Marshall-Arrow-Romer Externalities and City Growth

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It is often argued that *MAR* externalities reflect in the effect on local sectoral growth of the **share** of the local **sectoral employment** in local total employment (**relative concentration**), holding the **level** of the local **sectoral employment** fixed. We show that this is misleading, since it is equivalent to study the effect of the local **total employment**, holding the **level** of the local **sectoral employment** fixed. *MAR* externalities correctly reflect in the effect of **relative concentration**, holding local **total employment** constant. This change of specification significantly reverses the sign of the relative concentration effect on local growth in France.

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I. Introduction

Dynamic local externalities induce spatial agglomeration of firms and employment. As argued by Glaeser *et al.* [1992] and Henderson *et al.* [1995] (respectively, *GKSS* and *HKT* in the following), they favor localized growth, especially of cities. In these two recent companion papers, the authors test, among other points, whether these dynamic externalities are more important, and thus whether local sectoral growth is higher, the higher the concentration of the sector in the city, an effect they call Marshall-Arrow-Romer externalities (*MAR*).

To simply tackle this question, *GKSS* and *HKT* regress the local sectoral employment growth[3] on the share of the sector in local total employment, a variable named relative concentration, among other explanatory variables, all considered at the initial date. Their studies bear on US cities, between 1956 and 1987, and 1970 and 1987, respectively. In both cases, they also include the level of sectoral employment in the control variables. First, we show in this paper that the introduction of such a mean-reversion effect produces an over-estimation of *MAR* externalities and leads to incorrect interpretations of the results. Next, we propose an alternative specification and illustrate our point by a few regressions conducted on French data.

II. Local sectoral vs total employment as control variable

GKSS and *HKT* add the initial sectoral employment in regressions in order to capture mean reversion effects. The presence of these effects can be either due to the error term structure, and for instance be due to random measurement errors, or to β-convergence effects, as in the Solow growth model (See Barro and Sala-i-Martin [1995]). Since these last effects are due to the decrease of the marginal productivity of inputs, this reference is however inconsistent with the presence of local sectoral externalities. *GKSS* [p.1142] mention this point and write: "*The MAR view is somewhat incompatible with the presence of real (as opposed to measurement induced) mean reversion*…". Nevertheless, the end of the sentence justify their choice in the following way: "… *but since we are not correcting for potential measurement problems, we do not use such mean reversion as evidence against MAR externalities*".

Such a justification, first, should suggest a specific approach of the measurement error problem, which is not done, and, second, does not solve the interpretation problems that emerge when both negative mean reversion effects and positive effects of the concentration variable are significant, as in *HKT*. In terms of optimal local policy, this means that the local structure which is the most favorable to growth is both a low level of sectoral employment and a high share of

[3] Under weak assumptions on the production function, both papers show that although these externalities apply to the productivity of labor, they induce employment expansion, at least under perfect competition.

the sector in total employment. To implement this, having a low total employment in the city is the only solution. This is actually the right interpretation of the results presented in *HKT*, and, implicitly, this is the one given by the authors themselves. To illustrate their results, they [p.1074] present the following simulation: "*When 1970 machinery employment is held fixed, a one-standard-deviation (.030) increase in the share of machinery in overall local employment in 1970 increases 1987 machinery employment by 25%*". But, in order to increase the share of machinery in overall local employment, holding machinery employment fixed, the actual experiment conducted is a decrease of overall employment. This is the real effect that enhances local growth. Presented like that, the interpretation in terms of *MAR* externalities completely disappears.

We study now more precisely two different ways of testing these effects. Let $emp_{z,s,t}$ and $emp_{z,t}$ respectively denote the local sectoral and total employments at date t, where z stands for the city, and s for the sector. The dependent variable is the growth rate of the local sectoral employment. Let $con_{z,s,t}$ denote the relative concentration index, the share of sector s in local employment, and let $X_{z,s,t}$ denote a vector of other variables affecting local growth, but which do not depend on relative concentration and on local sectoral employment. The question we address is the following. Does an increase in *MAR* externalities correspond to an increase in relative concentration, holding the local sectoral employment constant (which in turns implies that it simply corresponds to a decrease of local total employment)? Or, does it corresponds to an increase in relative concentration, holding the local total employment constant? *GKSS* and *HKT* adopt the first point of view and consequently use what we call model (I) given by:

$$\text{(I)} \qquad log\left(\frac{emp_{z,s,t}}{emp_{z,s,t_0}}\right) = f_I\left(con_{z,s,t_0}, emp_{z,s,t_0}, X_{z,s,t_0}\right).$$

They claim that *MAR* externalities translate into the effect on local growth of relative concentration, holding local sectoral employment and $X_{z,s,t}$ variables constant and are thus given by:

$$CON_I = \left.\frac{\partial f_I}{\partial con_{z,s,t_0}}\right|_{emp_{z,s,t_0}, X_{z,s,t_0}}.$$

However, note that the local sectoral employment can be viewed as the product of the relative concentration index and of the local total employment: $emp_{z,s,t_0} = \frac{emp_{z,s,t_0}}{emp_{z,t_0}} \times emp_{z,t_0} = con_{z,s,t_0} \times emp_{z,t_0}$. By replacing this value in model (I), model (II) is obtained:

$$\text{(II)} \qquad log\left(\frac{emp_{z,s,t}}{emp_{z,s,t_0}}\right) = f_{II}\left(con_{z,s,t_0}, emp_{z,t_0}, X_{z,s,t_0}\right),$$

with: $f_{II}\left(con_{z,s,t_0}, emp_{z,t_0}, X_{z,s,t_0}\right) = f_I\left(con_{z,s,t_0}, con_{z,s,t_0} \times emp_{z,t_0}, X_{z,s,t_0}\right)$.

We argue that *MAR* externalities translate into the effect of relative concentration on local sectoral growth, holding local total employment and $X_{z,s,t}$ variables constant, and are thus given by:

$$CON_{II} = \left.\frac{\partial f_{II}}{\partial con_{z,s,t_0}}\right|_{emp_{z,t_0}, X_{z,s,t_0}}.$$

The first critical point we want to mention is given in lemma 1, proved in appendix A:

Lemma 1: ***When there is some mean reversion,*** $\left.\frac{\partial f_I}{\partial emp_{z,s,t_0}}\right|_{spe_{z,s,t_0}, X_{z,s,t_0}} < 0$ ***, as in GKSS and HKT, the relative concentration effect in model (I) (CON_I) is greater than the relative concentration effect in model (II) (CON_{II}).***

Second, let define model (III) that explains local growth by the levels of local sectoral and total employments, but no relative concentration effect:

$$\text{(III)} \qquad log\left(\frac{emp_{z,s,t}}{emp_{z,s,t_0}}\right) = f_{III}\left(emp_{z,s,t_0}, emp_{z,t_0}, X_{z,s,t_0}\right),$$

with: $f_{III}\left(emp_{z,s,t_0}, emp_{z,t_0}, X_{z,s,t_0}\right) = f_I\left(\frac{emp_{z,s,t_0}}{emp_{z,t_0}}, emp_{z,s,t_0}, X_{z,s,t_0}\right) = f_{II}\left(\frac{emp_{z,s,t_0}}{emp_{z,t_0}}, emp_{z,t_0}, X_{z,s,t_0}\right)$.

Using model (III), lemma 2 is proved in appendix A:

Lemma 2:

(i) The sign of CON_I is the opposite of the sign of the effect on local growth of the local total employment, holding local sectoral employment constant.

(ii) The sign of CON_{II} is the sign of the effect on local growth of the local sectoral employment, holding local total employment constant.

Our message can be summarized in the following proposition directly issued from lemmas 1 and 2:

Proposition: ***The effect of relative concentration in model (I) only depends on the effect of the local total employment on local growth, holding local sectoral employment fixed. It over-estimates true MAR externalities associated to the effects of the size of the sector in the city, given by the effect of relative concentration on local growth, holding local total employment fixed (model (II)).***

In model (I), interpretation problems rely on the fact that the local sectoral employment

effect, that the authors call the mean reversion effect, covers both a size and a sectoral composition effect. This prevents from correctly interpreting the relative concentration effect in terms of *MAR* externalities. To obtain the real effect of an increase of the local sectoral employment, that is, of *MAR* externalities, the mean reversion effect should be deduced from the relative concentration effect. Conversely, even this mean reversion effect is not easy to interpret. It corresponds to the effect of a variation of the local sectoral employment, holding relative concentration constant, that is, simultaneously increasing local total employment by the same amount.

Model (II) is more relevant to test *MAR* externalities. The local total employment controls for all effects related to the size of the city. These effects can be either positive, for instance due to a local demand effect, or to a high provision of local public goods, or negative, due to congestion, for instance on the land market, or on the local transportation network. The size of the city being controlled, the relative concentration index is next included, which controls for the size of the sector in local employment. Thus, it captures *MAR* externalities, which are understood as net of mean reversion. This effect represents the real impact on local growth of an increase of the local sectoral employment.

Finally, there is also a more minor debate on the use of relative versus absolute employment concentration, that is on whether model (II) or model (III) is more accurate. Actually, the interpretations in terms of *MAR* externalities is the same in both models, since it is controlled for total employment in both cases. However, the effect of the total size of the city is better interpreted in model (II) than in model (III). In model (II), the effect of an increase of local total employment is considered holding the relative concentration constant: a simultaneous proportional increase of the size of all sectors that keeps the sectoral composition of the city constant is implicitly assumed. In model (III), a variation in total employment assuming that local sectoral employment, and not relative concentration, is held constant, induces a simultaneous change of the relative concentration, and therefore includes *MAR* effects.

III. An example of France, 1984-1993

We now empirically illustrate our proposition by comparing the estimates obtained when a linear specification of model (I) is assumed, with those obtained when such a specification is assumed for model (II). We present such a comparison on French data for three specifications: one for which all explanatory variables are considered in levels, which is used by *GKSS*, one where the local sectoral employment is considered in logarithm and the relative concentration effect in level, as in *HKT*, and one which is fully log-linear. Our regressions are performed on 52 industrial sectors simultaneously and on 341 employment zones. The period of study is

1984-1993 and we use a generalized Tobit methodology estimated by maximum likelihood. Data are presented in appendix B and more detailed results[4] can be found in Combes [1999].

Observations number	17 732					
Non-zero observations	6 664					
Specification	**Levels (GKSS)**		**Mixed (HKT)**		**Logarithms**	
Model	**(I)**	**(II)**	**(I)**	**(II)**	**(I)**	**(II)**
Intercept	$-7.89\ 10^{-3}$	$1.12\ 10^{-1}$	$-6.09\ 10^{-1}$	-2.10	$-7.90\ 10^{-1}$	-3.12
	$(3.77\ 10^{-2})$	$(4.98\ 10^{-2})$	$(3.91\ 10^{-2})$	$(1.06\ 10^{-1})$	$(5.15\ 10^{-2})$	$(9.92\ 10^{-2})$
Sectoral Employment	-4.31	/	$-2.10\ 10^{-1}$	/	$-2.45\ 10^{-1}$	/
	$(4.94\ 10^{-1})$	/	$(6.33\ 10^{-3})$	/	$(9.01\ 10^{-3})$	/
Total Employment	/	$-9.8\ 10^{-7}$	/	$-1.53\ 10^{-1}$	/	$-2.45\ 10^{-1}$
	/	$(1.25\ 10^{-7})$	/	$(9.13\ 10^{-3})$	/	$(9.01\ 10^{-3})$
Relative Concentration	**$1.73\ 10^{-4}$**	**$-2.71\ 10^{-3}$**	**$4.97\ 10^{-3}$**	**$-2.66\ 10^{-3}$**	**$6.55\ 10^{-2}$**	**$-1.79\ 10^{-1}$**
	$(7.24\ 10^{-4})$	$(6.41\ 10^{-4})$	$(7.64\ 10^{-4})$	$(5.83\ 10^{-4})$	$(8.87\ 10^{-3})$	$(6.23\ 10^{-3})$

Standard errors in brakets - All variables significant at the 5% level, except intercept and relative concentration in the first column (*GKSS*, model (I)).

Our main observation is that, whatever the specification, the relative concentration variable has a positive impact on local growth in model (I) and a negative one in model (II). Except the positive but non significant effect of relative concentration in model (I) for the *GKSS* specification, the mean reversion effect is strong enough to make the estimates of the relative concentration simultaneously significantly positive in model (I) and significantly negative in model (II). Hence, the problem we underline in our proposition is really critical. Using model (I), we would incorrectly conclude that *MAR* externalities are present in the French industry during this period and that an increase in sectoral local employment would increase local growth. We may therefore suspect that the same would apply with the data on US cities used by *HKT*, since their mean reversion effect is strong. Concerning the period studied by *GKSS*, the problem is less sensitive, since even when they estimate model (I), a negative effect of the relative concentration variable is observed. However, this effect would be more negative if model (II) have been estimated. In our estimations, the positive effect of relative concentration observed in model (I), holding local sectoral employment constant, is only due to the negative effect of local total employment, which is observed in model (II). This latter effect implies that small cities have experienced higher sectoral growth rates. This can be explained by possible local congestion in big cities. *HKT* [p.1075] actually note that they obtain such a negative effect of local total employment when they estimate model (III). However, they do not mention that it fully changes the estimations and interpretations of the local sectoral employment variable.

[4] In this paper, we perform our regressions on each sector separately also considering 42 services sectors. Local diversity, competition and plant size effects are included in the explanatory variables.

Finally, note that when regressions are performed by pooling different sectors, as in *GKSS*, all explanatory variables must be normalized by the value they take for the sector at the national level, in order to allow comparisons between sectors[5]. We performed such a normalization in the above regressions. For instance, the dependent variable is the local sectoral employment growth minus the national sectoral growth. *GKSS* use such a normalization for the relative concentration variable. The share of the sector in overall local employment is divided by the share of the sector in national employment. They also include the national sectoral growth in the explanatory variables. But the local sectoral employment in specification (I) must be also divided by the sectoral national employment and comparable normalizations should be done for the $X_{z,s,t}$ variables, if any. Moreover, note that in the log-linear specification, a perfect colinearity exists between $emp_{z,s,t}$, $con_{z,s,t}$ and $emp_{z,t}$ This prevents from including of all these three variables in the same regression. Since in mixed specifications or in specifications in levels, the strict colinearity disappears, it would be a priori possible to simultaneously include all these variables. Nevertheless, the correlation remains very high between them and economic interpretations are impossible, since relative concentration cannot be increased, holding both sectoral and total employments fixed. *HKT* introduce local total employment at the end of the period, an effect they interpret in terms of static externalities. However, this variable remains highly correlated to the same one considered at the initial date and the interpretations problems between the local sectoral employment and the relative concentration effects remain exactly the same.

Appendix A: proofs of lemmas

Proof of lemma 1:

$$CON_{II} = \left.\frac{\partial f_I}{\partial emp_{z,s,t_0}}\right|_{spe_{z,s,t_0},X_{z,s,t_0}} \times \left.\frac{\partial emp_{z,s,t_0}}{\partial con_{z,s,t_0}}\right|_{emp_{z,s,t_0},X_{z,s,t_0}} + \left.\frac{\partial f_I}{\partial con_{z,s,t_0}}\right|_{emp_{z,s,t_0},X_{z,s,t_0}}$$

$$= emp_{z,t_0} \times \left.\frac{\partial f_I}{\partial emp_{z,s,t_0}}\right|_{spe_{z,s,t_0},X_{z,s,t_0}} + CON_I \quad .\blacksquare$$

Proof of lemma 2:

$$CON_I = -\frac{emp_{z,t_0}^2}{emp_{z,s,t_0}} \times \left.\frac{\partial f_{III}}{\partial emp_{z,t_0}}\right|_{emp_{z,s,t_0},X_{z,s,t_0}} \quad \text{and} \quad CON_{II} = emp_{z,t_0} \times \left.\frac{\partial f_{III}}{\partial emp_{z,s,t_0}}\right|_{emp_{z,t_0},X_{z,s,t_0}} .\blacksquare$$

Appendix B: data description

Data are taken from a plant panel ("Enquête Structure des Emplois", INSEE (French

[5] When regressions are performed on each sector separately, such normalizations only alters the intercept in a log-linear model.

National Institute of Statistics and Economic Studies)) which is exhaustive on plants larger than 20 workers. This panel include the plants' employment level, and also their skills composition, an information we do not use in this paper. Knowing the postal address of the plant, we aggregate the survey in 341 *zones d'emploi* ("employment areas", whose average area is 1570 km^2), entirely and continuously covering the French territory, whatever the employment density. *Zones d'emploi* definitions are based on the observation of workers daily migrations. This makes them economically more homogenous than administrative units, and it lowers some border effects. We use an INSEE's nomenclature (NAP 100) that aggregates sectors in 52 industrial sectors (on which the above regressions bear) and 42 services sectors. We use a Generalized Tobit methodology to control part of the possible bias due to the fact that data are censored: if only plants smaller than 20 workers are present in a sector in a zone, $emp_{z,s,t}$ is set to 0. We first model the probability of observing the sector in a zone, and we next perform our regressions conditionally on this event. We gain efficiency by using a maximum likelihood estimator.

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