t}}\right)$ (1.17)
Constant ratio of regional employment/population	$E_{ij}^{t+1} = P_{j}^{t+1}\left(\frac{E_{ij}^{t}}{P_{j}^{t}}\right)$ (1.18)
Constant shift	$E_{ij}^{t+1} = E_{i}^{t+1}\left(\frac{E_{ij}^{t}}{E_{i}^{t}}\right) + E_{i}^{t+1}\left[\left(\frac{E_{ij}^{t+1}}{E_{i}^{t+1}}\right) - \left(\frac{E_{ij}^{t}}{E_{i}^{t}}\right)\right]$ (1.19)
Explicit shift-share model for export industries	$E_{ij}^{t+1} = E_{i}^{t+1}\left(\frac{P_{j}^{t}}{P^{t}}\right) + E_{i}^{t+1}\left[\left(\frac{P_{j}^{t+1}}{P^{t+1}}\right) - \left(\frac{P_{j}^{t}}{P^{t}}\right)\right] + C_{i}^{t}$ (1.20)

A more sophisticated version of these models has been developed by the Bureau of Economic Analysis and is named *OBERS shift-share model*.

$$\frac{E_{ij}^{t}}{E_{i}^{t}} = \frac{E_{ij}^{t-1}}{E_{i}^{t-1}} + E_{i}^{t}\left[\left(\frac{E_{ij}^{t}}{E_{i}^{t}}\right) - \left(\frac{E_{ij}^{t-1}}{E_{i}^{t-1}}\right)\right] \qquad (1.21)$$

The trend of the regional weight of each sector is estimated with double-exponential regressions for each combination region-sector:

$$\log\left(\frac{E_{ij}^{t}}{E_{i}^{t}}\right) = \log a + b_{ij}\log t \qquad (1.22)$$

[2] In opposition to this model, the authors developed a constant share model based on geometric means of the historical sectoral weights.

3. Dynamic shift-share analysis and forecast

As we have already indicated, one of the most outstanding problems to carry out predictions based on shift-share models is the stability of the competitive effect, since the forecast possibilities highly depend on the investigator´s ability to anticipate the evolution of this component. In this sense, while authors as Brown (1969) deny the stability of this component some others as Paraskevopoulos (1971) and Gerking and Barrington (1981) consider these models stable enough for predictive purposes.

Kurre and Weller (1989) analize the evolution of the different effects through time series techniques. More specifically, the competitive effect is estimated by means of three-year moving averages.

The use of the dynamic shift-share analysis responds to one of the main criticisms to the classical model, which compares the initial and final periods without any intermediate point.

Some solutions to this limitation focus on the election of the weights, which can be referred to the initial year, to the final year or to a combination of both. With regard to the sectoral effect or industry-mix, the consideration of the initial year might ignore the changes experienced by the industrial structure along the period.

Thus, Stillwell (1969) proposes a modification which also considers the industy-mix of the final period.

On the other hand, the shift-share formulation does not consider the changes in the regional employment, since the national effect assigns to the region the national rate of growth (leading to an underestimation if the regional employment grows more quickly than the national one, or to an overestimation in the opposite situation).

The dynamic shift-share model developed by Barff and Knight (1988) offers the possibility to split the period of study into two or more subperiods, allowing the incorporation of some changes in the sectoral structure.

In the case that a stational pattern is detected the series can be smoothed through the application of moving averages, denoted by:

$$\Delta E_{p,p-k};\Delta E_{p+1,p-k+1};\Delta E_{p+2,p-k+2};\cdots;\Delta E_{p+k,p};\cdots;\Delta E_{t,t-k}$$

where t denotes the final period, being p an intermediate period and k the considered width.

The results are assigned at the final period:

$$E_{ij}^{t} - E_{ij}^{t-k} = EN_{ij}^{t,t-k} + ES_{ij}^{t,t-k} + EC_{ij}^{t,t-k}$$

and this expression could also be used to analyze the stability in time and the hypothesis formulated by Stevens and Moore (1980) about cyclic evolution.

4. Empirical application: perspectives of regional employment

The development of a co-ordinated strategy for employment has been specified as an objective in the Treaty establishing the European Community. Since then, many efforts have been made in order to formulate suitable strategies, establishing guidelines and recommendations to the Member States.

The strategic goal "to make out of the European Union the world´s most competitive knowledge-based economy, capable of ensuring sustainable development, full employment and greater social cohesion" was first stablished at the Lisbon Summit (2000) and afterwords confirmed by further European Councils.

The existence of different regional and sectoral behaviours in the evolution of the labor markets within the EU has been shown in several investigations. In some recent works (Mayor and López, 2002, 2004) we have applied the shift-share methodology to the European framework, using the information about employment collected by Eurostat in the REGIO database. More specifically, we have studied the period 1980-2000, considering three different sectors (agriculture, industry and services) and following the Nomenclature of Territorial Units for Statistics (NUTS).

The obtained results are summarized in Table 2, which shows some significative differences between countries. A remarkable case is The Netherlands where all the regions show positive estimated effects, while Portugal, on the opposite side, has negative signs in all the estimated effects of his three regions.

Table 2: Classification of european regions (NUTS) according to their sectoral and regional effects

	NEGATIVE SECTORAL EFFECT	POSITIVE SECTORAL EFFECT
NEGATIVE COMPETITIVE EFFECT	**GERMANY:** BADEN-WÜRTTEMBERG **SPAIN:** NORD-WEST **FRANCE:** BASSIN PARISIEN, OUEST **ITALY:** EXCEPT CALABRIA **PORTUGAL**	**BELGIUM:** REGION DE BRUXELLES DINAMARCA **GERMANY:** BREMEN, HAMBURG, HESSEN, NIEDERSACHSEN, NORDRHEIN-WESTFALEN, SAARLAND, SCHLESWIG-HOLSTEIN **FRANCE:** ÎLE DE FRANCE, EST, MÉDITERRANÉE **ITALY:** CALABRIA **UNITED KINGDOM:** YORKSHIRE AND THE HUMBER, WEST MIDLANDS, SOUTH WEST, WALES, SCOTLAND, NORTHERN IRELAND
POSITIVE COMPETITIVE EFFECT	**GERMANY:** BAYERN **GREECE:** VOREIA ELLADA, KENTRIKI NISSIA AIGAIOU-KRITI **SPAIN:** NORESTE, CENTRO, ESTE, SUR **FRANCE:** SUD-OUEST **IRELAND**	**BELGIUM:** VLAMAMS GEWEST, REGIÓN WALLONNE **GERMANY:** BERLIN, RHEINLAND-PFALTZ **GREECE:** ATTIKI **SPAIN:** COMUNIDAD DE MADRID, CANARIAS **FRANCE:** NORD-PAS-DE-CALAIS, CENTRE-EST **LUXEMBOURG** **NEDERLANDS** **UNITED KINGDOM:** EAST MIDLANDS

Source: Mayor and López (2002, 2004)

These results can be considered as a starting point for the elaboration of regional predictions. Nevertheless a more detailed analysis is advisable in order to define forecasting scenarios for a given region.

In this paper we focus in the Spanish region of Asturias, whose labour market shows low activity and employment rates, especially in the case of females and young people. This situation is summarized in table 3, which shows the main labour indicators refered to Asturias, Spain and the European Union.

Table 3: Labour Market Indicators in Asturias, Spain and the European Union

	Asturias	Spain	European Union
Unemployment rate (Total, %)	9,8	11,4	7,5
Unemployment rate (Female, %)	14,8	16,4	7,8
Unemployment rate (15-24 years, %)	23,1	22,.2	15,2
Employment Sectoral weights (%)			
Agriculture	7,2	5,9	4,0
Industry	31,4	31,2	28,2
Services	61,4	62,9	67,8

Source: Eurostat and INE

For our empirical application we have considered the laboral information provided by the Spanish Statistical Institute (INE) through the Economically Active Population Survey (EPA). This survey is a continuous investigation referred to a sample of around 200.000 persons (65.000 dwellings) whose data are collected by personal interview and telephone, carried out by fixed interviewers from the INE, carefully filtered and electronically processed.

In this section we include both ex-post and ex-ante predictions of the regional employment by activity sectors which have been obtained under some alternative national scenarios.

The ex-post predictions have been carried out in the period 2001-2003 under the constant share and the constant shift hypotheses. As expected, this second option (based on more realistic assumptions) leads to better results in terms of accuracy although both procedures are surpassed by alternative methods including dynamic analysis. In fact, in most of the considered series the best results are obtained when the competitive effect is forecasted through ARIMA models.

Table 4 summarizes the accuracy measures obtained when the considered procedures are used to forecast the regional employment with sectoral detail.

Table 4: Accuracy Measures for the Employment predictions (2001-2003)

		Square Root of Mean Quadratic Error	Mean Absolute Error (%)	Theil Index
Agriculture	Constant share	3,94	14,45%	0,06
	Constant shift	2,75	8,28%	0,04
	Dynamic constant-share	5,69	18,68%	0,09
	Dynamic-ARIMA	1,46	4,85%	0,03
Industry	Constant share	7,85	9,44%	0,05
	Constant shift	3,13	3,29%	0,02
	Dynamic constant-share	4,27	4,46%	0,03
	Dynamic-ARIMA	3,01	3,49%	0,02
Construction	Constant share	4,54	9,46%	0,05
	Constant shift	2,50	4,87%	0,03
	Dynamic constant-share	8,33	17,34%	0,09
	Dynamic-ARIMA	4,49	8,63%	0,05
Services	Constant share	4,21	1,56%	0,01
	Constant shift	15,43	6,55%	0,03
	Dynamic constant-share	6,03	2,13%	0,01
	Dynamic-ARIMA	7,15	2,88%	0,01
Total	Constant share	12,88	2,99%	0,01
	Constant shift	8,67	2,26%	0,01
	Dynamic constant-share	14,46	3,36%	0,02
	Dynamic-ARIMA	9,61	2,23%	0,01

In the case of the ex-ante prospects, the future scenarios have been defined with the predictions provided by some organization, adopting as a basic scenario the consensus forecast (arithmetic mean) while the maximum and minimum value are considered in the definition of the optimist and pessimist scenario, respectively.

According to the previously defined methods, the sectoral employment of Asturias has been forecasted under three alternative scenarios: optimistic, basic and pessimist.

The results corresponding to the constant-shift and constant share hypotheses are compared in table 5 while table 6 presents the prospects obtained as a result of the dynamic shift-share and ARIMA modelling of the competitive effect.

Table 5: Employment forecasts in Asturias under alternative scenarios 2004-2006

(Constant shift and Constant share hypotheses)

Employment in Agriculture						
	Pesimistic Scenario		**Baseline Scenario**		**Optimistic Scenario**	
	Constant shift	**Constant share**	**Constant shift**	**Constant share**	**Constant Shift**	**Constant share**
2004	24.958	25.510	25.563	26.115	25.630	26.182
2005	23.706	24.750	24.131	25.184	24.027	25.600
2006	22.090	23.566	22.756	24.261	21.979	24.948
Employment in Industry						
	Pesimistic Scenario		**Baseline Scenario**		**Optimistic Scenario**	
	Constant shift	**Constant share**	**Constant shift**	**Constant share**	**Constant shift**	**Constant share**
2004	73.661	73.907	73.512	73.758	74.166	74.412
2005	73.182	73.677	73.727	74.223	73.765	74.512
2006	73.068	73.811	73.980	74.729	73.665	75.165
Employment in Construction						
	Pesimistic Scenario		**Baseline Scenario**		**Optimistic Scenario**	
	Constant shift	**Constant share**	**Constant shift**	**Constant share**	**Constant shift**	**Constant share**
2004	42.373	42.925	45.153	45.705	46.956	47.508
2005	42.701	43.785	45.457	46.574	47.784	49.507
2006	42.290	43.902	45.553	47.246	47.699	51.222
Employment in Services						
	Pesimistic Scenario		**Baseline Scenario**		**Optimistic Scenario**	
	Constant shift	**Constant share**	**Constant shift**	**Constant share**	**Constant shift**	**Constant share**
2004	230.399	230.599	240.305	240.504	248.670	248.869
2005	238.216	238.614	247.270	247.675	256.527	257.146
2006	243.272	243.877	254.054	254.676	263.843	265.121
Total Employment						
	Pesimistic Scenario		**Baseline Scenario**		**Optimistic Scenario**	
	Constant shift	**Constant share**	**Constant shift**	**Constant share**	**Constant shift**	**Constant share**
2004	371.391	372.941	384.533	386.083	395.421	396.970
2005	377.805	380.825	390.585	393.657	402.103	406.765
2006	380.721	385.156	396.343	400.912	407.185	416.456

Table 6: Employment forecasts in Asturias under alternative scenarios 2004-2006 (Dynamic shift-share and ARIMA modelling of the competitive effect)

Employment in Agriculture			
	Pesimistic Scenario	Baseline Scenario	Optimistic Scenario
2004	25.371	26.141	26.083
2005	19.801	20.164	20.507
2006	19.088	19.667	20.279
Employment in Industry			
	Pesimistic Scenario	Baseline Scenario	Optimistic Scenario
2004	78.865	78.506	79.376
2005	76.060	76.563	76.832
2006	77.675	78.524	78.934
Employment in Construction			
	Pesimistic Scenario	Baseline Scenario	Optimistic Scenario
2004	46.869	49.883	51.203
2005	48.157	50.850	53.635
2006	44.603	47.801	51.314
Employment in Services			
	Pesimistic Scenario	Baseline Scenario	Optimistic Scenario
2004	223.477	234.606	240.545
2005	235.800	244.746	254.152
2006	239.194	250.338	260.582
Total Employment			
	Pesimistic Scenario	Baseline Scenario	Optimistic Scenario
2004	374.582	389.136	397.208
2005	379.818	392.322	405.125
2006	380.561	396.331	411.108

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