



HAL
open science

Dynamique temporelle et distribution spatiale des revenus en France : croissance des disparités ou convergence ?

Benjamin Egron

► **To cite this version:**

Benjamin Egron. Dynamique temporelle et distribution spatiale des revenus en France : croissance des disparités ou convergence ?. Economies et finances. Université de Nanterre - Paris X, 2019. Français. NNT : 2019PA100083 . tel-03917470

HAL Id: tel-03917470

<https://theses.hal.science/tel-03917470>

Submitted on 2 Jan 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Membre de l'université Paris Lumières

Benjamin Egron

Dynamique temporelle et distribution spatiale des revenus en France : croissance des disparités ou convergence?

Thèse présentée et soutenue publiquement le 08/11/2019
en vue de l'obtention du doctorat de Sciences économiques de l'Université Paris
Nanterre sous la direction de Mme Valérie Mignon (Université Paris Nanterre)

Jury :

| | | |
|--------------------|-------------------|---|
| Rapporteur | Christophe Hurlin | Professeur, Université d'Orléans |
| Rapporteur | Julie Le Gallo | Professeur, Université de Bourgogne France-Comté |
| Suffragant | Nadine Levratto | Directrice de recherche au CNRS, EconomiX |
| Directeur de thèse | Valérie Mignon | Professeur, Université Paris Nanterre |
| Suffragant | Sonia Paty | Professeur, Université Lumière Lyon 2 |

Remerciements

Mes premiers remerciements vont à ma directrice de thèse, Mme Valérie Mignon. Je la remercie de m'avoir fait confiance et de m'avoir accueilli au sein du laboratoire EconomiX. Elle est en grande partie responsable de l'excellente expérience que je retire de ces trois années passées à produire cette thèse et l'accomplissement de ce travail lui doit beaucoup. Je lui suis reconnaissant pour son entière disponibilité, ses relectures minutieuses et ses encouragements quand j'en avais besoin. Au-delà de ses qualités professionnelles évidentes, j'aimerais la remercier pour sa gentillesse.

Je voudrais remercier les rapporteurs de cette thèse M. Christophe Hurlin et Mme Julie Le Gallo d'avoir pris le temps de s'intéresser à mon travail et de l'intérêt qu'ils ont porté à cette thèse. Je remercie aussi Mme Nadine Levratto et Mme Sonia Paty d'avoir accepté d'examiner mon travail.

Mes remerciements vont également aux membres du bureau 601. D'abord à Benjamin David pour m'avoir accueilli lors de ma première année et pour toutes nos discussions stimulantes. Je pense aussi à tous ceux qui m'ont rejoint par la suite : Florian Morvillier, Pierre Durand, Chouaib Jouf, Axel Ehouman, Joseph Yapi, Charles-Emmanuel Teuf. Je n'ai partagé, avec eux, que des bons moments. Je tiens à remercier plus particulièrement Florian pour tout le temps passé en duo dans le bureau, les échanges sur nos travaux respectifs et son aide.

Ce travail n'aurait pas pu être mené dans de bonnes conditions sans tous les membres du laboratoire EconomiX. Je voudrais témoigner de l'excellente ambiance qu'il y règne et combien il a été plaisant de travailler à leur côté. Je remercie en particulier tous ceux qui ont relu mes travaux et ont permis leur amélioration.

Enfin, j'aimerais remercier ma famille qui m'a soutenu tout au long de mes études et pour leurs encouragements constants. Mes pensées vont également à Alexandra, sa présence a été d'une aide précieuse.

Table des matières

| | | |
|----------|---|-----------|
| 1 | Introduction générale | 10 |
| 1.1 | Les disparités de revenus : quels enjeux ? | 11 |
| 1.1.1 | Des enjeux de bien-être | 11 |
| 1.1.2 | Des enjeux de cohésion | 17 |
| 1.2 | Les objectifs et contributions de la thèse | 21 |
| 1.3 | Bibliographie | 23 |
| 2 | Réduction du ratio de dette publique : quels instruments pour quels effets ?¹ | 27 |
| 2.1 | Introduction | 27 |
| 2.2 | Faits stylisés | 30 |
| 2.2.1 | 2008-2010 : crise, politique de relance et explosion du ratio de dette | 30 |
| 2.2.2 | 2010-2016 : Consolidation budgétaire, des résultats très contrastés | 31 |
| 2.3 | Revue de la littérature | 36 |
| 2.3.1 | L'étude des multiplicateurs | 36 |

1. Une première version de ce chapitre a été publiée en tant que Document de travail : Egron B. (2018), "Réduction du ratio de dette publique : quels instruments pour quels effets ?", Working Paper EconomiX 2018-1, et est en révision auprès de la *Revue d'Economie Politique*.

| | | |
|----------|--|-----------|
| 2.3.2 | L'étude des épisodes de consolidation | 43 |
| 2.4 | Méthodologie | 45 |
| 2.4.1 | L'équation comptable de la dette | 45 |
| 2.4.2 | Le modèle TVAR | 47 |
| 2.4.3 | Calcul des IRF sur le ratio de dette | 49 |
| 2.5 | Présentation des données et statistiques descriptives | 51 |
| 2.5.1 | Source des données et calculs effectués | 51 |
| 2.5.2 | Statistiques descriptives et stationnarité | 52 |
| 2.6 | Estimations et résultats | 53 |
| 2.6.1 | Choix de modélisation | 53 |
| 2.6.2 | Principaux résultats | 55 |
| 2.7 | Robustesse | 62 |
| 2.7.1 | Modification de l'ordre de retard | 62 |
| 2.7.2 | Modification du seuil | 63 |
| 2.8 | Discussion | 65 |
| 2.9 | Conclusion | 66 |
| 2.10 | Annexes | 68 |
| 3 | Beta-convergence at municipalities' level : the French case² | 81 |
| 3.1 | Introduction | 81 |
| 3.2 | Economic convergence : scale, measure and literature review | 85 |

2. Une première version de ce chapitre est à paraître en tant que Document de travail : Egrou B. (2019), "Beta-convergence at municipalities' level : the French case", Working Paper EconomiX

| | | |
|-------|--|-----|
| 3.2.1 | From macro to micro | 85 |
| 3.2.2 | How to measure and test convergence? | 88 |
| 3.2.3 | A brief review of the literature on β -convergence | 92 |
| 3.3 | Methodology : accounting for spatial dependence | 95 |
| 3.3.1 | Spatial process and estimation | 96 |
| 3.3.2 | Spatial diagnosis | 99 |
| 3.3.3 | Spatial instability : non-linearities, spatial regimes and Geographically Weighted Regression | 101 |
| 3.4 | Data and descriptive statistics | 107 |
| 3.4.1 | Data | 107 |
| 3.4.2 | Global statistics | 108 |
| 3.4.3 | Descriptive statistics by regime | 110 |
| 3.5 | Absolute convergence | 111 |
| 3.5.1 | Global absolute convergence | 111 |
| 3.5.2 | Convergence and spatial instability | 113 |
| 3.6 | Conclusion | 129 |
| 3.7 | Bibliography | 132 |

4 Determinants of territorial inequalities 137

| | | |
|-------|--|-----|
| 4.1 | Introduction | 137 |
| 4.2 | Literature review : the determinants of territorial inequalities | 140 |
| 4.2.1 | Location of economic agents and territorial inequalities | 140 |
| 4.2.2 | Empirical evidence | 144 |

| | | |
|----------|--|------------|
| 4.2.3 | Income formation | 147 |
| 4.3 | Descriptive statistics and data presentation | 162 |
| 4.4 | Methodology | 169 |
| 4.5 | Results | 181 |
| 4.5.1 | Determinants of convergence | 188 |
| 4.5.2 | Interpretation of results | 193 |
| 4.6 | Conclusion | 195 |
| 4.7 | Bibliography | 196 |
| 4.8 | Appendix | 201 |
| 5 | Conclusion générale | 203 |

Chapitre 1

Introduction générale

Les disparités de revenus peuvent être étudiées à travers plusieurs mailles, la plus classique et la plus fine étant la dimension individuelle qui permet d'analyser les inégalités au sein d'une population donnée. Cependant, il est souvent plus utile pour l'analyse économique de travailler à des niveaux d'agrégation plus élevés afin d'étudier les inégalités entre différents groupes d'individus partageant une caractéristique commune. Il peut s'agir par exemple d'analyser les inégalités entre catégories socio-professionnelles ou les inégalités de revenus entre les hommes et les femmes. **La présente thèse choisit d'étudier les disparités de revenus à partir de deux mailles différentes et complémentaires : (i) entre groupes d'individus partageant des périodes de temps et (ii) entre groupes d'individus partageant un même territoire.** En effet, il est d'une part possible de considérer un seul territoire et d'observer des variations temporelles de revenus, constituant ainsi des inégalités entre les différentes périodes temporelles. D'autre part, nous pouvons considérer un territoire à travers ses subdivisions géographiques et apprécier les inégalités spatiales à un instant donné. Nous verrons également que l'utilisation combinée des deux dimensions, temporelle et spatiale, permet l'étude des phénomènes de convergence à travers la dynamique temporelle des disparités spatiales de revenus. Nos objectifs seront précisés en fin d'introduction générale et nous souhaitons tout d'abord

familiariser le lecteur avec un certain nombre de concepts utilisés par la suite. Dans un premier temps nous exposerons les enjeux et les risques liés aux disparités de revenus. Nous présenterons, dans un second temps, les objectifs de notre thèse ainsi que les méthodes choisies pour y répondre.

1.1 Les disparités de revenus : quels enjeux ?

Nous détaillons ici les différents risques et enjeux que recouvrent les disparités de revenus et les outils existants afin d'y remédier.

1.1.1 Des enjeux de bien-être

Un lien peut être effectué entre la théorie des inégalités et la théorie du risque (Gajdos (2001)) et nous pouvons alors interpréter une distribution de revenus comme une loterie. Il est possible, à partir de ce cadre théorique, de mettre en relation les inégalités de revenus et le bien-être à travers les fonctions de préférence des individus. Dès lors que nous faisons l'hypothèse que l'utilité marginale du revenu est décroissante, les individus présentent une aversion vis-à-vis du risque. Cela se traduit mécaniquement par une certaine "aversion aux inégalités" à l'échelle de la société. Ainsi, le bien-être ne pourra être maximal en présence de trop fortes inégalités. Cette interprétation des inégalités en tant que loterie se prête particulièrement bien aux inégalités temporelles, chaque individu ne valorise pas chaque période de la même manière du fait qu'une incertitude existe car la probabilité de vivre chaque période est de plus en plus faible à mesure que l'on considère des périodes éloignées de l'instant présent. De plus, les modèles macroéconomiques contemporains utilisent une fonction d'utilité bien connue en théorie du risque, la fonction d'utilité CRRA (*Constant Relative Risk Aversion*). L'utilisation d'une telle fonction d'utilité implique une relation croissante et concave entre le niveau de richesse et l'utilité, en conséquence les individus cherchent à lisser leur richesse au cours du temps afin d'éviter

de trop grandes variations de richesse et donc de trop grandes inégalités entre les périodes de vie.

A un niveau plus agrégé et toujours avec pour objectif de maximiser le bien-être inter-temporel, l'une des fonctions de l'État est de stabiliser l'activité économique en assurant une faible variabilité du PIB dans temps. Pour cela, l'État dispose de deux outils principaux : les multiplicateurs budgétaires et la dette publique. Les multiplicateurs budgétaires correspondent à l'effet d'une variation des dépenses ou des recettes sur le PIB, il existe donc autant de multiplicateurs que de dépenses et de recettes. Cependant, en général les économistes raisonnent de manière agrégée, soit en considérant le multiplicateur de dépenses, regroupant toutes les dépenses possibles, ou alors par type de dépenses, souvent en différenciant les dépenses d'investissement des dépenses de consommation. La même simplification peut être réalisée sur les recettes. L'évaluation des multiplicateurs ainsi que le recours aux politiques budgétaires soulèvent la question de l'auto-régulation possible du système économique et du rôle de l'État. En particulier, compte tenu de l'effet négatif d'une trop grande variabilité de l'activité économique, existe-t-il des interventions de politiques budgétaires permettant de réguler davantage le système économique afin d'accroître le bien-être en comparaison à une situation de laissez-faire ? Dans l'affirmative, à quelles règles ces interventions doivent-elles être soumises, à la fois en termes d'ampleur et de conditions de déclenchement ?

Ces questions ont animé la recherche macroéconomique depuis maintenant plus d'un demi-siècle et les réponses ont évolué au cours du temps (Keynes (1936), Hicks (1937), Barro (1974), Kydland et Prescott (1977), Baxter et King (1993), Blanchard et Gali (2007)). Après la seconde guerre mondiale, les économies occidentales ont appliqué les principes Keynésiens en utilisant systématiquement les politiques budgétaires comme outil privilégié de régulation macroéconomique. Cependant, à la fin des années 1970, la plupart des économies connaissent une situation de stagflation où se combinent à la fois un fort niveau d'inflation et de chômage. Les politiques budgétaires mises en œuvre, non seulement n'ont pas permis de relancer l'activité économique, mais semblaient aggraver le problème en encourageant l'inflation. Le recours

aux multiplicateurs budgétaires a donc perdu rapidement son intérêt, à la fois au sein de la communauté des décideurs politiques et celle des économistes. En effet, à la même époque, se développe la théorie des anticipations rationnelles (Muth (1961), Sargent et Wallace (1975)) qui, sous certaines hypothèses restrictives, invalide totalement l'intervention publique du fait de l'équivalence Ricardienne qui stipule que toute hausse des dépenses publiques aura comme contrepartie une augmentation soit des recettes, soit de la dette publique (donc des recettes futures) conduisant les agents à épargner en conséquence puisqu'ils anticipent les hausses d'impôts à venir. L'effet d'éviction est total de sorte qu'une hausse de la dépense publique d'un euro entraîne une baisse de la dépense privée d'un même montant, laissant ainsi l'activité économique inchangée. Cependant, l'analyse keynésienne, *via* le simple modèle IS-LM en économie ouverte, permet également d'avancer des arguments afin d'expliquer des politiques budgétaires inopérantes à partir des années 1970, en particulier l'effet d'éviction par les importations et l'effet d'éviction par le taux d'intérêt. Le taux d'ouverture des économies occidentales a très fortement augmenté au cours de la seconde moitié du 20^e siècle, dès lors une politique budgétaire expansive peut conduire à une forte augmentation des importations, affectant peu la production nationale. S'agissant de l'effet d'éviction par le taux d'intérêt, la dépense publique engendre une hausse du taux d'intérêt en particulier lorsque que la dépense est financée par l'emprunt. L'État draine une partie de l'épargne conduisant à une diminution de l'investissement privé et donc de la demande globale. Cela peut également affecter négativement la productivité si les dépenses publiques sont des dépenses de consommation qui viendront alors se substituer à des dépenses d'investissement privées. La hausse du taux d'intérêt peut également provenir du respect d'une règle de Taylor de la part de la politique monétaire afin de contrecarrer l'inflation engendrée par la dépense publique. La hausse du taux d'intérêt diminuera l'investissement des entreprises et des ménages conduisant à une baisse de la demande globale allant à l'encontre de l'effet initial d'une augmentation des dépenses publiques.

Depuis la crise de 2008, l'étude empirique des multiplicateurs s'est renouvelée et ceux-ci ne sont plus considérés comme constants. Au contraire, le consensus actuel s'accorde à dire que les

multiplicateurs peuvent enregistrer de grandes variations à mesure que le contexte économique évolue (Eggertsson (2011), Auerbach et Gorodnichenko (2012), Blanchard et Leigh (2013), Gerschert et Rannenberg (2018)). Il devient alors crucial d'être en mesure d'évaluer correctement l'impact des politiques budgétaires en tenant compte des conditions économiques dans lesquelles elles s'inscrivent. En effet, le recours à l'intervention publique peut être dommageable si elle est réalisée sur la base de mauvaises informations. Suite à la politique d'austérité que plusieurs pays d'Europe ont dû mettre en place afin de réduire leur déficit public, Blanchard et Leigh (2013) nous renseignent sur le fait qu'une mauvaise connaissance des multiplicateurs a engendré une perte d'activité bien supérieure à ce qui était attendu. Dès lors, l'effet peut être contre-productif dans la mesure où la baisse du PIB se traduit par une réduction des recettes publiques pouvant surcompenser la baisse initiale des dépenses publiques. La politique d'austérité, dans le meilleur des cas, conduit à une légère baisse du déficit et, dans le pire des cas, le déficit se creuse en même temps que l'activité économique ralentit très fortement. Ainsi, l'utilisation de la politique budgétaire fait apparaître une tension entre la volonté de réduire la variabilité de l'activité économique à court terme, en particulier atténuer les récessions, et les coûts à long terme de cette intervention à travers l'accumulation de la dette publique. La combinaison des deux objectifs n'est *a priori* pas impossible mais requiert une connaissance relativement précise de la valeur des multiplicateurs afin d'identifier clairement (i) les situations où l'expansion budgétaire a un effet maximal sur l'activité économique tout en ayant peu d'impact sur la dette publique et (ii) les situations où, au contraire, l'effet sur l'activité économique est faible et l'impact sur la dette publique est grand, auquel cas, la politique de consolidation budgétaire est opportune. Dans ces circonstances, l'État est en mesure d'opérer, grâce à la politique budgétaire, une redistribution de revenu entre les différentes périodes de temps et de concilier à la fois la volonté d'une activité économique stable au sein de la vie des agents économiques, mais aussi une équité entre les générations.

Le bien-être associé à une distribution spatiale des richesses peut également s'appréhender à

travers la théorie du risque dans la mesure où chaque individu fait face à une distribution de probabilité décrivant la probabilité qu'il a d'appartenir à chacune des zones géographiques d'un territoire économique donné. Dans ce cas, l'aversion au risque des agents économiques implique que le bien-être général, issu des fonctions de préférence des agents, est décroissant avec les inégalités spatiales. En effet, le surcroît de bien-être accordé aux habitants des régions riches ne compensera pas la perte en bien-être subie par les habitants des régions pauvres du fait de l'utilité marginale décroissante de la richesse. Même si les agents économiques choisissent dans une certaine mesure leur localisation, ce choix est souvent dicté par des raisons sur lesquelles ces derniers n'ont pas ou peu d'influence. Plusieurs facteurs peuvent être à l'origine d'inégalités spatiales de revenus (Combes, Mayer et Thisse (2006)), en particulier ce qui influence la localisation des agents économiques au sein d'un territoire comme par exemple la présence de ressources ou d'aménités, les coûts de transport, l'existence d'infrastructures, la localisation des autres agents (effet d'agglomération ou, au contraire, de congestion)... La distribution inégale des agents économiques va engendrer par la suite une inégalité entre les zones géographiques à produire de la valeur ajoutée. Les inégalités spatiales peuvent également provenir de l'interaction des zones géographiques entre elles, à travers les échanges commerciaux, la migration pendulaire ou bien le fait que le capital d'un territoire soit détenu par les habitants d'un autre territoire (voir notamment la théorie de la base économique, Tiebout (1956)). Ainsi, les territoires n'ont pas tous la même capacité à capter de la valeur ajoutée extérieure, or si la propension à consommer localement est importante des effets multiplicateurs spatiaux peuvent être à l'œuvre. En effet, si les habitants d'un territoire captent de la valeur ajoutée extérieure puis consomment au sein de leur propre territoire, cela augmente l'activité économique domestique, ce qui peut à terme améliorer leur capacité à capter de la valeur ajoutée extérieure. Ce type de mécanisme peut alors renforcer des inégalités spatiales déjà présentes. Enfin, les disparités spatiales de revenus engendrent des inégalités dans la fourniture des biens publics du fait que toutes les administrations locales ne disposent pas des mêmes capacités à récupérer des ressources fiscales. Cela peut engendrer des différences structurelles entre les territoires. Or, les performances des en-

treprises sont pour partie liées aux caractéristiques des territoires sur lesquelles elles opèrent (Carré et Levratto (2011)), ces différences peuvent alors s'auto-entretenir menant à des pertes en bien-être.

Là encore, l'État dispose d'outils afin de remédier, ou du moins d'atténuer, les inégalités spatiales. En France, le territoire national s'organise à travers un ensemble de collectivités territoriales. La France se compose, en 2019, de 34967 communes regroupées en 96 départements, eux-même regroupés en 18 régions. Chacune de ces entités administratives dispose d'une certaine autonomie budgétaire et fiscale comme le précise l'article 72-2 de la constitution : "*Les collectivités territoriales bénéficient de ressources dont elles peuvent disposer librement dans les conditions fixées par la loi. Elles peuvent recevoir tout ou partie du produit des impositions de toutes natures. La loi peut les autoriser à en fixer l'assiette et le taux dans les limites qu'elle détermine.*". Cette liberté va de paire avec les compétences que se voit attribuer chaque type de collectivité territoriale et tout transfert de compétences doit s'accompagner d'un transfert de ressources. Enfin, l'article 72-2 précise également, depuis la révision constitutionnelle de 2003, que "*La loi prévoit des dispositifs de péréquation destinés à favoriser l'égalité entre les collectivités territoriales.*", ainsi la lutte contre les inégalités territoriales est donc un objectif à valeur constitutionnelle. La péréquation constitue le principal outil contre les inégalités territoriales et s'intègre au sein des dotations globales de fonctionnement des collectivités territoriales. La péréquation correspond à un transfert de ressources de l'État vers les collectivités territoriales, ce transfert s'effectue selon des critères d'équité. Par exemple, les régions bénéficiaires de la dotation de péréquation sont celles dont l'indicateur de ressources fiscales par habitant est inférieur à l'indicateur de ressources fiscales par habitant moyen de l'ensemble des régions et dont le produit intérieur brut est 1,3 fois inférieur au produit intérieur brut moyen de l'ensemble des régions. Les communes bénéficient également du principe de péréquation à travers la dotation de solidarité urbaine et de cohésion sociale, la dotation de solidarité rurale et la dotation nationale de péréquation. Là encore, les attributions reposent sur des principes d'équité dont

l'objectif est d'assurer à l'ensemble des habitants du territoire national un niveau d'offre de biens publics équivalent et ce malgré la très grande disparité des territoires. De plus, cette intervention publique peut également amorcer et entretenir un phénomène de convergence entre les territoires afin de combler les inégalités de revenus. Cet objectif nécessite naturellement de mesurer le niveau d'inégalité et de convergence en France afin d'assurer un bon pilotage des dépenses publiques locales à travers la péréquation, mais également afin d'évaluer l'efficacité des politiques publiques. Si la péréquation peut être un outil dans l'obtention d'une plus grande convergence, il s'agit aussi d'identifier et de comprendre les déterminants du phénomène de convergence/divergence entre les régions pour, éventuellement, agir directement à leur endroit. Cela permet d'effectuer des dépenses précises afin de modifier la structure d'un territoire dans le but que celui-ci opère un rattrapage, ces dépenses peuvent alors prendre la forme d'investissements précis avec pour objectif d'encourager l'émergence d'une activité économique ou d'infrastructures publiques particulières.

Nous avons vu que les inégalités, qu'elles soient temporelles ou spatiales, ont, toutes choses égales par ailleurs, un impact négatif sur le bien-être. Mais nous allons voir que les inégalités peuvent également engendrer une dégradation de la cohésion sociale et politique au sein d'une économie.

1.1.2 Des enjeux de cohésion

Au sein de la sous-section précédente, nous avons expliqué comment la théorie du risque permettait de lier les inégalités au bien-être à travers les préférences des agents et du fait de leur aversion vis-à-vis du risque. Dans le cas des inégalités temporelles, les différentes générations d'individus ont une certaine probabilité de vivre les périodes futures ce qui les incite à lisser leur revenu au cours du temps (Blanchard (1984)). Dès lors que deux générations ne sont pas trop distantes dans le temps, de sorte qu'elles vivent des instants communs, cette inter-

dépendance les encourage à la cohésion inter-générationnelle. Cela peut prendre la forme de transferts inter-générationnels du fait que les individus valorisent le bien-être de leurs enfants (Barro, (1974); Becker et Tomes (1979)). La situation est cependant plus complexe lorsque l'éloignement temporel de deux générations est tel que les liens d'interdépendance ne sont plus évidents, la solidarité inter-générationnelle s'exerce alors beaucoup plus faiblement. La transition énergétique met très clairement en lumière cette défaillance de cohésion entre générations et la problématique de la dette publique en est également un exemple. Les échelles de temps mises en jeu sont telles que les efforts présents sont difficiles à consentir et en particulier si leurs effets sont incertains. Pour cette raison, il est crucial d'identifier les bons outils et les bonnes conditions économiques permettant la réduction de la dette publique puisque la connaissance de l'efficacité des mesures mises en place contribue à la cohésion inter-générationnelle. De plus, la compréhension des mécanismes sous-jacents permet de mettre en lumière les liens d'interdépendance pouvant exister même entre des générations séparées par de grandes périodes de temps.

Outre la cohésion inter-générationnelle, la maîtrise de l'activité économique au cours du temps, à l'aide de la politique budgétaire et de la dette publique, laisse apparaître des enjeux de cohésion au sein des unions monétaires telle que l'Union Européenne (Von Hagen et Eichengreen, (1998)). En effet, l'Union Européenne, depuis le traité de Maastricht, impose des critères de convergence à ses pays membres dont deux font directement référence à la politique budgétaire : (i) le déficit public doit être inférieur à 3% du PIB et (ii) le niveau d'endettement public doit être inférieur à 60% du PIB. Ces critères se justifient par le fait qu'en union monétaire, si l'endettement global est soutenable, alors chaque pays bénéficie de taux d'intérêt faibles facilitant le recours à l'emprunt public. Dans ces conditions un phénomène de passager clandestin peut émerger (Chari et Kehoe (2007); Chari et Kehoe (2008)) dans la mesure où certains pays peuvent bénéficier du comportement vertueux d'autres pays afin de s'endetter à des taux d'intérêt faibles. La crise des dettes souveraines au sein de l'Union Européenne a révélé, en 2010,

le risque en termes de cohésion sociale et politique entre les différents pays d'Europe. De ce point de vue, la cohésion spatiale est dépendante de la capacité de chaque pays à réguler ses disparités de revenus temporelles en faisant judicieusement appel au déficit et à la dette publique. De plus, la coordination des politiques budgétaires peut devenir un enjeu important dès lors que les différents pays forment une union monétaire (Lenoble-Liaud, (2001), Creel (2001)). Cette problématique est également valide à l'échelle des villes d'un même pays, ces dernières ont intérêt à coordonner leur offre de biens publics afin d'internaliser les externalités dues aux effets de débordement. La coopération peut alors être une solution dans le but d'atteindre une gestion de l'offre de biens publics plus efficace (Frère, Leprince et Paty (2014)). Au contraire, le manque de coopération peut renforcer les externalités fiscales (horizontales et verticales) entre les collectivités territoriales créant des interactions stratégiques et conduisant à une offre sous-optimale du bien public (Madiès, Paty et Rocaboy (2005)).

Enfin, les inégalités territoriales et le manque de convergence spatiale peuvent aussi remettre en question la cohésion entre des territoires économiques partageant une même politique budgétaire, comme c'est le cas pour les régions ou les villes d'un même pays. En effet, le fait que les habitants d'une zone géographique bénéficient de revenus bien plus faibles que le reste du pays entraîne mécaniquement une différence de contribution au budget global de l'union budgétaire. De plus, la capacité de chaque budget local à obtenir des ressources *via* les impôts locaux diffère entre les administrations locales, ce qui nécessite des efforts de péréquation de la part de l'union budgétaire. Là encore, un phénomène de passager clandestin peut émerger, de plus, l'absence de convergence des régions défavorisées peut engendrer à terme un manque de solidarité de la part des régions les plus favorisées, ces dernières estimant être dépossédées de la valeur ajoutée qu'elles produisent. D'autre part, un manque de redistribution spatiale peut susciter une injustice du fait que les habitants des régions les plus défavorisées ne bénéficieront pas de la même offre de bien public et donc des mêmes chances de réussite. Bien que la cohésion d'un territoire dépende de facteurs socio-historiques beaucoup plus complexes que la simple application d'une

politique budgétaire à travers un territoire, cette dernière peut devenir suffisamment pesante afin d'exacerber des tensions politiques et sociales, en particulier en temps de crise. En effet, les politiques de restrictions budgétaires obligent à répartir l'effort entre différentes catégories de ménages souvent spatialement auto corrélées. Dès lors, certains espaces géographiques sont plus durement impactés et peuvent contester l'autorité de l'union budgétaire jusqu'à, éventuellement, réclamer l'indépendance budgétaire et fiscale. Suite à la crise financière de 2008, puis la crise des dettes souveraines de 2010, plusieurs tensions régionales sont apparues en Union Européenne et au sein même des pays qui la composent. Depuis le référendum du 23 juin 2016 et l'épisode du Brexit, le Royaume-Uni est conduit à organiser un projet de sortie de l'Union Européenne. Si les raisons qui ont mené au résultat du référendum sont nombreuses, notons tout de même que la contribution nette au budget européen était perçue comme une injustice par une partie de la population britannique. Mentionnons également la déclaration d'indépendance (unilatérale) de la Catalogne en 2017. Si, là encore, les raisons peuvent être nombreuses, soulignons que la Catalogne réclamait la négociation d'un nouvel accord fiscal, ce qui fut refusé par le gouvernement espagnol en 2012. Pour toutes ces raisons, les inégalités territoriales peuvent affaiblir la cohésion politique au sein d'un territoire. Si nous avons vu que la convergence territoriale était l'un des objectifs constitutionnels de la France, elle fait également partie du projet de l'Union Européenne à travers le traité relatif à son fonctionnement dont l'article 174 précise que "*Afin de promouvoir un développement harmonieux de l'ensemble de l'Union, celle-ci développe et poursuit son action tendant au renforcement de sa cohésion économique, sociale et territoriale. En particulier, l'Union vise à réduire l'écart entre les niveaux de développement des diverses régions et le retard des régions les moins favorisées.*". Ainsi, la mesure et la compréhension du phénomène de convergence territoriale constituent une problématique importante et actuelle au sein de la recherche en économie.

1.2 Les objectifs et contributions de la thèse

Nous avons exposé les différents enjeux et risques des disparités de revenus. La suite de la thèse aura ainsi pour objectif d'**analyser les mécanismes économiques engendrant des disparités de revenus à la fois temporelles et spatiales et d'étudier les moyens disponibles afin d'y remédier**. Nous retenons la France comme cadre d'application. Ce choix se justifie par le fait, qu'à notre connaissance, aucune étude n'a jusqu'alors été réalisée visant à évaluer quantitativement la convergence ou les disparités de revenus au sein des territoires français. De ce point de vue notre contribution est notable puisque nous nous plaçons à une échelle très fine d'analyse, notre échantillon comportant près de 30000 municipalités françaises. L'exhaustivité de notre échantillon de même que la granularité des observations nous permettent dès lors de mener une étude originale complète et détaillée.

L'aspect des **disparités temporelles de revenus** fera l'objet du premier chapitre (chapitre 2) où nous étudierons l'interaction entre les multiplicateurs budgétaires et la dette publique dans la mesure où ils constituent les deux outils principaux permettant de lisser le revenu dans le temps et présentent des enjeux à la fois à court et long termes. La littérature concernant les multiplicateurs budgétaires est importante (Ramey (2011)) et nous chercherons plus précisément à identifier quels sont les meilleurs instruments et le "meilleur" contexte économique afin d'amorcer une réduction du ratio de dette publique. L'un des principaux enjeux de ce chapitre sera la prise en compte de la variabilité de la valeur des multiplicateurs au cours du temps afin d'intégrer le fait que les conditions économiques, en particulier le fait d'être en récession ou en expansion, influent sur les valeurs prises par les multiplicateurs budgétaires. Afin de répondre à cette problématique, nous aurons recours à la modélisation VAR (*Vector Autoregressive*) en l'augmentant d'une non-linéarité. Cette dernière prendra la forme de deux régimes (récession/expansion), afin d'incorporer la variabilité des effets marginaux et donc d'autoriser les multiplicateurs budgétaires à varier au cours du temps. L'évaluation des multiplicateurs sera

ensuite complétée par des simulations de politique budgétaire *via* l'utilisation de l'équation comptable de la dette. Nous serons alors en mesure d'évaluer l'effet des différentes politiques budgétaires sur le ratio de dette publique selon que l'économie se situe en phase d'expansion ou de récession.

Les deux chapitres suivants auront pour objet les **inégalités spatiales de revenus**, sujet sur lequel la littérature associée est moins fournie que celle concernant les multiplicateurs, notamment au niveau empirique pour cause de disponibilité des données. Au sein de ces deux chapitres nous nous concentrerons sur un aspect relativement peu étudié par la littérature existante : les inégalités spatiales à échelle fine. En effet, alors que beaucoup d'études ont été réalisées à l'échelle de pays ou de régions, nous nous focaliserons sur les inégalités spatiales à l'échelle des villes. Le deuxième chapitre (chapitre 3) sera consacré à la mesure et la caractérisation du phénomène de convergence entre les territoires français. En particulier, nous répondrons aux questions suivantes : (i) existe-t-il un phénomène de convergence et, dans l'affirmative, quelle est sa vitesse ? (ii) Le processus de convergence est-il linéaire ? (iii) La convergence est-elle uniforme sur l'ensemble du territoire ? Afin de répondre à ces interrogations, nous nous inscrirons dans la lignée des travaux existants en recourant aux principaux modèles d'économétrie spatiale (SAR, SMA et SARMA). L'hétérogénéité du phénomène de convergence peut être étudiée à travers ces modèles en ajoutant des régimes spatiaux. Cependant, le grand nombre de données à notre disposition, ainsi que l'échelle spatiale à laquelle nous nous trouvons révèlent une complexité difficilement appréhendable par le simple ajout de régimes spatiaux. Nous aurons en conséquence recours aux modèles GWR (*Geographically Weighted Regression*) autorisant une très grande diversité des vitesses de convergence à travers l'espace. Cette flexibilité nous permettra de dépasser les limites des modèles usuels et de décrire l'hétérogénéité du phénomène de convergence avec une grande finesse.

Après avoir caractérisé le plus précisément possible le phénomène de convergence, nous chercherons à expliquer ses propriétés. Cette analyse fera l'objet du troisième chapitre (chapitre 4)

au cours duquel nous chercherons à identifier les déterminants de la convergence spatiale en répondant à la question suivante : quels sont les facteurs encourageant la convergence spatiale et, au contraire, quels sont ceux qui la freinent ? Nous chercherons donc à expliquer la variation au cours du temps d'une mesure d'inégalités à partir d'un grand nombre de variables explicatives. Nous verrons que la dynamique d'une mesure d'inégalités fait mécaniquement apparaître des non-linéarités dans la relation qui la lie aux variables explicatives. Dans ces conditions, nous aurons recours à un modèle non-paramétrique : le modèle de Forêt Aléatoire. Ce modèle issu de la recherche en apprentissage automatique présente comme avantage d'incorporer une méthode de sélection de variables afin d'identifier les déterminants les plus pertinents et d'autoriser une grande flexibilité dans l'évaluation de la relation liant la variable à expliquer aux variables explicatives. Nous serons alors en mesure d'identifier les sources de l'hétérogénéité du phénomène de convergence.

1.3 Bibliographie

Auerbach, Alan J., and Yuriy Gorodnichenko. "Fiscal multipliers in recession and expansion." *Fiscal policy after the financial crisis*. University of Chicago Press, 2012. 63-98.

Barro, Robert J. "Are government bonds net wealth?." *Journal of political economy* 82.6 (1974) : 1095-1117.

Baxter, Marianne, and Robert G. King. "Fiscal policy in general equilibrium." *The American Economic Review* (1993) : 315-334.

Becker, Gary S., and Nigel Tomes. "An equilibrium theory of the distribution of income and intergenerational mobility." *Journal of political Economy* 87.6 (1979) : 1153-1189.

Blanchard, Olivier J. "Debt, deficits and finite horizons." (1984).

Blanchard, Olivier, and Jordi Galí. "Real wage rigidities and the New Keynesian model." *Journal of money, credit and banking* 39 (2007) : 35-65.

Blanchard, Olivier J., and Daniel Leigh. "Growth forecast errors and fiscal multipliers." *American Economic Review* 103.3 (2013) : 117-20.

Carré, Denis, and Nadine Levratto. "Dynamique des territoires, agglomération et localisation des firmes." *Innovations* 2 (2011) : 183-206.

Chari, Varadarajan V., and Patrick J. Kehoe. "On the need for fiscal constraints in a monetary union." *Journal of Monetary Economics* 54.8 (2007) : 2399-2408.

Chari, Varadarajan V., and Patrick J. Kehoe. "Time Inconsistency and free-riding in a monetary union." *Journal of Money, Credit and Banking* 40.7 (2008) : 1329-1356.

Combes, Pierre-Philippe, Thierry Mayer, and Jacques-François Thisse. *Economie géographique : L'intégration des nations et des régions*. 2006.

Creel, Jérôme. "Asymétries budgétaires dans la zone euro, un essai de modélisation du Pacte de stabilité." *Revue française d'économie* 16.3 (2002) : 91-127.

Eggertsson, Gauti B. "What fiscal policy is effective at zero interest rates?." *NBER Macroeconomics Annual* 25.1 (2011) : 59-112.

Frère, Quentin, Matthieu Leprince, and Sonia Paty. "The impact of intermunicipal cooperation on local public spending." *Urban studies* 51.8 (2014) : 1741-1760.

Gechert, Sebastian, and Ansgar Rannenberg. "Which fiscal multipliers are regime-dependent? A meta-regression analysis." *Journal of Economic Surveys* 32.4 (2018) : 1160-1182.

Gajdos, Thibault. "Les fondements axiomatiques de la mesure des inégalités." *Revue d'économie politique* 111.5 (2001) : 683-719.

Hicks, John R. "Mr. Keynes and the "classics"; a suggested interpretation." *Econometrica : journal of the Econometric Society* (1937) : 147-159.

Keynes, John Maynard. "1936." *The general theory of employment, interest and money* 7 (1973).

Kydland, Finn E., and Edward C. Prescott. "Rules rather than discretion : The inconsistency of optimal plans." *Journal of political economy* 85.3 (1977) : 473-491.

Lenoble-Liaud, Hélène. "L'union monétaire européenne : faut-il avoir peur du passager clandestin?." *Revue d'économie politique* 111.6 (2001) : 861-884.

Madiès, Thierry, Sonia Paty, and Yvon Rocaboy. "Externalités fiscales horizontales et verticales." *Revue d'économie politique* 115.1 (2005) : 17-63.

Muth, John F. "Rational expectations and the theory of price movements." *Econometrica* :

Journal of the Econometric Society (1961) : 315-335.

Ramey, Valerie A. "Can government purchases stimulate the economy?." *Journal of Economic Literature* 49.3 (2011) : 673-85.

Sargent, Thomas J., and Neil Wallace. "' Rational' expectations, the optimal monetary instrument, and the optimal money supply rule." *Journal of political economy* 83.2 (1975) : 241-254.

Tiebout, Charles M. "Exports and regional economic growth." *Journal of political economy* 64.2 (1956) : 160-164.

Von Hagen, Jürgen, and Barry Eichengreen. "Federalism, fiscal restraints, and European monetary union." *The American Economic Review* 86.2 (1996) : 134-138.

Chapitre 2

Réduction du ratio de dette publique : quels instruments pour quels effets ?¹

2.1 Introduction

La crise financière et, plus largement, économique survenue fin 2007 - début 2008, a contraint les Etats européens à intervenir massivement afin de sauver le système financier et contrecarrer le ralentissement économique. Nous avons alors assisté à une forte hausse des dettes souveraines qui ont atteint des niveaux sans précédent depuis la seconde guerre mondiale (voir figure 2.1).

Si les politiques de relance ont bien eu lieu (voir *infra*), leurs durées ont été courtes. Pour beaucoup de pays, le niveau de dette publique ainsi que les engagements européens (pour les pays de l'UE) les ont contraint à mener une politique d'austérité budgétaire dans le but d'assainir les finances publiques. Cependant, les résultats de telles politiques apparaissent très contrastés.

1. Une première version de ce chapitre a été publiée en tant que Document de travail : Egron B. (2018), "Réduction du ratio de dette publique : quels instruments pour quels effets?", Working Paper EconomiX 2018-1, et est en révision auprès de la *Revue d'Economie Politique*.

Pour certains pays (Grèce, Espagne, France, Portugal...) aucune diminution du ratio de dette publique n'a pu être amorcée, pour d'autres (Pays-Bas, Irlande...), les temps de réponse à la politique de consolidation furent parfois longs. Ces observations viennent donc naturellement questionner la validité des politiques de consolidation budgétaire lorsqu'il s'agit de réduire le ratio de dette publique. En partant de ce constat, l'objet de ce chapitre est de déterminer les conditions sous lesquelles les politiques de consolidation budgétaire peuvent conduire à la réduction du ratio de dette publique. Plus généralement, nous nous interrogeons sur la possibilité de prescrire une politique de réduction du ratio de dette qui soit la plus efficace possible étant donné les conditions économiques prévalant lors de sa mise en œuvre.

Cette problématique induit un questionnement sur la composition de l'ajustement budgétaire (réduction des dépenses et/ou hausse des recettes) ainsi que sur les conditions économiques favorisant la capacité de ce dernier à réduire le ratio de dette (conditions monétaires, état des finances publiques, position dans le cycle...). Notons que la question de la composition de l'ajustement fait apparaître une certaine contradiction dans la littérature. En effet, les études analysant directement l'effet des épisodes de consolidation budgétaire sur le ratio de dette publique (Alesina et Perotti (1995, 1996); Von Hagen et Strauch (2001); Von Hagen, Hallet et Strauch (2002); Ardagna (2009); Guichard et al. (2007); Molnar (2012)) sont quasiment unanimes à prescrire un ajustement budgétaire par une baisse des dépenses plutôt que par une hausse des recettes. Dans certains cas, des effets anti-keynésiens ont même pu être mis en évidence (Alesina et Ardagna (2009)). A l'inverse, les études s'intéressant à l'évaluation des multiplicateurs (Blanchard et Perotti (2002); Perotti (2004); Biau et Girard (2005); Mountford et Uhlig (2009)) semblent aboutir en général au fait que, à court terme, le multiplicateur de dépenses est positif et plus élevé que le multiplicateur de recettes; le signe de ce dernier n'étant pas toujours bien défini (Boussard et al. (2013)). Cela marque une contradiction avec les articles précédents dans la mesure où une baisse des dépenses devrait davantage impacter à la baisse le PIB et, en conséquence, le ratio de dette à la hausse. De plus, cette perte d'acti-

tivité économique devrait aussi impacter à la baisse les recettes publiques annulant en partie la baisse du déficit primaire. Dans ce cadre méthodologique, Eyraud et Weber (2013) font le lien entre l'estimation des multiplicateurs et l'impact des politiques de consolidation budgétaire. Ils montrent alors qu'une politique de consolidation budgétaire peut engendrer à court terme une hausse du ratio de dette publique. Cependant, leur modèle ne distingue pas les instruments (recettes/dépenses) puisque les auteurs considèrent directement le surplus primaire. De plus, ils ne tiennent pas compte des conditions économiques et du fait que celles-ci peuvent influencer la valeur des multiplicateurs.

Notre étude prolonge celle de Eyraud et Weber (2013), en tenant compte du fait que les variables intervenant dans la dynamique du ratio de dette n'entretiennent pas les mêmes relations d'interdépendance et d'auto-corrélation selon que l'économie se trouve en phase de récession ou en phase d'expansion. Pour cela, nous recourons à un modèle VAR à changement de régime. De plus, nous effectuons la distinction entre la baisse des dépenses et la hausse des recettes plutôt que de considérer directement la baisse du déficit primaire. Prenant comme cas d'application la France, les principaux résultats que nous mettons en évidence sont les suivants : (1) nous observons bien une contracyclicité du multiplicateur de dépenses publiques, ce qui vient confirmer les résultats obtenus par Auerbach et Gorodnichenko (2012) (AG (2012) par la suite) et Batini et al. (2012). (2) Une politique de consolidation peut engendrer à court terme une augmentation du ratio de dette publique. Ce résultat est déjà présent chez Eyraud et Weber (2013), notre principale contribution consiste alors à montrer que (3) ce phénomène est significativement plus fort en phase de récession. (4) De plus, à partir de nos estimations nous prescrivons, dans le but de réduire le ratio de dette, un renforcement de l'intervention publique en phase de récession consistant en une augmentation des dépenses et des recettes, soutenu à court terme par une politique monétaire accommodante. Au total, il ressort que la réduction des dépenses publiques en phase de récession économique n'est pas une solution efficace à court terme pour réduire le ratio de dette publique.

Le chapitre est organisé comme suit. Dans la section 2.2 nous présentons un certain nombre de faits stylisés relatifs à l'Union Européenne, venant justifier notre problématique ainsi que notre méthodologie. En section 2.3, nous exposons les principaux résultats théoriques et empiriques issus de la littérature. Les sections 2.4 et 2.5 sont consacrées à la présentation de notre méthodologie et de nos données. Les principaux résultats de nos estimations sont reportés en section 2.6 et nous évaluons leur robustesse en section 2.7. Enfin, la section 2.8 propose une discussion des deux approches méthodologiques rencontrées dans la littérature et la section 2.9 conclut le chapitre.

2.2 Faits stylisés

2.2.1 2008-2010 : crise, politique de relance et explosion du ratio de dette

Suite à la crise de 2008 nous observons une très forte hausse du ratio de dette en Europe. En effet, la figure 2.1 nous indique une augmentation de 30 points en moyenne pour les pays de l'Union Européenne. Pour certains pays, comme l'Espagne, le Portugal, l'Irlande ou la Grèce, l'augmentation est même plus importante. Cette hausse peut avoir de multiples causes : augmentation des dépenses publiques, augmentation de la charge de la dette, baisse des recettes publiques ou bien diminution du taux de croissance du PIB. Bien entendu toutes ces causes peuvent jouer un rôle simultanément tout en entretenant un lien d'interdépendance, dont nous tiendrons compte lors de notre modélisation économétrique. La figure 2.2 nous indique que la cause principale à l'augmentation du ratio de dette se situe dans le décrochage à la baisse des recettes publiques à partir de 2008 sans que les dépenses publiques soient ajustées à cette nouvelle trajectoire (courbes rouges). Dès lors, l'augmentation du déficit entraîne mécaniquement une hausse du ratio de dette. Le second effet majeur est la chute du taux de croissance du PIB

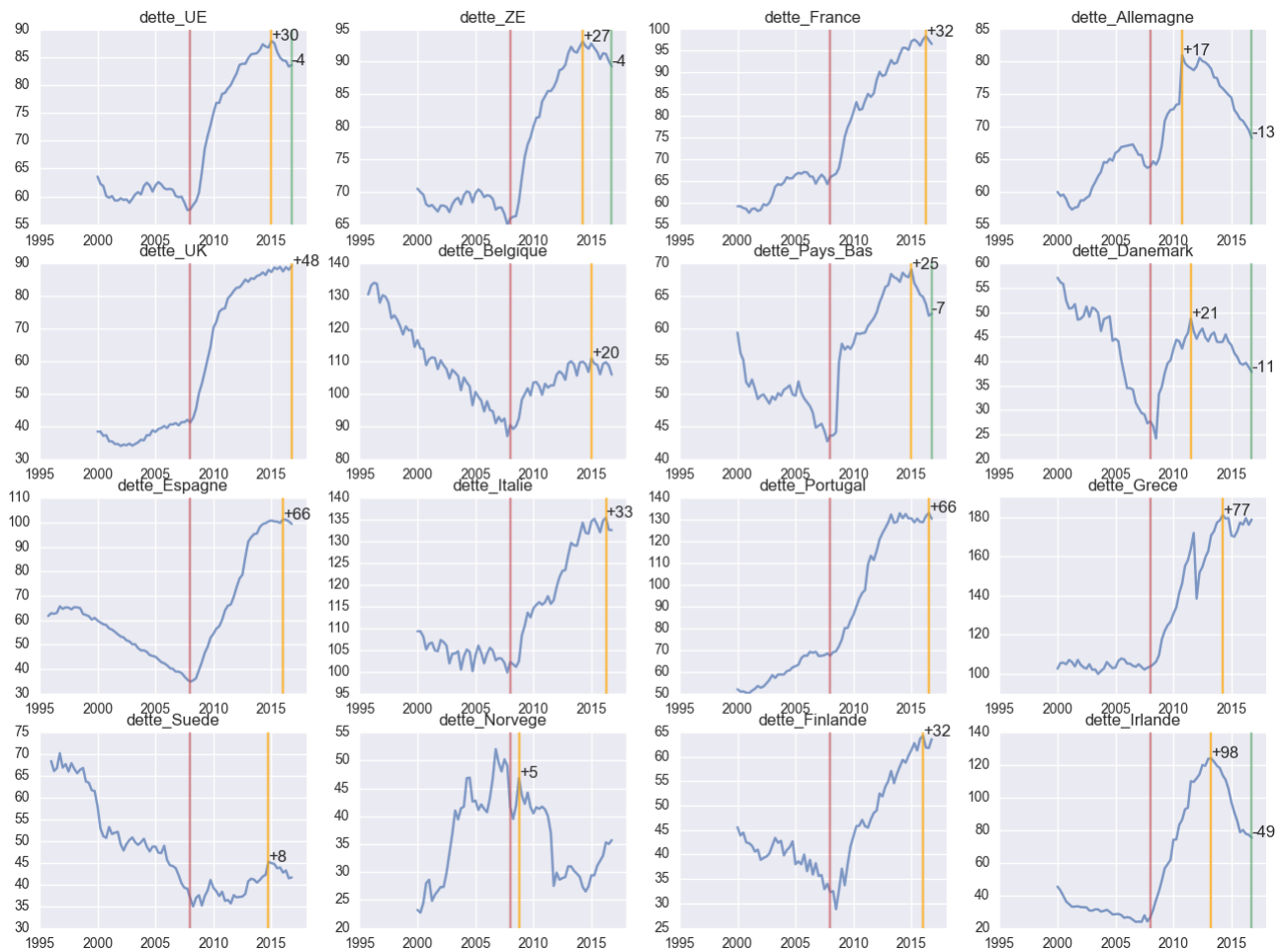
(figure 2.3), contribuant à affaiblir le dénominateur du ratio de dette. Il est important de noter que pour la plupart des pays (excepté le Royaume-Uni et la Suède) la trajectoire des dépenses publiques conserve, entre 2008 et 2010, sa tendance d'avant crise. Ce fait peut être qualifié de politique de relance dans la mesure où il marque une très nette progression des dépenses publiques en part de PIB. Au total, nous pouvons conclure que la très forte augmentation du ratio de dette publique suite à la crise de 2008 est avant tout l'effet de l'effondrement du taux de croissance du PIB ainsi que des recettes publiques, ces deux phénomènes étant étroitement liés par le fait que les recettes publiques sont fortement indexées sur le PIB. Ainsi, l'explosion de la dette publique révèle davantage un problème de perte d'activité économique qu'un problème de dépenses publiques non contrôlées.

2.2.2 2010-2016 : Consolidation budgétaire, des résultats très contrastés

À partir de 2010, une politique de consolidation budgétaire - consistant à réduire l'écart entre les dépenses et les recettes publiques - est amorcée dans la plupart des pays de l'UE. Sur la figure 2.1, nous avons reporté les tendances (courbes oranges) de ces deux variables sur l'intervalle 2010-2016, il est alors très clair que les dépenses et les recettes entament une convergence à partir de 2010. Le mode de convergence diffère entre les pays : pour certains (Allemagne, France, Belgique) cela passe davantage par une augmentation de la croissance des recettes, pour d'autres (Grèce, Portugal, Espagne) par un ralentissement de la croissance des dépenses.

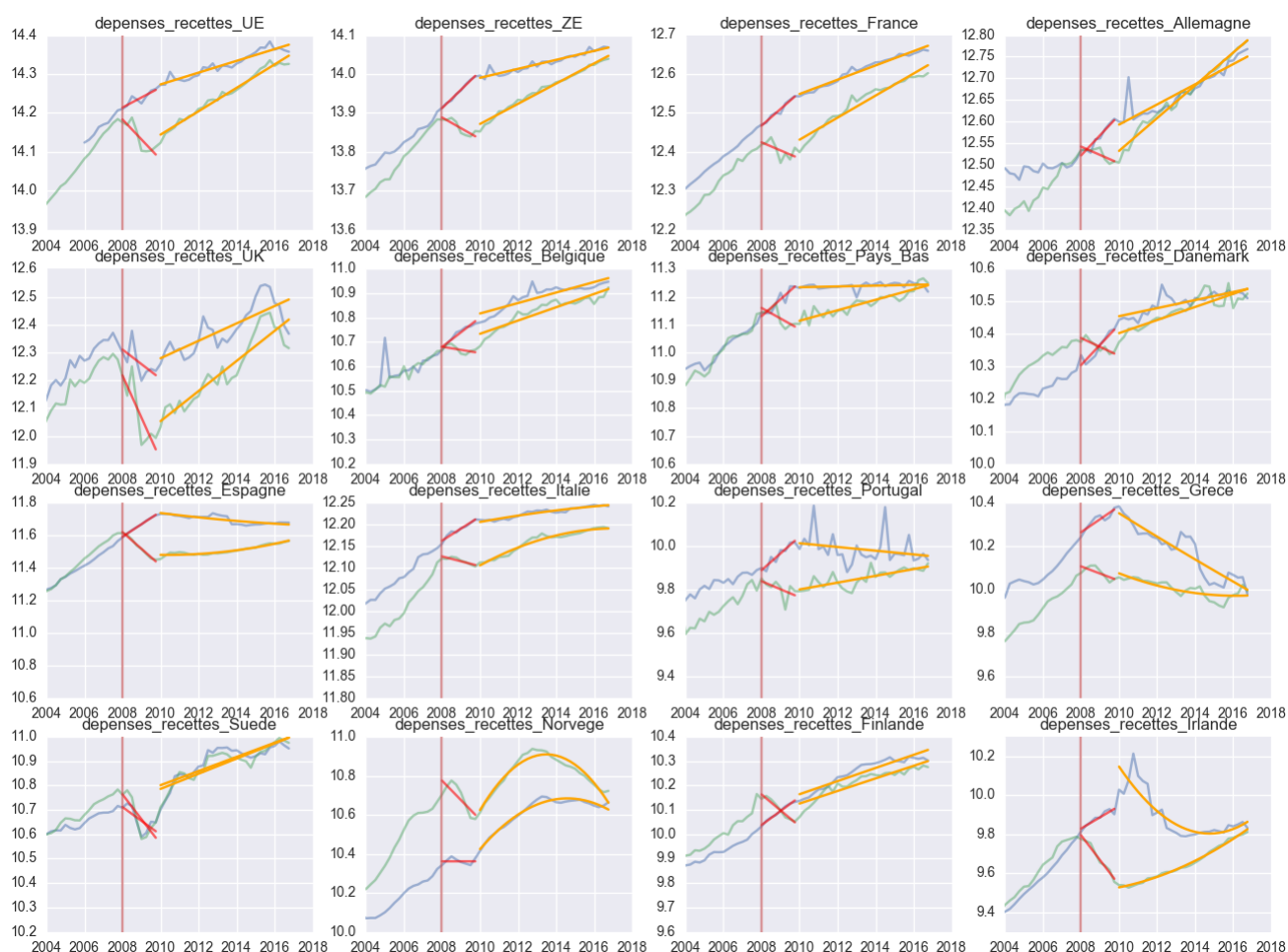
Du constat précédent, nous en déduisons que, pour la majorité des pays, nous devrions assister à une baisse du ratio de dette publique ou du moins à un ralentissement de sa croissance à partir de 2010. Cependant, la figure 2.2 nous montre que les résultats sont beaucoup plus contrastés. Nous observons effectivement une baisse du ratio de dette pour certains pays comme l'Allemagne (-13 pts entre 2011 et 2017), l'Irlande (-49 pts entre 2013 et 2017), le Danemark (-11

FIGURE 2.1 – Ratio de dette publique pour différents pays de l'UE



La droite rouge marque la crise économique (2008), la droite orange indique le niveau le plus élevé atteint par le ratio dette publique sur la période suivant la crise. Il est également précisé l'écart en points de pourcentage entre le ratio de dette en 2008 et le moment où il est le plus élevé. Pour certains pays la droite verte indique qu'ils ont réussi à amorcer une réduction du ratio de dette publique, on note alors le montant de cette réduction entre le moment où le ratio de dette était le plus élevé et le ratio de dette au quatrième trimestre 2016. Source des données : Eurostat.

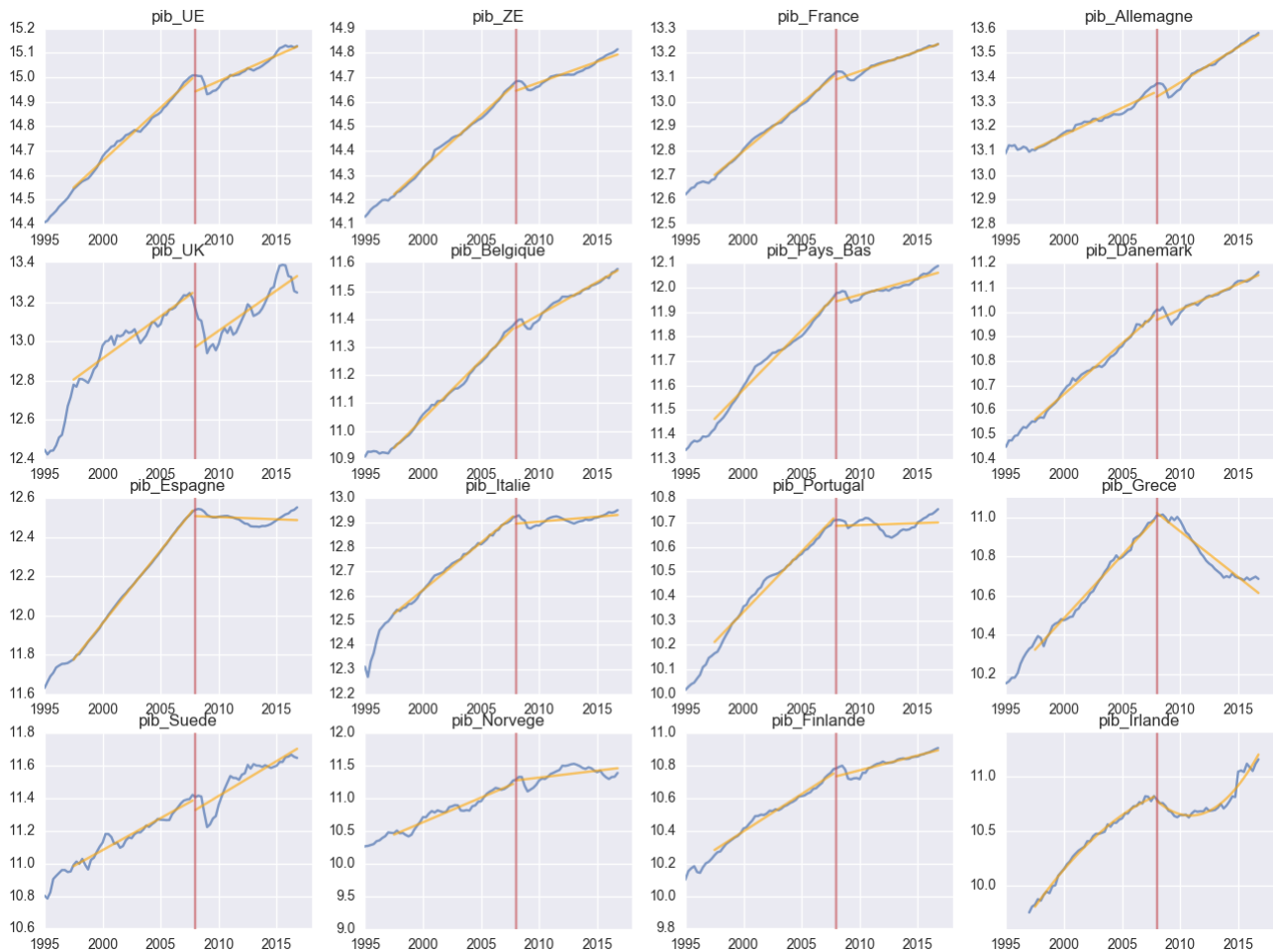
FIGURE 2.2 – Dépenses et recettes publiques en logarithme pour différents pays de l'UE



Les dépenses sont en bleu alors que les recettes sont en vert, la droite verticale rouge marque la crise économique (2008). Les droites rouge et orange permettent d'apprécier la tendance des deux trajectoires sur la période 2008-2010 puis sur la période 2010-2017. Plus les droites orange tendent à se rapprocher et plus cela marque la mise en place d'une politique de contraction budgétaire (baisse des dépenses et/ou hausse des recettes). Source des données : Eurostat.

pts entre 2011 et 2017) et les Pays-Bas (-7 pts entre 2015 et 2017). Pour l'ensemble de l'UE, il ressort également une baisse du ratio de dette mais celle-ci est beaucoup plus faible (-4 pts

FIGURE 2.3 – PIB en logarithme pour différents pays de l'UE



La droite rouge marque la crise économique (2008), les droites orange indiquent la tendance du PIB avant et après la crise économique. Source des données : Eurostat.

entre 2015 et 2017) et n'a lieu que cinq ans après le début de la politique de consolidation. Pour d'autres pays, les résultats sont moins probants. En effet, nous n'observons pas de diminution significative, mais une augmentation continue du ratio de dette sur la période 2010-2015 avant de se stabiliser. Enfin, pour quelques pays, le constat est plus problématique. En effet, pour l'Espagne, l'Italie, le Portugal et la Grèce (et dans une moindre mesure la France) nous obser-

vons une constance dans l'augmentation du ratio de dette entre 2010 et 2015, alors même que les politiques de consolidation sont à l'œuvre. L'explication à ce phénomène est relativement simple puisque ce sont ces mêmes pays dont le taux de croissance du PIB a subi la plus forte baisse suite à la crise de 2008. Ainsi, malgré le creusement du déficit impactant négativement le numérateur du ratio de dette, ce dernier continue d'augmenter à la même vitesse compte tenu de la diminution du dénominateur.

Bien sûr, il existe une interdépendance forte entre les recettes, les dépenses et le PIB. Il est évident que les choix effectués en matière de politique budgétaire (trajectoires des recettes et des dépenses) influencent la trajectoire du PIB qui, elle-même, vient impacter les recettes et les dépenses. Compte tenu de ce phénomène, il est opportun de remarquer que les pays échouant à ralentir la progression du ratio de dette sont les seuls à avoir effectué un ajustement du déficit *via* une baisse des dépenses publiques en niveau. De plus, ils présentent un niveau de recettes publiques en très faible augmentation, voire en diminution pour la Grèce. Le mécanisme théorique suggéré par ces faits stylisés est relativement simple. La baisse des dépenses publiques (réduction du déficit) provoque un ralentissement économique et contribue à la baisse du PIB (baisse du dénominateur du ratio de dette), cette dernière impacte négativement les recettes publiques ce qui vient annuler, au moins en partie, la réduction du déficit amorcée par la diminution des dépenses publiques². Ainsi, l'effet final sur le ratio de dette devient ambigu. Il dépend de la sensibilité du PIB aux variations des dépenses publiques (multiplicateur de dépenses) et de la sensibilité des recettes aux variations du PIB.

Bien que les faits stylisés suggèrent un tel mécanisme, une validation statistique est nécessaire afin d'évaluer si les multiplicateurs sont suffisamment élevés pour engendrer une hausse du ratio de dette à la suite d'une baisse des dépenses.

2. Une présentation plus formelle d'un tel mécanisme est effectuée dans Denes, Eggertsson et Gilbukh (2013) à travers un modèle DSGE.

2.3 Revue de la littérature

Lorsque l'on étudie la capacité des politiques de consolidation budgétaire à réduire le ratio de dette, deux questions se posent naturellement : (1) par quels moyens doit-on opérer la consolidation budgétaire ? (2) et dans quelles conditions économiques ? Plusieurs pans de la littérature peuvent être mobilisés pour répondre à ces deux questions. L'étude des multiplicateurs (de dépenses et de recettes) apparaît comme essentielle dans la mesure où l'efficacité d'une politique de consolidation tient à sa capacité à ne pas trop impacter l'activité économique. Plus généralement, le relevé historique des épisodes de consolidation budgétaire et l'étude économétrique de leurs effets sur le ratio de dette publique constituent une littérature en relation directe avec notre problématique. Revenons sur ces deux littératures.

2.3.1 L'étude des multiplicateurs

Les multiplicateurs : résultats théoriques

Le cadre théorique de la macroéconomie keynésienne traditionnelle offre des conclusions relativement claires à propos des multiplicateurs. Une réduction des dépenses et/ou une hausse des recettes de l'Etat entraînent une réduction du PIB à court terme par une baisse de la demande globale. La taille des multiplicateurs dépend toutefois des conditions économiques, en particulier l'existence de capacités de production non utilisées, le degré d'ouverture de l'économie, le régime de change ou encore le degré de flexibilité des prix. Au travers des modèles DSGE (*Dynamic Stochastic General Equilibrium*), une nouvelle littérature macroéconomique théorique s'est développée dans l'analyse des multiplicateurs. Dans ce cadre, il est important de distinguer les effets de demande des effets d'offre. Baxter et King (1993), à travers un modèle de type RBC (*Real Business Cycle*), montrent qu'un multiplicateur supérieur à l'unité peut être associé à une relance budgétaire permanente. Cependant, ce multiplicateur élevé n'est permis que par le fait que la production incorpore un capital public dont l'investissement public

permet l'augmentation, ce qui correspond à un pur effet d'offre. Le capital étant plus important, par l'apport de capital public, la production augmente en conséquence. Ce mécanisme ne peut toutefois prendre place qu'à moyen/long terme. Ce qui nous intéresse davantage est la mise en évidence d'un effet demande, c'est à dire que l'accroissement de la demande globale par la consommation et/ou l'investissement public entraîne une augmentation de l'activité à court terme. Nous allons donc nous concentrer sur les travaux traitant de la capacité des relances budgétaires à stimuler l'activité économique à travers le canal de la demande. Dans ce cadre, Woodford (2011) constitue une bonne exposition concernant les différents mécanismes théoriques intervenant dans la détermination de la valeur des multiplicateurs. En particulier, l'analyse néoclassique traditionnelle réalisée à partir de modèles RBC peut difficilement faire apparaître des multiplicateurs proches de l'unité. Le mécanisme associé à ce résultat est simple dans la mesure où une relance budgétaire se traduira immédiatement par un appauvrissement des ménages qui réduiront leur consommation en conséquence venant annuler en partie la relance de la demande globale³. Ce mécanisme fonctionne même si les dépenses publiques sont financées par endettement dans la mesure où l'équivalence ricardienne assure l'indifférence entre le financement par taxe et par endettement. De plus, l'accroissement de la demande globale est absorbé en partie par une augmentation des prix et pas seulement par une augmentation des quantités. Woodford (2011) montre aussi que l'introduction de la concurrence monopolistique ne permet pas de modifier ce résultat.

L'émergence de l'école des Nouveaux Keynésiens a permis de relancer l'intérêt sur les effets de la politique budgétaire et la valeur des multiplicateurs. En effet, l'abandon de l'hypothèse de parfaite flexibilité des prix impose aux entreprises de répondre à une hausse de la demande par une augmentation des quantités, ce qui permet d'accroître le multiplicateur. Dès lors, les effets de la politique budgétaire sont directement influencés par la politique monétaire et la règle de fixation du taux d'intérêt (Davig et Leeper (2011); Christiano et al. (2011); Eggertsson

3. Voir notamment Woodford (2011).

(2006)). Eggertsson (2011) montre qu'en présence de taux d'intérêt nominaux proches de zéro le multiplicateur de dépense est multiplié par 5 et le multiplicateur de recette devient positif alors que ce dernier est négatif en temps normal. Enfin, l'incorporation de contraintes financières pesant sur les agents économiques (Gali et al. (2007)) permet également d'augmenter la valeur du multiplicateur de dépenses dans la mesure où cela implique une forte dépendance entre la consommation des agents à l'instant t et leur revenu à la même date, évitant ainsi que les dépenses de l'État viennent se substituer aux dépenses des ménages. Au total, ces modèles ont mis en avant qu'en période de forte récession, combinant des taux d'intérêt plancher et d'importantes frictions financières sur les agents, les multiplicateurs pouvaient largement dépasser l'unité.

Toujours d'un point de vue théorique, Denes, Eggertsson et Gilbukh (2012) et Bi, Leeper et Leith (2013) s'intéressent plus particulièrement à la capacité des politiques de consolidation à réduire le ratio de dette publique. Denes, Eggertsson et Gilbukh (2012) montrent que les effets que peuvent produire une réduction des dépenses publiques et/ou une augmentation des recettes publiques sur le déficit public dépendent fortement des conditions économiques. En particulier, les auteurs montrent que les politiques d'austérité sont moins efficaces lorsque les taux d'intérêt nominaux sont proches de zéro. Dans ces circonstances l'économie est entièrement déterminée par le côté de la demande, c'est à dire que la quantité produite est totalement déterminée par la volonté d'achat des agents et non par la volonté de production. Des politiques d'austérité peuvent dès lors conduire à une hausse du déficit public du fait de la trop grande détérioration de la demande globale. Les auteurs soulignent alors l'importance de stimuler la demande globale à court terme par de la dépense publique. Bi, Leeper et Leith (2013) s'intéressent plus précisément à la capacité des épisodes de consolidation à être expansionnistes et donc à réduire le ratio de dette. Ils concluent que la configuration requise afin d'observer un tel résultat est restrictive, de sorte qu'actuellement, il est peu vraisemblable que des politiques d'austérité puissent engendrer des épisodes d'expansions.

Les multiplicateurs : résultats empiriques

Depuis l'article de Blanchard et Perotti (2002), une importante littérature empirique s'est développée autour de l'évaluation des multiplicateurs à partir de modèles VAR, en distinguant à la fois l'instrument (les multiplicateurs de dépenses publiques, les multiplicateurs de recettes publiques) et l'horizon temporel (les multiplicateurs de court terme, les multiplicateurs de long terme). Les deux tableaux (figures 2.4 et 2.5) repris de l'article de Boussard et al. (2013) résument les différents travaux effectués et les valeurs obtenues pour les multiplicateurs.

FIGURE 2.4 – Multiplicateur de dépenses

| Studies | Sample | Short-term multiplier[1] | Medium-term Multiplier [2] | Identification strategy[3] |
|---------------------------------------|---------------------------|---|------------------------------|---|
| Blanchard and Perotti (2002) | US (1947:1-1997:4) | 0.5 | 0.5[4] | Decision lags in policy making and imposition of contemporaneous GDP elasticities |
| Perotti (2004) | US (1960:1-1979:4) | 1.29 | 1.4 | Blanchard-Perotti |
| | US (1980:1-2001:4) | 0.36 | 0.28 | |
| Gali et al. (2007) | US (1954:1-2003:4) | 0.7 | 1.74 | Cholesky decomposition |
| Ramey (2011) | US (1939:1-2008:4) | 0.6 to 1.2 | No estimate | Narrative approach |
| Mountford and Uhlig (2009) | US (1955:1-2000:4) | 0.65 ^[5] , 0.46, 0.28 ^[6] | -0.22 | Sign restrictions on impulse responses |
| Fatas and Mihov (2001) | US (1960:1 - 1996:4) | Similar to Gali et al. (2007) | Similar to Gali et al.(2007) | Cholesky decomposition |
| Perotti (2004) | Germany (1960:1-1974:4) | 0.36 | 0.28 | Blanchard-Perotti |
| | Germany (1975:1-1989:4) | | | |
| Heppke - Falk et al. (2006) | Germany (1974:1-2004:4) | 0.62 | 1.27 | Blanchard-Perotti |
| Baum and Koester (2011) | Germany (1976:1-2009:4) | 0.7 | 0.69 | Blanchard-Perotti and Threshold VAR |
| Benassy-Quere and Cinadomo (2006) | Germany (1971:1-2004:4) | 0.23 | -0.23 | FVAR and Blanchard-Perotti |
| Biau and Girard (2005) | France (1978:1-2003:4) | 1.9 | 1.5 | Blanchard-Perotti |
| Giordano et al. (2007) | Italy (1982:1-2004:4) | 1.2 | 1.7 | Blanchard-Perotti |
| De Castro (2006) | Spain (1980:1-2001:2) | 1.14-1.54 | 0.58-1.04 | Cholesky decomposition |
| De Castro and Hernández de Cos (2008) | Spain (1980:1-2004:4) | 1.3 | 1 | Blanchard-Perotti |
| De Castro and Fernández (2011) | Spain (1981:1-2008:4) | 0.94 | 0.55 | Blanchard-Perotti |
| IMF (2005) | Portugal (1995:3-2004:4) | 1.32 | 1.07 | Blanchard-Perotti |
| Perotti (2004) | UK (1963:1-1979:4) | 0.48 | 0.27 | Blanchard-Perotti |
| | UK (1980:1-2001:2) | -0.27 | -0.6 | |
| Benassy-Quere and Cinadomo (2006) | UK (1971:1-2004:4) | 0.12 | -0.3 | FVAR and Blanchard-Perotti |
| Buriel et al. (2010) | Euro Area (1981:1-2007:4) | 0.87 | 0.85 | Blanchard-Perotti |

Source : Boussard et al. (2013)

Les modèles retenus dans ces travaux intègrent principalement comme variables endogènes le

FIGURE 2.5 – Multiplicateur de recettes

| Studies | Sample | Short-term multiplier | Medium-term multiplier | Identification strategy |
|-----------------------------------|--------------------------|----------------------------|----------------------------|---|
| Blanchard and Perotti (2002) | US (1947:1-1997:4) | Within range -0.7 and -1.3 | Within range -0.4 and -1.3 | Decision lags in policy making and imposition of contemporaneous GDP elasticities |
| Perotti (2004) | US (1960:1-1979:4) | -1.41 | -23.87 | Blanchard-Perotti |
| | US (1980:1-2001:4) | 0.7 | 1.55 | |
| Favero and Giavazzi (2007) | US (1980:1-2006:4) | 0.29 | 0.65 | Narrative approach |
| Mountford and Uhlig (2009) | US (1955:1-2000:4) | -0.16 | -2.35 | Sign restrictions on impulse responses |
| Romer and Romer (2010) | US (1945:1-2007:4) | | -3 | Narrative approach |
| Perotti (2004) | Germany (1960:1-1974:4) | 0.29 | -0.05 | Blanchard-Perotti |
| | Germany (1975:1-1989:4) | -0.04 | 0.59 | |
| Baumand Koester (2011) | Germany (1976:1-2009:4) | -0.66 | -0.53 | Blanchard-Perotti and TVAR |
| Benassy-Quere and Cimadomo (2006) | Germany (1971:1-2004:4) | -1.17 | -1.08 | FVAR and Blanchard-Perotti |
| Biau and Girard (2005) | France (1978:1-2003:4) | -0.5 | -0.8 | Blanchard-Perotti |
| Giordano et al. (2007) | Italy (1982:1-2004:4) | 0.16 | | Blanchard-Perotti |
| De Castro (2006) | Spain (1980:1-2001:2) | 0.05 | 0.39 | Cholesky decomposition |
| Afonso and Sousa (2009) | Portugal (1979:1-2007:4) | + | + | Blanchard-Perotti |
| Perotti (2004) | UK (1963:1-1979:4) | -0.23 | -0.21 | Blanchard-Perotti |
| | UK (1980:1-2001:2) | 0.43 | 0.7 | |
| Benassy-Quere and Cimadomo (2006) | UK (1971:1-2004:4) | -0.23 | -0.07 | FVAR and Blanchard-Perotti |
| Cloyne (2011) | UK (1945-2010) | Between -0.5 and -1.0 | -2.5 | Narrative approach |
| Burriel et al. (2010) | Euro Area (1981-2007) | -0.63 | -0.49 | Blanchard-Perotti |

Source : Boussard et al. (2013)

PIB, les dépenses de l'Etat et les revenus de l'Etat. Les résultats obtenus sont assez disparates et dépendent en particulier du pays étudié et de la période choisie. Si certains auteurs parviennent à mettre en évidence des multiplicateurs de dépenses supérieurs à l'unité (Biau et Girard (2005), Giordano et al. (2007), De Castro et Hernandez de Cos (2008)), pour la plupart des études ce sont des multiplicateurs compris entre zéro et un qui ressortent. Le multiplicateur de recettes semble être moins important que le multiplicateur de dépenses et, contrairement à ce dernier, son signe n'est pas bien défini à travers les différentes études menées. Notons que l'article de Favero et Giavazzi (2007) a comme particularité d'incorporer le ratio de dette publique comme variable exogène, avec comme justification le fait que l'État fixe la trajectoire de ses recettes et de ses dépenses aussi en fonction de la soutenabilité de sa dette. Cependant,

la limite de ces travaux est qu'ils ne tiennent pas compte des changements dans les conditions économiques. Ainsi, les multiplicateurs obtenus ne sont que des multiplicateurs "moyens" sur la période étudiée, ce qui est restrictif puisqu'il semblerait que la taille des multiplicateurs puisse varier fortement dans le temps.

Dans cette optique, plusieurs études ont cherché à incorporer le cycle économique comme l'un des déterminants des multiplicateurs. L'approche méthodologique adoptée est celle des modèles VAR à changement de régime. La variable de transition devant dissocier le régime d'expansion du régime de récession, une moyenne mobile du taux de croissance du PIB est généralement choisie. Cette approche a l'avantage de conserver dans une certaine mesure la méthodologie des modèles VAR (interne à chacun des régimes) et donc de se placer dans la continuité des anciens travaux et de faciliter ainsi la comparaison des résultats. Il s'agit donc davantage d'une généralisation de la méthode d'estimation des multiplicateurs que d'un changement de paradigme.

L'article de référence initiant cette approche est celui de AG (2012), les auteurs y estiment les multiplicateurs sur données américaines (composées du PIB, des dépenses et des recettes de l'État) à partir d'un modèle à changement de régime de type STVAR (*Smooth Transition Vector Autoregressive*). Alors que le modèle linéaire prédit un multiplicateur de dépenses ne dépassant pas 0,9, le modèle STVAR donne un multiplicateur de dépenses de 0,5 en phase d'expansion et supérieur à 2 en phase de récession. Les auteurs parviennent donc très clairement à mettre en évidence une contracyclicité du multiplicateur de dépenses. Par la suite, plusieurs articles sont venus confirmer ce résultat. En utilisant une méthodologie quelque peu différente⁴ de AG (2012), Caggiano et al. (2014) aboutissent à des résultats plus contrastés dans la mesure où la contracyclicité des multiplicateurs n'est obtenue que pour des "événements rares", c'est-à-dire des récessions ou des expansions dépassant les deux écarts types. Enfin, Batini et al. (2012)

4. Les auteurs procèdent au calcul de GIRF (fonctions d'impulsion/réponse généralisées) et incluent dans leur spécification les anticipations sur les dépenses publiques.

reproduisent une étude relativement proche⁵ de AG (2012) mais sur un échantillon plus large de pays (USA, France, Japon, Italie, Zone Euro). Leurs estimations mettent aussi en évidence une contracyclicité du multiplicateur de dépenses, les résultats associés à la France étant les suivants : un multiplicateur instantané de 1,39 en phase d'expansion et de 2,62 en phase de récession. Cependant, à long terme (multiplicateurs cumulés) la différence s'estompe, après 8 trimestres le multiplicateur est de 1,88 en expansion contre 1,79 en récession. Bien que l'article de Batini et al. (2012) concerne davantage l'évaluation des multiplicateurs en tenant compte du cycle économique, les auteurs analysent les conséquences de leurs résultats sur la dynamique du ratio de dette. Pour cela, ils font appel à un modèle théorique qu'ils associent avec les estimations issues de leur modèle TVAR. Ils montrent alors que plus la politique de consolidation est brutale et moins elle sera efficace afin de réduire le ratio de dette. Au contraire, les auteurs préconisent des politiques de consolidation lissées dans le temps et passant davantage par une hausse des recettes que par une baisse des dépenses.

Dans les différents articles cités précédemment, l'objet principal reste l'évaluation des multiplicateurs et le lien avec le ratio de dette publique n'est pas incorporé de manière à pouvoir évaluer l'impact des politiques budgétaires sur le ratio de dette publique. Favero et Giavazzi (2007) font exception puisque les auteurs introduisent une spécification économétrique couplant un modèle VAR avec l'équation comptable régissant la dynamique du ratio de dette ; ce faisant leur modèle permet le calcul de fonctions de réponse impulsionnelles (IRF) sur le ratio de dette à partir d'un choc de politique budgétaire. Cependant, les auteurs ne mènent pas cette étude, leur objectif premier étant de montrer l'importance de la prise en compte de la contrainte budgétaire de l'État dans l'estimation des multiplicateurs. Par contre, plusieurs études menées par le FMI (Cherif et Hasanov (2010, 2012), Eyraud et Weber (2013)) reprennent la spécification introduite par Favero et Giavazzi (2007) avec pour finalité d'évaluer l'effet d'une politique de consolidation budgétaire sur le ratio de dette publique. Cherif et Hasanov (2010,

5. Les auteurs estiment un modèle TVAR et calculent les GIRF.

2012) concluent qu'une baisse du déficit primaire permet de faire diminuer le ratio de dette mais cet effet n'est pas robuste aux différentes spécifications testées dans l'article. De même, ils concluent que l'inflation n'est pas un moyen efficace pour réduire le ratio de dette, alors que le PIB semble être le déterminant principal de la dynamique du ratio de dette. Eyraud et Weber (2013) étendent l'étude de Cherif et Hasanov (2010, 2012) au cas du Japon et en la complétant par des simulations réalisées à partir de l'équation comptable régissant la dynamique du ratio de dette. Les auteurs montrent qu'une politique de consolidation est d'autant plus susceptible d'engendrer une hausse du ratio de dette que celui-ci est initialement élevé et que le multiplicateur est important. Cet effet contre-intuitif peut être obtenu pour des valeurs tout à fait réalistes, à savoir un ratio de dette à 60% et un multiplicateur fixé à l'unité. Ce résultat est corroboré par une analyse empirique sur le cas du Japon (qui présente un fort niveau d'endettement et qui est supposé avoir un multiplicateur élevé). En reprenant une méthodologie très proche de celle de Cherif et Hasanov (2010, 2012), ils montrent qu'une réduction du déficit primaire entraîne une baisse du PIB, de l'inflation et une augmentation du ratio de dette.

2.3.2 L'étude des épisodes de consolidation

Parallèlement à l'étude des multiplicateurs, une littérature plus spécifique, initiée en particulier par Alesina et Perotti (1995), s'est développée sur l'analyse des épisodes de consolidation. Cette littérature s'intéresse aux déterminants du déclenchement et du succès des épisodes de consolidation budgétaire, le succès d'un épisode de consolidation budgétaire étant entendu comme le fait d'avoir abouti à une stabilisation/diminution du ratio de dette publique. La méthodologie principalement employée consiste dans une première étape à retravailler les données : les épisodes de consolidation budgétaire sont identifiés en appliquant un seuil à la baisse sur le déficit primaire ajusté du cycle, le succès de l'épisode de consolidation est codé avec une variable binaire selon que le ratio de dette a opéré une diminution dans les années (1, 2 ou 3 généralement) suivant l'épisode de consolidation. Dans un second temps, un modèle probit/logit est estimé

afin de déterminer quelles sont les variables impactant significativement le succès d'un épisode de consolidation.

Le premier résultat se trouve dans Alesina et Perotti (1995) qui montrent, par une analyse essentiellement descriptive, que la composition de l'ajustement budgétaire importe dans le succès de ce dernier. Autrement dit, la baisse des dépenses et la hausse des recettes ne sont pas deux stratégies équivalentes lorsque l'on souhaite améliorer l'équilibre budgétaire. Plus précisément, les ajustements budgétaires basés sur des baisses de dépenses (en particulier les transferts et la masse salariale publique) conduisent à des améliorations de l'équilibre budgétaire durables contrairement aux ajustements budgétaires basés sur des hausses de recettes. Ce résultat semble très bien établi puisqu'il est confirmé par plusieurs études ultérieures, notamment Von Hagen et Strauch (2001), Von Hagen, Hallet et Strauch (2002), Ardagna (2009), Guichard et al. (2007), Alesina et Ardagna (2009) et Molnar (2012). Ce résultat est important car il rentre, *a priori*, en contradiction avec les études menées sur l'évaluation des multiplicateurs. En effet, dans la mesure où le multiplicateur de dépenses est en général plus élevé que celui des recettes, la baisse des dépenses devrait davantage impacter le PIB que la hausse des recettes. Il est important de souligner que les articles précédemment cités montrent que les ajustements budgétaires ayant permis une réduction du ratio de dette sont en général associés à une baisse des dépenses, mais cela ne permet pas de conclure quant au lien de causalité entre ces deux variables. Au delà de la composition de l'ajustement budgétaire, des conditions économiques favorisant le déclenchement et le succès des épisodes de consolidation ont été mis en évidence. Alesina et Perotti (1995) et Molnar (2012) montrent que le taux de croissance du PIB favorise le succès des épisodes de consolidation, alors que Von Hagen et Strauch (2001) montrent que les phases d'expansion du cycle économique favorisent le déclenchement des épisodes de consolidation mais impactent négativement leurs probabilités de succès. Guichard et al. (2007) indiquent qu'un haut niveau de déficit favorise le déclenchement d'un épisode de consolidation. Dans le même ordre d'idées, Von Hagen et Strauch (2001) trouvent un lien positif entre le niveau du ratio

de dette et la probabilité de déclenchement d'un épisode de consolidation. Plus étonnant, ils obtiennent également un lien positif entre le niveau du ratio de dette et la probabilité de succès de l'épisode de consolidation. Cela est surprenant car dès lors que l'on fait l'hypothèse qu'un épisode d'ajustement budgétaire est récessionniste et déflationniste, l'augmentation du service de la dette induite par une baisse de la croissance et de l'inflation sera d'autant plus forte que le ratio de dette est élevé. Ce faisant, la réduction du ratio de dette est plus difficile. Les conditions monétaires semblent également jouer un rôle, une politique monétaire accommodante et des taux d'intérêt à la baisse semblent favoriser le déclenchement et l'efficacité des politiques de consolidation (Alesina et Perotti (1996) ; Von Hagen et Strauch (2001) ; Ahrend, Catte et Price (2006) et Molnar (2012)). Ce résultat s'explique aisément dans la mesure où la baisse des taux d'intérêt réduit le service de la dette et favorise l'inflation engendrant un effet de seignuriage.

2.4 Méthodologie

2.4.1 L'équation comptable de la dette

Afin de mieux appréhender la dynamique du ratio de dette et d'illustrer formellement notre stratégie économétrique, nous présentons dans un premier temps la dynamique comptable du ratio de dette formalisée comme une équation aux différences d'ordre 1.

Le stock de dette publique obéit à une équation aux différences relativement complexe puisqu'à chaque instant t la variation du stock de dette s'égalise au montant que l'État doit rembourser dû aux différentes dettes contractées aux périodes précédentes et arrivant à échéance en t auxquelles s'ajoute le déficit primaire. Nous avons donc l'équation suivante :

$$\Delta B_t = \sum_{\tau=-\infty}^t r_{\tau,t} D_{\tau,t} + G_t - S_t$$

Où B_t est le stock de dette, $D_{\tau,t}$ est le montant de dette contracté à la période τ et arrivant à échéance en t , $r_{\tau,t}$ le taux d'intérêt payé lors de la contraction du montant de dette et pour une échéance donnée, G_t les dépenses publiques et S_t les recettes publiques. De plus, nous avons l'égalité $B_{t-1} = \sum_{\tau < t, s \geq t} D_{\tau,s}$, c'est à dire que le stock de dette en $t - 1$ est égal à la somme de tous les montants de dette contractés précédemment et non remboursés. Il est ainsi possible de se ramener à une dynamique d'ordre 1 en redéfinissant le taux d'intérêt afin que l'égalité comptable suivante soit respectée :

$$\Delta B_t = r_t B_{t-1} + G_t - S_t$$

Où $r_t = \frac{\sum_{\tau < t, s \geq t} r_{\tau,s} D_{\tau,s}}{\sum_{\tau = -\infty}^t D_{\tau,t}}$ est le taux d'intérêt apparent sur la dette, c'est à dire le montant d'intérêts payé à l'instant t divisé par le stock de dette au même instant.

Nous nous intéressons, dans le cadre de ce chapitre, au ratio de dette défini de la manière suivante : $b_t = B_t/P_t Y_t$, où P_t est le niveau général des prix et Y_t le PIB en volume. On en déduit que :

$$\Delta b_t = \left[\frac{1 + r_t}{(1 + \pi_t)(1 + \gamma_t)} - 1 \right] b_{t-1} + \frac{G_t - S_t}{Y_t} \quad (2.1)$$

Avec $\pi_t = \frac{P_t - P_{t-1}}{P_t}$ et $\gamma_t = \frac{Y_t - Y_{t-1}}{Y_t}$. A partir de cette équation comptable il est aisé d'analyser les effets des différents instruments de politique publique :

1. Une hausse du niveau de dépenses publiques ou une baisse des recettes publiques aura pour effet d'augmenter le déficit primaire et donc la variation du ratio de dette.
2. Une hausse du niveau général des prix aura pour conséquence une augmentation de l'inflation et donc une baisse de la variation du ratio de dette.

Cependant, cette analyse "simpliste" ne tient pas compte des effets d'interaction entre les différentes variables intervenant dans la dynamique du ratio de dette. Comme nous l'avons précédemment expliqué, nous devons nous attendre à ce qu'une modification du niveau de

dépenses publiques entraîne une variation du PIB conduisant, à son tour, à une variation des recettes. Dès lors, les effets sont ambigus et il est nécessaire de modéliser explicitement les différentes interactions. De plus, le raisonnement effectué pour les dépenses reste valable pour les autres déterminants de la dynamique du ratio de dette. Ainsi, l'étude de la dynamique des dépenses, des recettes, du PIB et du niveau général des prix doit être menée conjointement en tenant compte des effets d'interdépendance contemporaine et inter-temporelle. C'est à ce stade que la modélisation VAR intervient en posant simplement

$$X_t = f(X_{t-1}, \dots, X_{t-p}) + u_t$$

Avec $X_t = (g_t, s_t, y_t, p_t)'$ et u_t le terme d'erreur⁶. Une fois la fonction f définie et estimée, nous serons en mesure de déterminer l'effet d'une variation d'une variable sur l'ensemble des variables puis d'analyser l'effet total (effet comptable plus effets indirects) sur le ratio de dette *via* l'équation (2.1).

2.4.2 Le modèle TVAR

Nous avons vu précédemment que l'effet d'une variation des dépenses publiques sur la trajectoire du ratio de dette dépend fortement de la valeur des multiplicateurs budgétaires. Or, la littérature économique a récemment mis en évidence une cyclicité de ces multiplicateurs (AG (2012) et Batini, Calegari et Melina (2013)). Il est important de tenir compte de cette cyclicité car l'une des différences importantes observées entre les pays d'Europe est le fait que certains pays comme l'Allemagne ont pu réaliser des politiques de consolidation budgétaire tout en maintenant un taux de croissance élevé alors que d'autres pays comme l'Espagne, la Grèce ou le Portugal ont réalisé des politiques de consolidation en présence de taux de croissance très faibles, voire négatifs.

6. Les variables notées en minuscules correspondent au logarithme des variables en niveau notées en majuscules.

Ce besoin d'incorporer une cyclicité dans l'interdépendance de nos variables expliquées nécessite l'abandon de l'hypothèse de linéarité, du moins en partie. En effet, en ayant recours aux modèles à seuil de type TVAR (*Threshold VAR*) nous pouvons conserver la linéarité interne à chacun des régimes, cependant une fonction indicatrice permet de piloter le passage entre les régimes en fonction d'une variable de transition. En choisissant comme variable de transition le taux de croissance du PIB (en moyenne sur les trimestres précédents) retardé nous définissons deux régimes : expansion et récession. Le modèle se présente sous la forme suivante ⁷ :

$$X_t = \sum_{i=1}^p [(1 - \mathbb{I}(z_t, c))A_i^1 + \mathbb{I}(z_t, c)A_i^2]X_{t-i} + [(1 - \mathbb{I}(z_t, c))\phi^1 + \mathbb{I}(z_t, c)\phi^2]d_t + u_t$$

Avec X_t le vecteur des variables endogènes, d_t le vecteur des variables exogènes comprenant la constante, une tendance linéaire, une tendance quadratique et le ratio de dette publique, A_i^j la matrice contenant les coefficients associés au retard i et au régime j , ϕ^j la matrice de coefficients associée aux variables exogènes pour le régime j . Enfin $\mathbb{I}(z_t, c)$ est la fonction indicatrice valant 0 lorsque $z_t > c$ et 1 lorsque $z_t < c$, c étant le seuil délimitant les phases d'expansion et de récession. Le terme d'erreur u_t est un vecteur aléatoire gaussien de moyenne nulle mais dont la matrice de covariance dépend du régime dans lequel le modèle se trouve : $\text{Var}[u_t] = (1 - \mathbb{I}(z_t, c))\Omega^1 + \mathbb{I}(z_t, c)\Omega^2$, où Ω^j correspond à la matrice de covariance dans le régime j . Cette spécification est nécessaire dans la mesure où elle nous permet d'obtenir des fonctions d'impulsions/réponses contemporaines différentes selon le régime considéré. Concernant la variable de transition, notée z_t , nous suivons le choix de AG (2012) en prenant la moyenne du taux de croissance du PIB ⁸. Enfin, l'incorporation du ratio de dette publique en tant que variable exogène se justifie par le fait que les choix de politique budgétaire peuvent s'effectuer en partie en fonction de l'évolution de cette variable, les États étant contraints d'assurer la soutenabilité de la dette publique à long terme ⁹. Les chocs structurels sont identifiés par la décomposition

7. L'estimation d'un tel modèle est détaillée en annexe.

8. Plusieurs définitions sont testées laissant place à davantage de réactivité : y_{t-1} , $(y_{t-1} - y_{t-2})/2$, $(y_{t-1} - y_{t-3})/3$ et $(y_{t-1} - y_{t-4})/4$.

9. Voir notamment Favero et Giavazzi (2007).

de Cholesky dans chacun des deux régimes, en reprenant l'ordre des variables retenu par AG (2012). Enfin, contrairement à certains modèles non linéaires, nous ne nous intéresserons pas ici à l'étude des fonctions d'impulsions généralisées dans la mesure où nous souhaitons disposer des réponses spécifiques à chacun des régimes.

Une fois le modèle estimé, nous disposerons alors des coefficients dans chacun des deux régimes, ce qui nous permettra d'obtenir des fonctions d'impulsions/réponses conditionnellement au régime et d'identifier les multiplicateurs dans chacun des régimes.

2.4.3 Calcul des IRF sur le ratio de dette

Une fois les IRF conditionnelles obtenues, notre objectif final est d'évaluer l'impact d'un choc d'une variable endogène sur le ratio de dette publique. Nous nous plaçons dans le régime 1¹⁰, notre procédure se déroule en trois étapes :

1. L'équation de la dynamique du ratio de dette est réécrite afin de faire apparaître les variables en logarithme :

$$b_t = \left[\frac{1 + r_t}{(1 + p_t - p_{t-1})(1 + y_t - y_{t-1})} \right] b_{t-1} + \frac{\exp(g_t) - \exp(s_t)}{\exp(y_t)}$$

Étant donné cette équation, de chaque trajectoire $\{X_t\}_{t \geq 1}$ se déduit une trajectoire $\{b_t\}_{t \geq 1}$.

2. Le modèle TVAR étant estimé nous disposons des coefficients associés au régime 1, nous pouvons alors calculer les matrices contenant les valeurs des IRF aux différents temps, c'est à dire les matrices Θ_i telles que¹¹

$$X_t = \sum_{i=1}^{\infty} \Theta_i w_{t-i}$$

10. La procédure est identique pour le régime 2.

11. Voir Lutkepohl (2005) page 58.

Où les w_{t-i} sont des chocs orthogonaux. Ainsi, si nous nous plaçons à l'état stationnaire en $t = 0$ et si nous supposons un choc δ sur la k -ème variable au même instant, nous avons $X_t = (\Theta_t)_{*,k}\delta$, $(\Theta_t)_{*,k}$ étant la k -ème colonne de la matrice Θ_t . La trajectoire de X_t associée sera donc $\{X_t\}_{t \geq 1} = \{(\Theta_t)_{*,k}\delta\}_{t \geq 1}$.

3. Nous considérons ensuite deux trajectoires :

- Une première trajectoire où les variables endogènes sont supposées constantes et égales à leurs dernières observations $\{X_t\}_{t \geq 1}^{\text{sans choc}} = \{X_{2016Q4}\}_{t \geq 1}$. A cette trajectoire est associée une trajectoire du ratio de dette (conformément à l'étape 1) $\{b_t\}_{t \geq 1}^{\text{sans choc}}$.
- Une seconde trajectoire où les variables endogènes dévient en raison d'un choc sur la k -ème variable endogène, $\{X_t\}_{t \geq 1}^{\text{avec choc}} = \{X_{2016Q4} + (\Theta_t)_{*,k}\delta\}_{t \geq 1}$. Là encore nous pouvons en déduire une trajectoire pour le ratio de dette que nous notons $\{b_t\}_{t \geq 1}^{\text{avec choc}}$.

4. Enfin, nous calculons la différence entre les deux trajectoires du ratio de dette, $\{b_t\}_{t \geq 1}^{\text{avec choc}} - \{b_t\}_{t \geq 1}^{\text{sans choc}}$, ce qui nous permet d'évaluer l'influence du choc sur la trajectoire du ratio de dette comparativement à une situation où le choc n'aurait pas eu lieu. Cette stratégie est nécessaire dans la mesure où les variables ne se situent pas à leur état stationnaire. Au final, nous obtenons une fonction d'impulsions/réponses pour le ratio de dette publique.

En section 2.6, nous exécutons cette procédure afin d'évaluer l'effet d'un choc portant sur nos différents instruments de politique publique (dépenses, recettes et niveau des prix) et selon les deux régimes (expansion et récession).

2.5 Présentation des données et statistiques descriptives

2.5.1 Source des données et calculs effectués

Notre étude est réalisée sur le cas de la France. Ce choix se justifie en partie par la disponibilité des données¹² et par le fait que la France fait office de cas intermédiaire au sein de l'Europe. En effet, la France affiche un niveau de ratio de dette du même ordre de grandeur que celui de l'Union Européenne et sa trajectoire est également très proche (voir figure 2.1). De manière générale, la France présente des trajectoires de dépenses et de recettes similaires à celles de l'Union Européenne (voir figure 2.2). De ce point de vue, la France peut être considérée comme un cas représentatif au sein de l'UE, à partir duquel nos conclusions pourront être généralisées. En particulier, il est intéressant d'observer si la conclusion de Eyraud et Weber (2013) selon laquelle une baisse des dépenses publiques peut conduire à une hausse du ratio de dette tient toujours lorsque l'on étudie un autre pays que le Japon. En effet, le Japon présente *a priori* des caractéristiques qui rendent favorable l'émergence de ce résultat¹³. De ce point de vue, la France apparaît comme un pays davantage "représentatif".

Nous disposons, dans le cas de la France, de cinq séries temporelles : les dépenses publiques, les recettes publiques, le PIB, le niveau général des prix et le stock de dette. Ces séries proviennent d'Eurostat, excepté le niveau général des prix extrait de l'OCDE, et sont toutes exprimées en valeur. Concernant les dépenses publiques nous disposons de la décomposition entre les dépenses de consommation finale publiques, l'investissement public, la charge de la dette et les autres dépenses. Dans un premier temps nous redéfinissons les dépenses publiques en ne sélectionnant

12. Dans le cas de la France nous disposons de séries permettant de vérifier l'équation comptable de la dette sur un horizon temporel suffisamment important. En effet, être en mesure de recalculer la trajectoire du ratio de dette à partir de la trajectoire de ses composantes est primordial comme nous avons pu le voir dans la partie méthodologique.

13. En particulier un ratio de dette publique extrêmement élevé et un long épisode de trappe à liquidité.

que les dépenses de consommation finale et d'investissement (dépenses discrétionnaires) et nous retranchons les autres dépenses des recettes publiques. Ensuite, les séries de dépenses publiques, recettes publiques et PIB sont redéfinies en volume grâce au niveau général des prix.

La série du stock de dette couvre la période 2000Q1 à 2016Q4 et présente une saisonnalité contrairement aux autres séries qui sont désaisonnalisées et qui s'étalent de 1980Q1 à 2016Q4. Cependant, étant donné que nous disposons des recettes et des dépenses publiques, nous pouvons facilement calculer le besoin de financement de l'État, c'est-à-dire la variation de la dette publique (figure 2.6). A partir d'une condition initiale nous pouvons ainsi recalculer l'ensemble de la trajectoire de la dette de 1980 à 2016Q4 (figure 2.6) et en déduire le ratio de dette publique de 1980Q1 à 2016Q4 en divisant par le PIB.

Toutes les séries, excepté le ratio de dette, sont exprimées en logarithme.

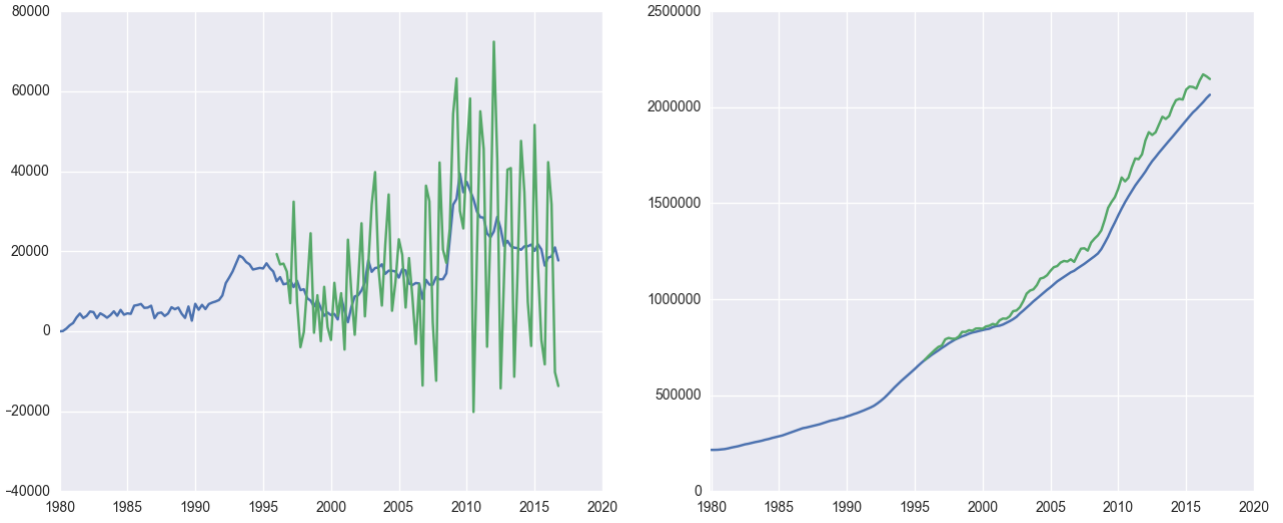
2.5.2 Statistiques descriptives et stationnarité

La plupart des faits stylisés présentés dans la section 2.2 sont valables pour le cas de la France (figure 2.7). On observe là encore une hausse des dépenses publiques en 2008, associée à une forte baisse des recettes publiques. Dans le même temps une chute du PIB a lieu, il s'ensuit une très forte augmentation du ratio de dette. Malgré une contraction budgétaire depuis 2010, la croissance du ratio de dette reste élevée.

Naturellement, différentes séries présentent une non-stationnarité, cependant celle-ci est d'ordre déterministe. Dans la lignée des travaux effectués sur l'évaluation des multiplicateurs¹⁴, ce problème est traité par l'incorporation d'une tendance déterministe. Une tendance quadratique est également ajoutée, ce qui se justifie aisément au regard de la trajectoire de l'indice des prix.

14. Voir notamment Blanchard et Perotti (2002).

FIGURE 2.6 – Dette publique française



(1) La courbe verte correspond à la variation de la dette calculée à partir de la série de dette en valeur non désaisonnalisée (Source : Eurostat), la courbe bleue correspond à la variation de la dette calculée comme la différence entre les dépenses et les recettes publiques désaisonnalisées (Source : Eurostat). (2) La courbe verte correspond à la dette en valeur non désaisonnalisée (Source : Eurostat), la courbe bleue correspond la dette calculée par "intégration" (l'année 2000 est prise comme condition initiale) des différences entre les dépenses et les recettes publiques désaisonnalisées (Source : Eurostat).

2.6 Estimations et résultats

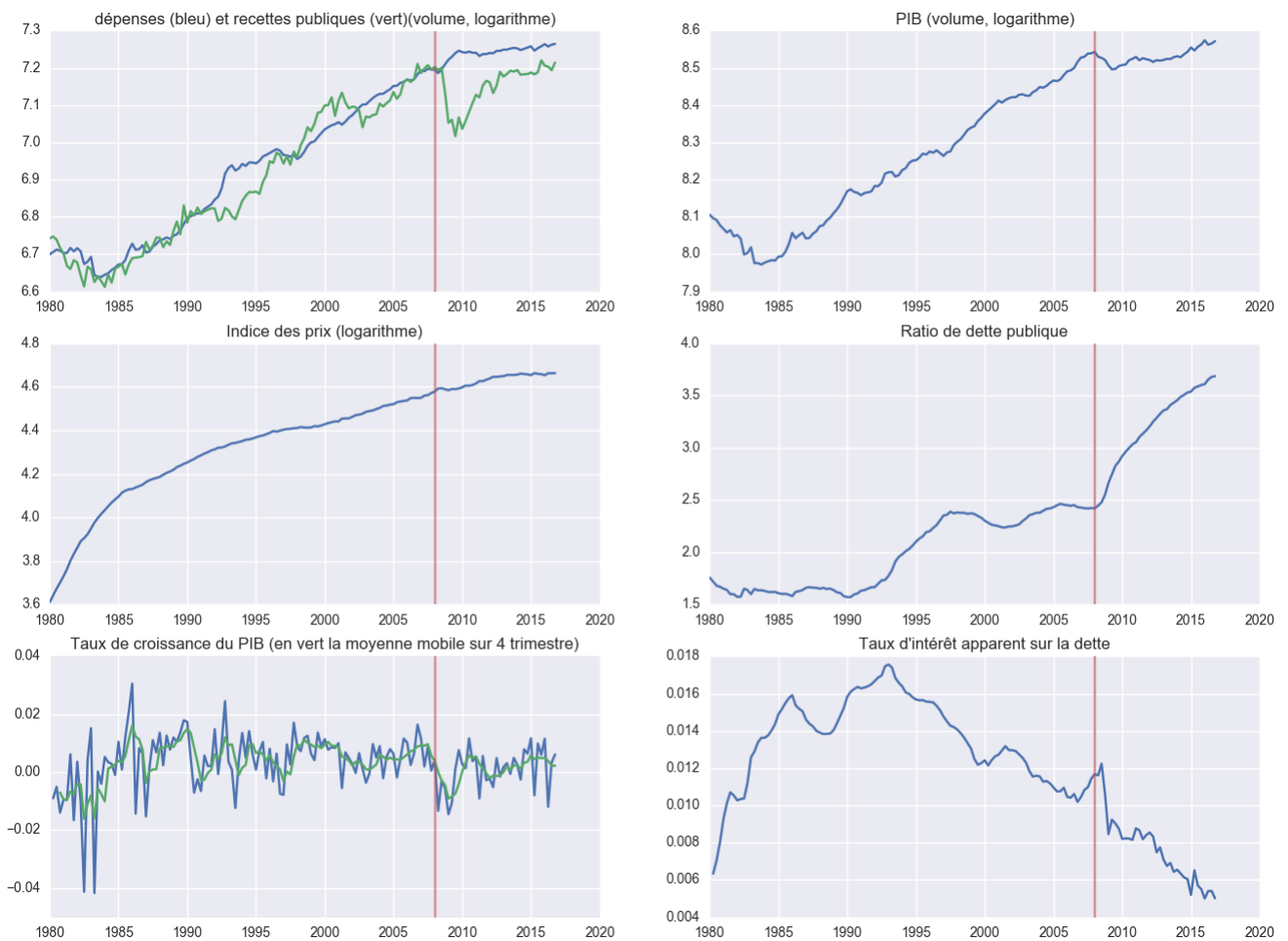
2.6.1 Choix de modélisation

Nous reprenons le modèle présenté en section 2.3 :

$$X_t = \sum_{i=1}^p [(1 - \mathbb{I}(z_t, c))A_i^1 + \mathbb{I}(z_t, c)A_i^2]X_{t-i} + [(1 - \mathbb{I}(z_t, c))\phi^1 + \mathbb{I}(z_t, c)\phi^2]d_t + u_t$$

Nous rappelons que le vecteur des variables endogènes $X_t = (g_t, s_t, y_t, p_t)$ est composé des dépenses publiques, des recettes publiques, du PIB et de l'indice de prix, toutes ces variables étant

FIGURE 2.7 – France, statistiques descriptives



Source des données : Eurostat.

exprimées en logarithme. Le vecteur des variables exogènes $d_t = (\text{constante}, t, t^2, b_t)$ comporte une constante, une tendance linéaire, une tendance quadratique et le ratio de dette.

Dans la mesure où, à notre connaissance, il n'existe pas, de procédure statistique permettant de sélectionner l'ordre de retard d'un modèle TVAR, nous procédons comme suit. Dans un premier temps nous calculons les critères d'information sur le modèle VAR simple. Deux des

critères (AIC et FPE) préconisent $p = 6$ alors que deux autres (HQ et SC) préconisent $p = 2$. Étant donné que notre modèle non linéaire contiendra deux fois plus de coefficients que le modèle linéaire nous retenons l'ordre de retard le plus faible, $p = 2$ ¹⁵. Notre variable de transition est le taux de croissance du PIB retardé en moyenne mobile sur 4 trimestres. Pour chaque spécification le seuil de transition c est systématiquement réajusté par la méthode des moindres carrés non linéaires. Il convient de noter que l'intervalle sur lequel on choisit le seuil c est défini afin qu'il y ait suffisamment d'observations dans le régime de récession (au moins 25% de l'échantillon, ce qui correspond à 37 observations) tout en ne dépassant pas 50% des observations sans quoi notre interprétation en termes de récession perdrait de son sens. L'inférence est réalisée via des procédures *bootstrap* (détaillées en annexe) nous permettant d'obtenir les intervalles de confiance sur les différentes IRF calculées. Précisons que le paramètre de seuil ne fait pas l'objet d'inférence, une fois déterminé par moindres carrés non linéaires, il est considéré comme donné lors des simulations *bootstrap*. Cependant, nous évaluons la sensibilité de nos résultats à une variation de ce paramètre dans la section robustesse. Le seuil obtenu est très proche de zéro (0,0005) ce qui fournit une interprétation claire : l'économie est en récession lorsque le taux de croissance en moyenne mobile est négatif. Nous trouvons alors que l'économie française se trouve en récession 25% du temps sur la période 1980 – 2016.

2.6.2 Principaux résultats

IRF issus de l'estimation du modèle TVAR

Les IRF sont reportées en figure 2.8. Les intervalles de confiance sont en général plus importants pour le régime de récession, ce qui traduit, en partie, le fait que ce régime possède moins d'observations que le régime d'expansion.

15. Cependant, et à des fins de robustesse, plusieurs estimations sont effectuées selon l'ordre de retard, nous retenons $p \in \{2, 3, 4\}$ (voir section robustesse).

Les principaux résultats issus de l'estimation des IRF sont les suivants :

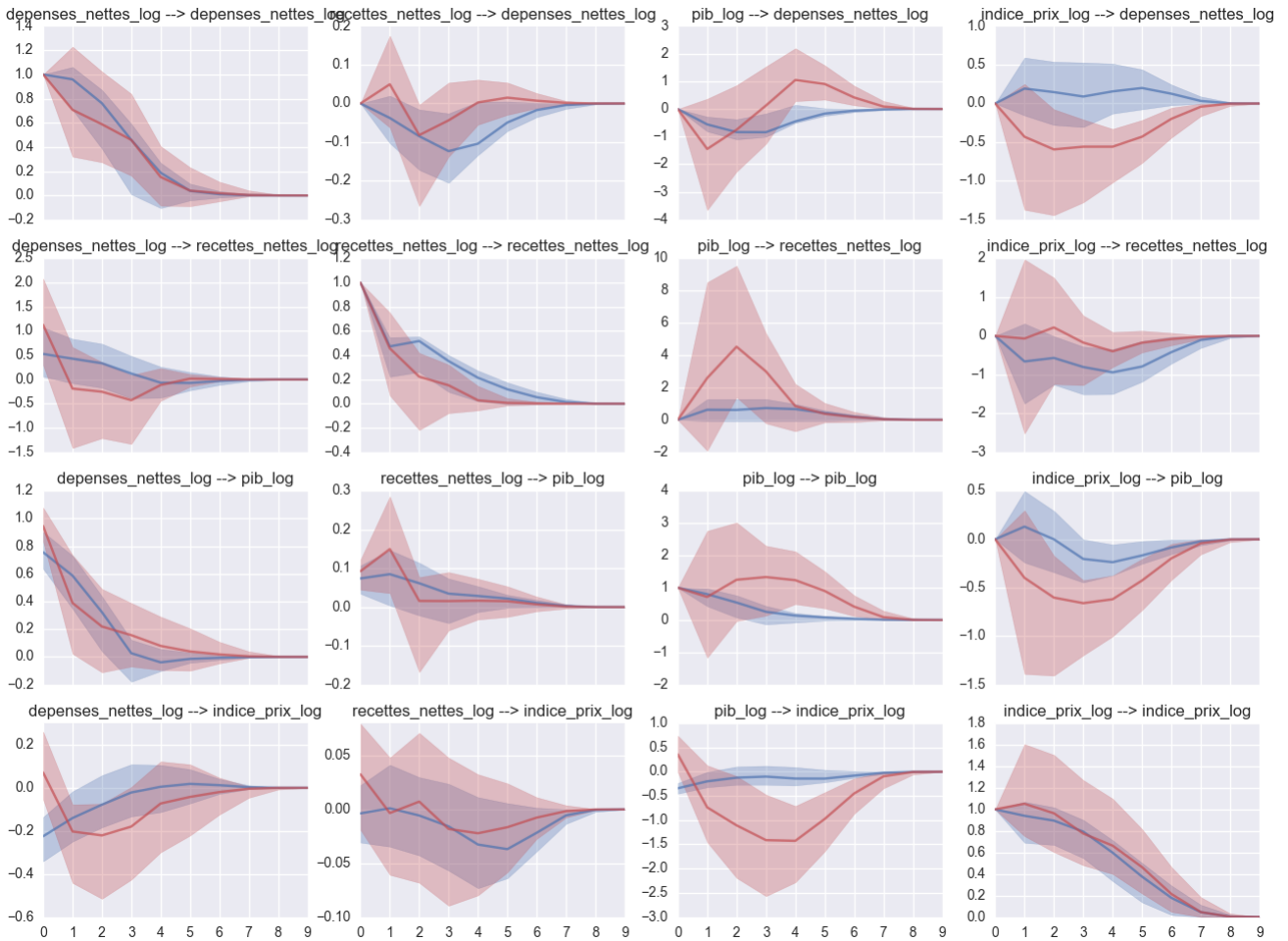
1. Nous observons une contracyclicité du multiplicateur de dépenses à court terme. En effet, l'augmentation instantanée du PIB suite à un choc positif sur les dépenses publiques est de 0,945 en période de récession alors qu'elle est de 0,756 en période d'expansion. Cette différence est significative. Cependant, à long terme la différence entre les deux multiplicateurs s'estompe et devient non significative (voir figure 2.9).
2. Le multiplicateur de recettes affiche un signe positif même s'il est bien moins élevé que le multiplicateur de dépenses. Nous n'observons pas de différence significative entre les réponses associées à chacun des régimes.
3. Nous remarquons également qu'un choc positif sur le niveau du PIB impacte très peu les recettes en période d'expansion alors que son effet est fort en période de récession.
4. Enfin, nous observons un effet quelque peu contre intuitif puisque les prix sont négativement impactés par une hausse des dépenses publiques ou du PIB.

A partir de l'estimation des IRF il est possible de calculer le multiplicateur de dépenses (noté md_t) aux différents temps par la formule suivante :

$$md_t = \frac{\sum_{\tau=1}^t y_{\tau}}{\sum_{\tau=1}^t g_{\tau}}$$

Le multiplicateur instantané est donné par $md_1 = \frac{y_1}{g_1}$. Sur la figure 2.9, nous effectuons le calcul pour différents temps et selon les deux régimes, nous reportons également la différence entre les deux multiplicateurs. Nous observons que le multiplicateur de dépenses est supérieur en régime de récession durant les 8 trimestres suivant le choc. Cependant la différence entre les deux s'estompe avec le temps, n'étant significative qu'à l'instant du choc. Nous retrouvons donc ici un résultat déjà mis en évidence sur les États-Unis par AG (2012) et plus largement par Batini et al. (2012) illustrant la contracyclicité du multiplicateur de dépenses. Ce résultat implique donc qu'une politique de consolidation budgétaire sera d'autant moins efficace en période de récession. Le fait que le multiplicateur de recettes soit positif indique que les politiques de consolidation doivent davantage être mises en oeuvre *via* une augmentation des recettes

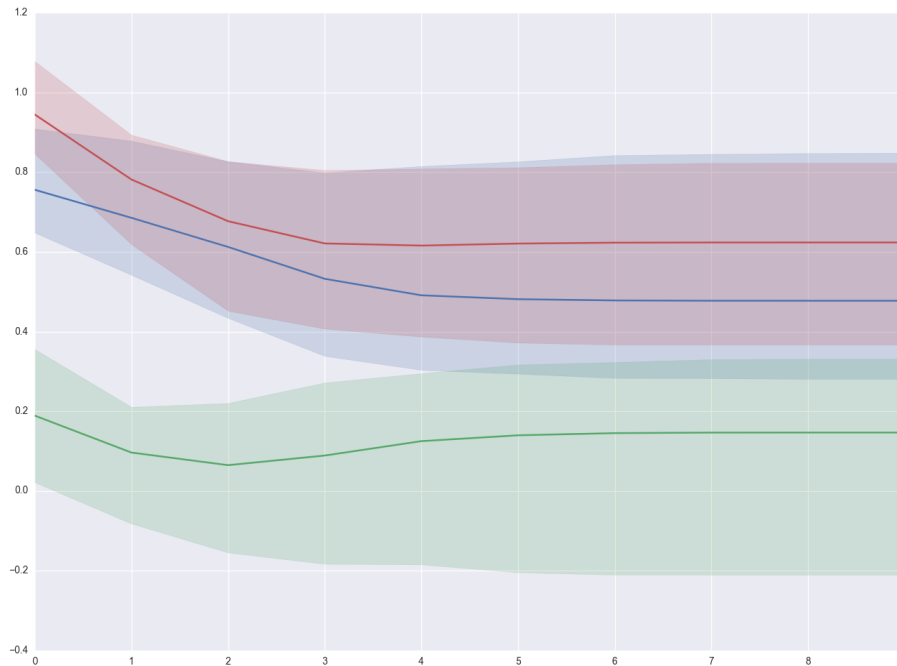
FIGURE 2.8 – IRF ; $z_t = (y_{t-1} - y_{t-5})/4$; $p = 2$



Les courbes en bleu indiquent les IRF dans le régime d'expansion, les courbes en rouge indiquent les IRF dans le régime de récession. Les intervalles de confiance sont tracés pour un risque à 10%.

qu'une réduction des dépenses. Enfin, le fait que les recettes publiques soient très sensibles aux variations du PIB en période de récession implique que l'accent devrait être mis sur le soutien à l'activité économique afin d'éviter toute augmentation brutale du déficit public.

FIGURE 2.9 – Multiplicateurs de dépenses ; $z_t = (y_{t-1} - y_{t-5})/4$; $p = 2$



La courbe en bleu indique la valeur du multiplicateur de dépenses dans le régime d'expansion, la courbe en rouge indique la valeur du multiplicateur de dépenses dans le régime de récession. La courbe en vert correspond à la différence entre les deux multiplicateurs. Les intervalles de confiance sont tracés pour un risque à 10%.

Ces résultats mettent en évidence des effets pouvant nourrir l'idée selon laquelle en période de récession il peut être contre productif de se focaliser sur la réduction du déficit public. Cependant, à ce stade de l'analyse nous ne sommes pas en mesure de déterminer si ces effets sont suffisamment forts afin que : (1) une politique de contraction budgétaire soit moins efficace en période de récession ; (2) une politique de contraction budgétaire puisse engendrer une hausse du ratio de dette à court terme. Pour cela nous passons à l'étape suivante qui consiste à calculer les IRF sur le ratio de dette publique.

IRF sur le ratio de dette publique

Calculons à présent l'IRF sur le ratio de dette conformément à la méthode décrite en section 2.3. Les chocs sont spécifiés pour représenter 1% de la variable en niveau. Les principaux résultats sont les suivants :

1. Une baisse des dépenses publiques entraîne une hausse significative du ratio de dette à court terme quel que soit le régime considéré. Cependant cette hausse est significativement plus importante en période de récession, de l'ordre de 0,037 point de pourcentage contre 0,018 en période d'expansion (figure 2.10).
2. Une hausse des recettes implique une baisse significative du ratio de dette publique à court terme, même si celle-ci est relativement faible (moins de 0,01 point de pourcentage). Nous n'observons aucune distinction significative entre les deux régimes (figure 2.10).
3. Une hausse du niveau des prix engendre une baisse significative du ratio de dette publique à court terme, de l'ordre de 0,036 point de pourcentage. Là encore, aucune différence significative entre les deux régimes n'est observée (figure 2.11).
4. Enfin le PIB est la variable endogène ayant le plus fort impact sur la trajectoire du ratio de dette publique. Ceci est d'autant plus vrai en période de récession puisque qu'une augmentation du PIB permet une diminution du ratio de dette de l'ordre de 0,05 point de pourcentage à court terme (figure 2.11).

Les résultats obtenus viennent donc confirmer les mécanismes théoriques suggérés par les faits stylisés. Ainsi la variation des dépenses publiques à la baisse n'apparaît pas comme une solution à la réduction du ratio de dette, du moins à court terme. Ce résultat est particulièrement fort en période de récession et peut être lourd de conséquences lorsque c'est l'augmentation du ratio de dette publique qui mène à la décision de réduire les dépenses publiques. En effet, un cercle vicieux peut émerger : la hausse du ratio de dette engendre une baisse des dépenses qui elle-même conduit à une hausse du ratio entraînant à son tour une réduction des dépenses.

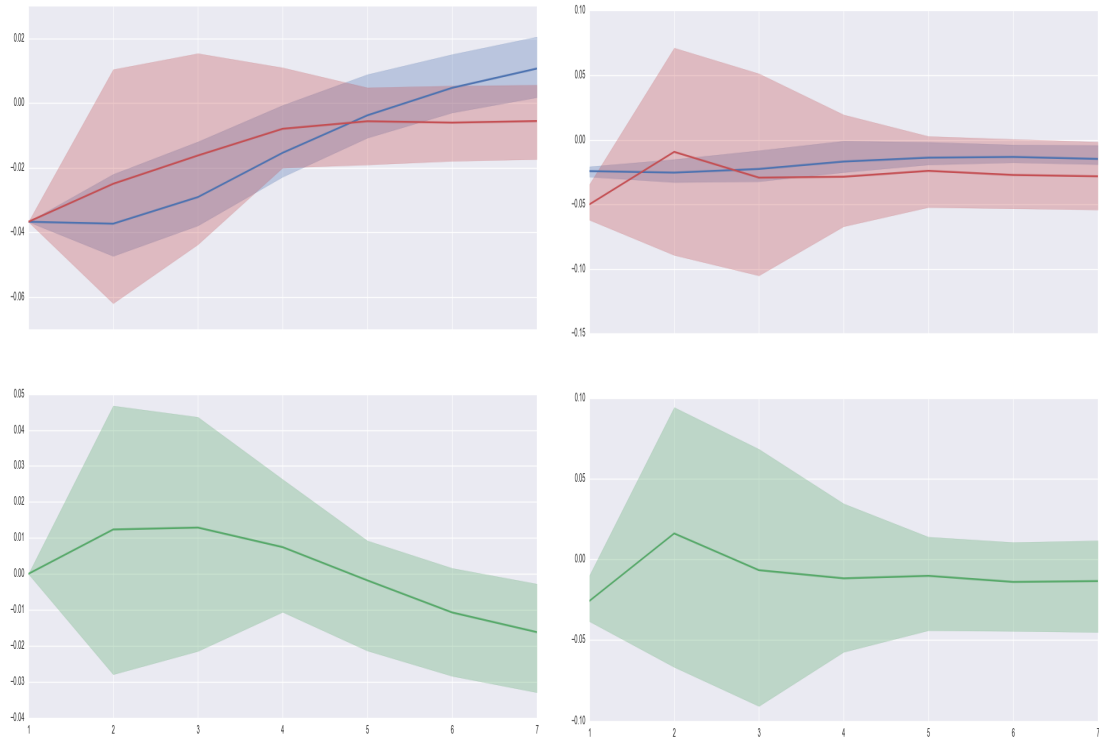
FIGURE 2.10 – IRF ratio de dette pour un choc négatif de dépenses (gauche) et pour un choc positif de recettes (droite) ($p = 2$, $z_t = (y_{t-1} - y_{t-5})/4$).



La courbe en bleu indique l'IRF dans le régime d'expansion, la courbe en rouge indique l'IRF dans le régime de récession. La courbe en vert correspond à la différence entre les deux IRF. Les intervalles de confiance sont tracés pour un risque à 10%.

Ce résultat est en cohérence avec le fait que le ratio de dette est particulièrement sensible aux variations du PIB en période de récession. Dans cette configuration, il convient d'éviter toute baisse du PIB trop importante avant d'amorcer des politiques de réduction des dépenses. Nous remarquons que si une politique de consolidation doit avoir lieu, il semble que l'instrument des recettes publiques soit le plus adapté pour deux raisons : premièrement il permet une baisse du ratio de dette à court terme tout en ayant un effet significatif à long terme, deuxièmement les réponses sont semblables dans chacun des régimes ce qui permet une réduction de l'incertitude portant sur l'effet de la politique. Enfin, la stimulation du niveau des prix à la hausse *via* la

FIGURE 2.11 – IRF ratio de dette pour un choc positif de prix (gauche) et pour un choc positif de PIB (droite) ($p = 2$, $z_t = (y_{t-1} - y_{t-5})/4$).



La courbe en bleu indique l'IRF dans le régime d'expansion, la courbe en rouge indique l'IRF dans le régime de récession. La courbe en vert correspond à la différence entre les deux IRF. Les intervalles de confiance sont tracés pour un risque à 10%.

politique monétaire peut également apparaître comme une solution à court terme, cependant à long terme l'effet n'est pas probant. En phase de récession, l'effet à long terme est non significatif sur le ratio de dette, en phase d'expansion il est significativement positif.

Au total, nos résultats suggèrent donc la mise en place d'un *policy mix* consistant à renforcer l'intervention de l'État en phase de récession par une hausse des dépenses, permettant de soutenir l'activité économique, et des recettes publiques, afin d'empêcher la hausse du déficit

public. Une telle stratégie peut éventuellement être accompagnée à court terme d'une politique monétaire de stimulation des prix. Nos conclusions sont donc relativement proches de celles formulées par les différents travaux du FMI (Batini et al. (2012), Eyraud et Weber (2013)) bien que notre méthodologie soit différente.

2.7 Robustesse

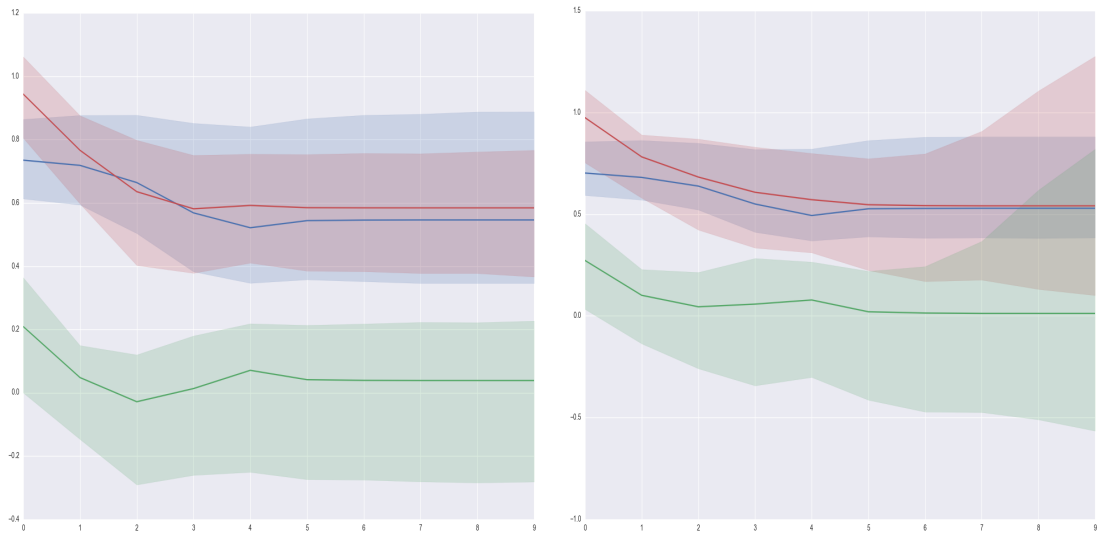
2.7.1 Modification de l'ordre de retard

Nous ré-estimons le modèle pour deux autres ordres de retard : $p = 3$ et $p = 4$. Les IRF (figure 2.14 et figure 2.15 en annexe) du modèle TVAR montrent que les principales conclusions obtenues sur le modèle avec un ordre de retard égal à 2 restent valides.

Nous recalculons (figure 2.12) également le multiplicateur de dépenses pour $p = 3$ et $p = 4$. Là aussi nos conclusions précédentes sont robustes, puisque le multiplicateur de dépenses est plus important en phase de récession mais que la différence entre les deux multiplicateurs est significative seulement à l'instant du choc. Enfin, nous recalculons les IRF portant sur le ratio de dette en modifiant l'ordre de retard (figures 2.16, 2.17, 2.18 et 2.19 en annexes). A nouveau nos résultats sont validés : (1) une baisse des dépenses publiques entraîne une hausse du ratio de dette à court terme et cette hausse est significativement plus importante lorsque l'on se trouve en période de récession. (2) Une hausse des recettes ou du niveau des prix conduit à une baisse du ratio de dette sans qu'il n'y ait de différence significative entre les deux régimes. (3) Une hausse du PIB engendre une réduction du ratio de dette et cette baisse est significativement plus importante lorsque l'on se trouve en période de récession.

Au total, il ressort que nos conclusions sont robustes au choix de l'ordre de retard.

FIGURE 2.12 – Multiplicateurs de dépenses pour $p = 3$ (à gauche) et $p = 4$ (à droite).



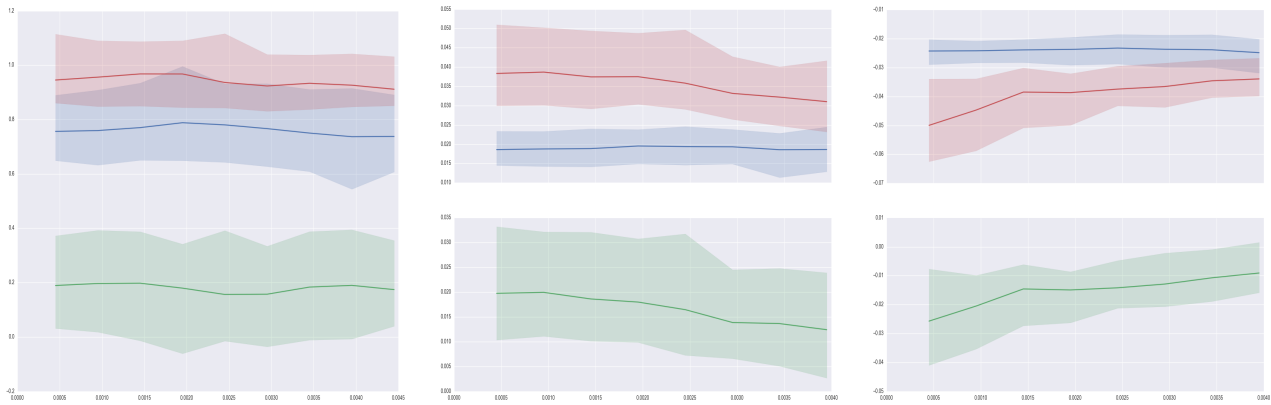
La courbe en bleu indique la valeur du multiplicateur de dépenses dans le régime d'expansion, la courbe en rouge indique la valeur du multiplicateur de dépenses dans le régime de récession. La courbe en vert correspond à la différence entre les deux multiplicateurs. Les intervalles de confiance sont tracés pour un risque à 10%.

2.7.2 Modification du seuil

Comme nous l'avons précédemment mentionné, le seuil est déterminé par la méthode des moindres carrés non linéaires et est considéré comme fixé lors des répliques *bootstrap*. L'inférence porte donc uniquement sur les coefficients des matrices caractérisant l'autocorrélation dans chacun des régimes. Examinons cependant la robustesse de nos résultats à une variation du seuil.

Nous avons montré que le multiplicateur de dépenses instantané était significativement supérieur en phase de récession. Afin d'évaluer la robustesse de ce résultat, nous calculons le multiplicateur de dépenses instantané dans les deux régimes et pour différents seuils (figure

FIGURE 2.13 – Robustesse : multiplicateur de dépenses instantané (gauche), réponse instantanée du ratio de dette à un choc de dépenses (centre), réponse instantanée du ratio de dette à un choc de PIB (droite). ($p = 2$, $z_t = (y_{t-1} - y_{t-5})/4$).



La courbe en bleu indique la réponse instantanée dans le régime d'expansion, la courbe en rouge indique la réponse instantanée dans le régime de récession. La courbe en vert correspond à la différence entre les deux réponses instantanées. Les intervalles de confiance sont tracés pour un risque à 10%.

2.13). Pour un seuil compris entre 0,00045 et 0,0012 le multiplicateur de dépenses en phase de récession est significativement supérieur au multiplicateur de dépenses en phase d'expansion. Cependant, pour un seuil supérieur à 0,0012 nous perdons la significativité. Par contre, les résultats obtenus sur les réponses instantanées du ratio de dette à un choc de dépense (à la baisse) ou à un choc de PIB (à la hausse) sont robustes à la modification du seuil. A chaque fois, le ratio de dette répond significativement et de façon systématique, l'ampleur de la réponse est significativement plus importante en période de récession. A nouveau, il ressort de cette analyse de robustesse une faible sensibilité de nos résultats à une modification du seuil.

2.8 Discussion

La composition de l'ajustement budgétaire que nous recommandons soulève, dans une certaine mesure, une contradiction avec un résultat relativement bien établi privilégiant la baisse des dépenses (Alesina et Perotti (1995, 1996); Von Hagen et Strauch (2001); Von Hagen, Hallet et Strauch (2002); Ardagna (2002); Guichard et al. (2007); Molnar (2012)). En effet, les études évaluant directement l'impact des épisodes de consolidation sur la variation du ratio de dette concluent que ces derniers sont davantage efficaces lorsqu'ils sont basés sur des réductions de dépenses publiques plutôt que sur des augmentations de recettes publiques. Cependant, nous pouvons justifier, dans une certaine mesure, cette contradiction par la différence majeure résidant dans la méthodologie employée. En effet, les articles analysant l'effet des politiques de consolidation le font à partir de l'estimation de modèles probit/logit et traitent donc les données en coupe transversale¹⁶ afin de mettre en évidence les conditions économiques qui agissent significativement sur la probabilité de succès d'une politique de consolidation. De ce fait, ces études se concentrent plutôt sur les effets de long terme et ne tentent en aucun cas d'exploiter la dimension temporelle des données. Le principal inconvénient de cette méthodologie est qu'il faut au préalable définir ce qu'est une "politique de consolidation" et quand est-ce que l'on peut considérer qu'une politique de consolidation est un "succès". La méthodologie que nous employons se concentre davantage sur la structure temporelle des données, en particulier nous identifions la structure d'autocorrélation des variables intervenant dans la dynamique du ratio de dette. Nous exploitons ensuite l'équation comptable du ratio de dette afin "d'exporter" l'effet d'un choc instantané, portant sur une variable endogène du modèle TVAR, sur le ratio dette. Le principal inconvénient de cette méthodologie reste l'identification des chocs structurels. Notre analyse est donc davantage une analyse de court terme et ne vient donc pas complètement

16. Le succès d'une politique de consolidation est considéré comme une variable binaire; le succès d'un épisode de consolidation étant l'observation d'une baisse (ou d'une stabilisation) du ratio de dette les années suivant l'épisode de consolidation. Les observations sont tirées des différents épisodes de consolidation pour différents pays et différentes dates.

contredire les travaux effectués sur l'analyse des épisodes de consolidation. Tout du moins elle la nuance : quand bien même la réduction des dépenses serait le moyen le plus efficace pour réduire le ratio de dette, il se peut que des effets néfastes se produisent à court terme. De plus, ces effets néfastes sont d'autant plus vraisemblables que l'économie se trouve dans une phase récessionniste.

2.9 Conclusion

L'objet de ce chapitre est d'étudier les conditions requises pour que les politiques de consolidation budgétaire conduisent à une réduction du ratio de dette publique. A cette fin, nous proposons une modélisation VAR à seuil nous permettant de tenir compte de la situation - expansion ou récession - dans laquelle se trouve l'économie. Dans ce cadre méthodologique, nous montrons qu'une réduction du niveau des dépenses publiques peut, à court terme, conduire à une hausse du ratio de dette publique, et que cette contraction est significativement plus forte en période de récession. Au contraire, une augmentation du niveau des recettes publiques permet, à court terme, une baisse du ratio de dette publique quelque soit le régime dans lequel se trouve l'économie.

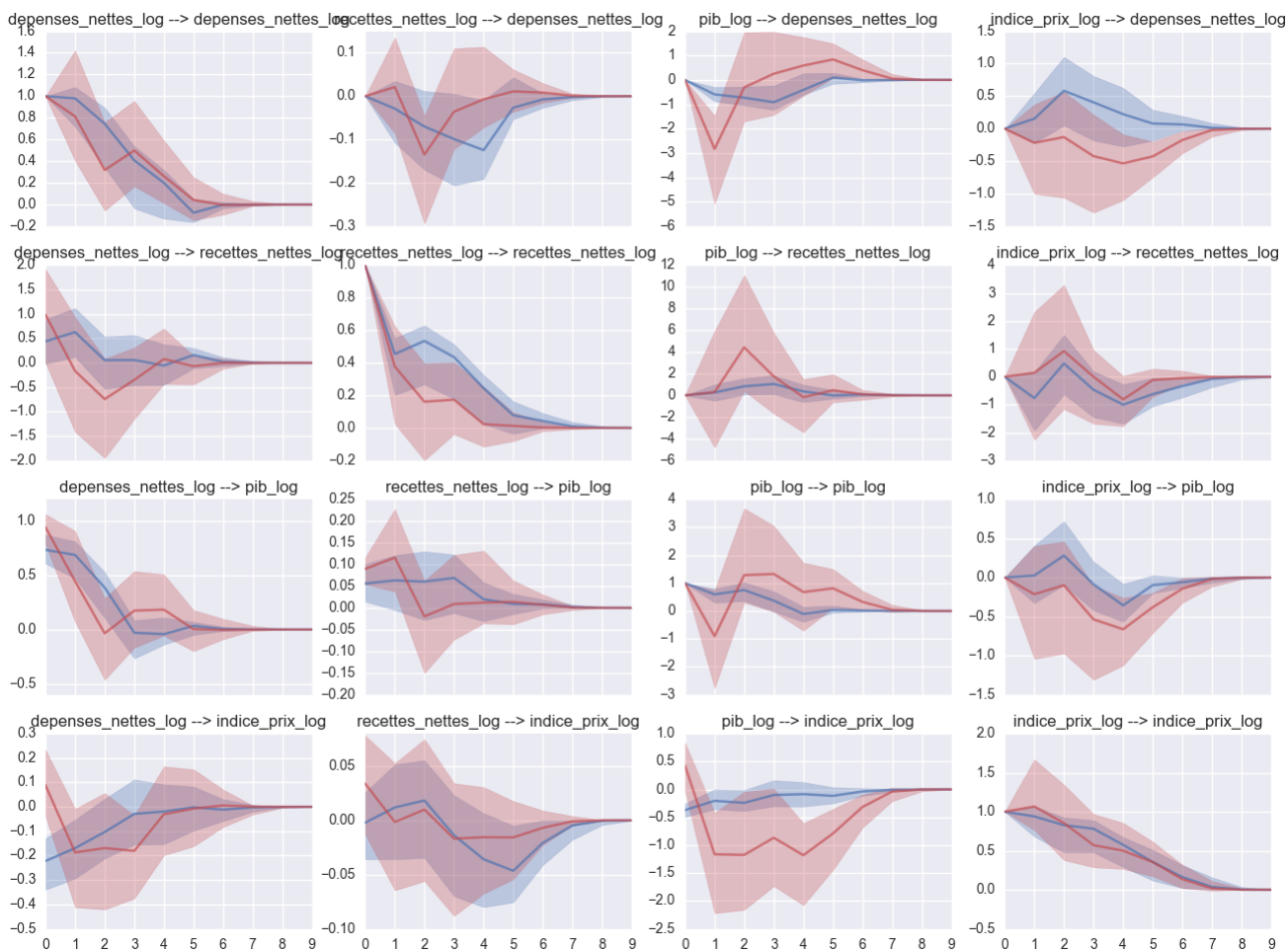
Le ratio de dette publique faisant intervenir deux composantes (le niveau de dette et le niveau de PIB), il existe deux principaux moyens de le diminuer : réduire le déficit public et/ou augmenter le PIB. Ces deux leviers ne sont pas indépendants l'un de l'autre et il est primordial d'être en capacité de mesurer les relations d'interdépendance entre les variables intervenant dans la dynamique du ratio de dette. En période de récession, les multiplicateurs étant particulièrement élevés, un fort couplage existe entre les deux composantes. En d'autres termes, la modification du déficit public par la variation des dépenses et/ou des recettes publiques impacte fortement le PIB qui, lui même, affecte fortement les recettes en retour et donc le déficit public. Dans ces conditions, nos résultats suggèrent qu'en période de récession l'État doit avant tout se concentrer sur la composante PIB et favoriser, à court terme, des politiques de relance

budgétaire en priorité face au déficit public. Au contraire, en période d'expansion, le couplage entre les deux composantes est faible, les politiques publiques n'impactant que peu le PIB et les recettes étant également moins sensibles aux variations de PIB. L'État peut alors davantage se focaliser sur la composante déficit public afin de diminuer le ratio de dette publique, sans avoir besoin de se soucier des effets sur l'activité économique.

2.10 Annexes

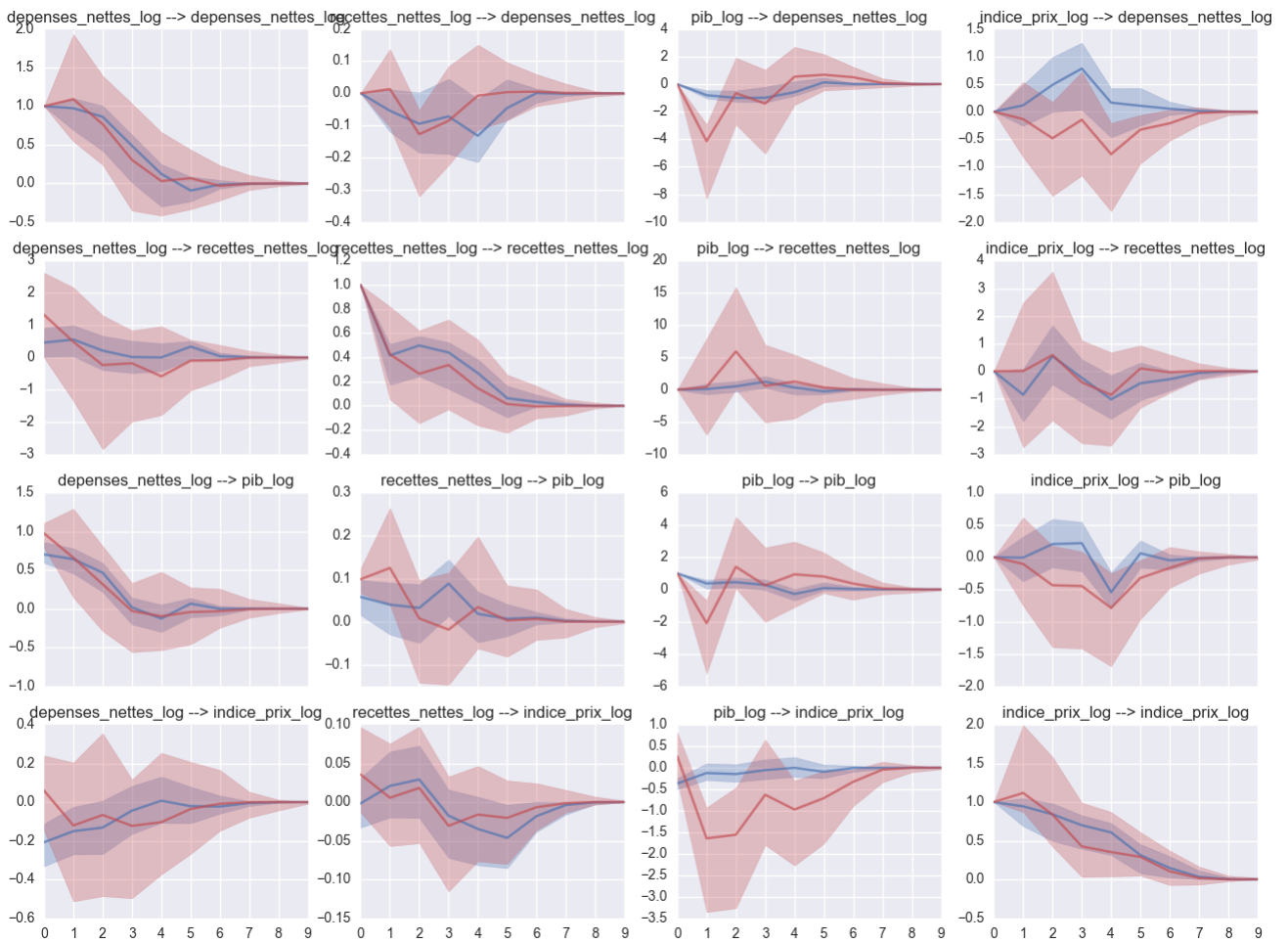
IRF, modèle TVAR et ratio de dette pour $p = 3$ et $p = 4$

FIGURE 2.14 – IRF ; $z_t = (y_{t-1} - y_{t-5})/4$; $p = 3$



Les courbes en bleu indiquent les IRF dans le régime d'expansion, les courbes en rouge indiquent les IRF dans le régime de récession. Les intervalles de confiance sont tracés pour un risque à 10%.

FIGURE 2.15 – IRF ; $z_t = (y_{t-1} - y_{t-5})/4$; $p = 4$



Les courbes en bleu indiquent les IRF dans le régime d'expansion, les courbes en rouge indiquent les IRF dans le régime de récession. Les intervalles de confiance sont tracés pour un risque à 10%.

Estimation du modèle TVAR

On considère un modèle VAR à changement de régime avec variables exogènes, dans le cas de deux régimes et p retards. Le modèle s'écrit :

$$y_t = \sum_{i=1}^p ((1 - g_t)A_i^1 + g_t A_i^2) y_{t-i} + ((1 - g_t)\phi^1 + g_t \phi^2) d_t + u_t$$

FIGURE 2.16 – IRF ratio de dette pour un choc négatif de dépenses (gauche) et pour un choc positif de recettes (droite) ($p = 3$, $z_t = (y_{t-1} - y_{t-5})/4$).



La courbe en bleu indique l'IRF dans le régime d'expansion, la courbe en rouge indique l'IRF dans le régime de récession. La courbe en vert correspond à la différence entre les deux IRF. Les intervalles de confiance sont tracés pour un risque à 10%.

Les notations sont les suivantes :

- y_t le vecteur des variables exogènes de taille $[K, 1]$.
- A_i^j la matrice des coefficients capturant l'effet du retard i dans le régime j , de taille $[K, K]$.
- d_t le vecteur regroupant les variables exogènes, incluant la constante et le trend, de taille $[H, 1]$
- ϕ^j la matrice capturant l'effet des variables exogènes sur les variables endogènes dans le régime j , de taille $[K, H]$.

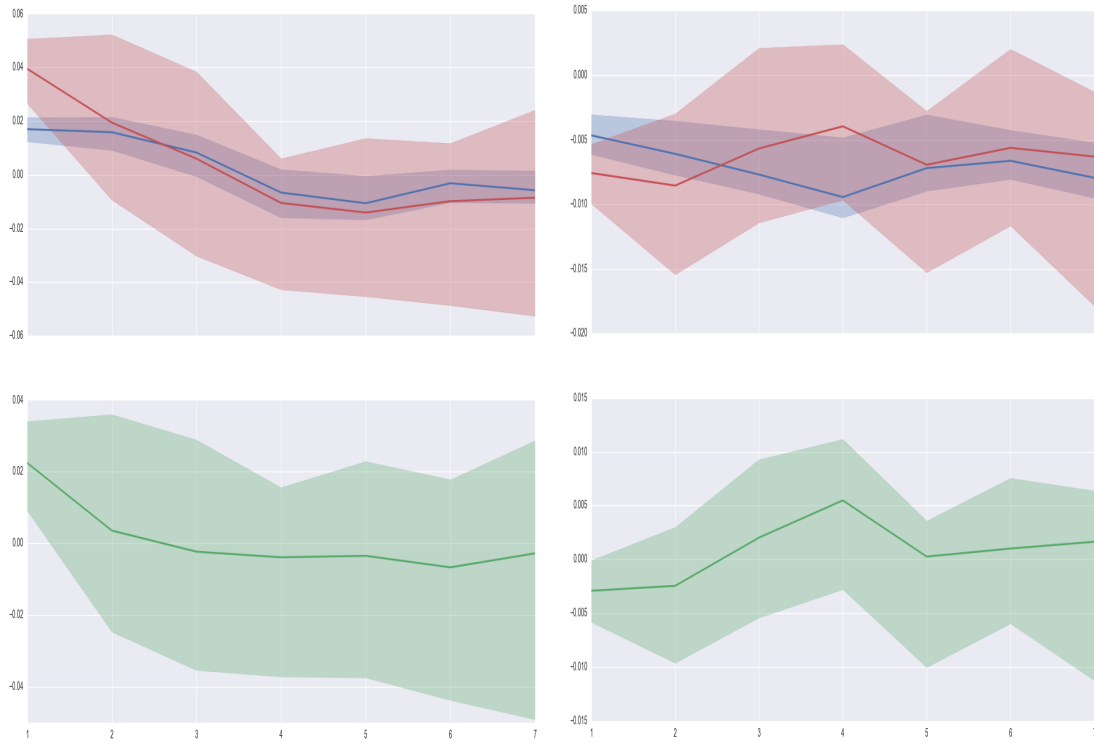
FIGURE 2.17 – IRF ratio de dette pour un choc positif de prix (gauche) et pour un choc positif de pib (droite) ($p = 3$, $z_t = (y_{t-1} - y_{t-5})/4$).



La courbe en bleu indique l'IRF dans le régime d'expansion, la courbe en rouge indique l'IRF dans le régime de récession. La courbe en vert correspond à la différence entre les deux IRF. Les intervalles de confiance sont tracés pour un risque à 10%.

- g_t est une variable scalaire comprise entre $[0, 1]$ caractérisant la combinaison linéaire des deux régimes à chaque instant. Cette variable est en général fonction d'une autre variable nommée variable de transition. Dans le cas d'un modèle TVAR la fonction est une fonction indicatrice, dans le cas d'un modèle STVAR on utilise généralement une fonction logistique.
- u_t est le terme d'erreur. Nous supposons que celui-ci suit une loi normale de moyenne nulle dans chacun des régimes, cependant sa matrice de variance-covariance diffère selon les régimes : $V[u_t] = (1 - g_t)\Omega^1 + g_t\Omega^2$.

FIGURE 2.18 – IRF ratio de dette pour un choc négatif de dépenses (gauche) et pour un choc positif de recettes (droite) ($p = 4$, $z_t = (y_{t-1} - y_{t-5})/4$).

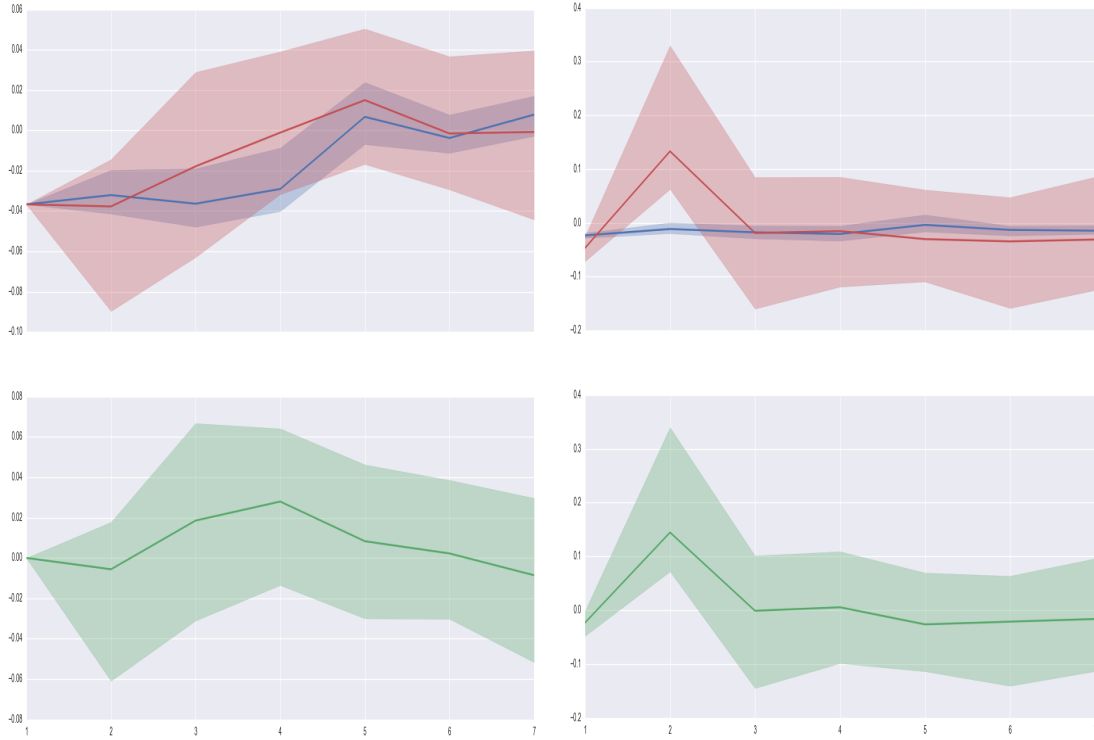


La courbe en bleu indique l'IRF dans le régime d'expansion, la courbe en rouge indique l'IRF dans le régime de récession. La courbe en vert correspond à la différence entre les deux IRF. Les intervalles de confiance sont tracés pour un risque à 10%.

En utilisant les règles de multiplication sur les matrices block, le modèle peut être reformulé de la manière suivante :

$$y_t = \psi_t \left[\sum_{i=1}^p A_i y_{t-i} + \phi d_t \right] + u_t$$

FIGURE 2.19 – IRF ratio de dette pour un choc positif de prix (gauche) et pour un choc positif de pib (droite) ($p = 4, z_t = (y_{t-1} - y_{t-5})/4$).



La courbe en bleu indique l'IRF dans le régime d'expansion, la courbe en rouge indique l'IRF dans le régime de récession. La courbe en vert correspond à la différence entre les deux IRF. Les intervalles de confiance sont tracés pour un risque à 10%.

Avec $\psi_t = ((1 - g_t)I_K, g_t I_K)$, $A_i = \begin{pmatrix} A_i^1 \\ A_i^2 \end{pmatrix}$, $\phi = \begin{pmatrix} \phi^1 \\ \phi^2 \end{pmatrix}$. Le modèle peut être écrit de manière

encore plus compacte en posant $B = (A_1, A_2, \dots, A_p, \phi)$ et $x_t = \begin{pmatrix} y_{t-1} \\ \dots \\ y_{t-p} \\ d_t \end{pmatrix}$. On a alors :

$$y_t = \psi_t B x_t + u_t$$

On pose également $\Omega = \begin{pmatrix} \Omega^1 \\ \Omega^2 \end{pmatrix}$, ainsi $V(u_t) = \psi_t \Omega$.

Les erreurs étant supposées suivre une loi normale, l'estimation s'effectue par la méthode du maximum de vraisemblance (Hurlin et Mignon (2018)). La log vraisemblance du modèle est donnée par

$$L(\beta, \Omega) = \text{const} - \frac{1}{2} \sum_{t=1}^T \{ \log(\det(\psi_t \Omega)) + u_t'(\psi_t \Omega)^{-1} u_t \}$$

Avec $u_t = y_t - \psi_t B x_t$ et T le nombre d'observations temporelles. On note $\text{vec}(B) = \beta$, on détermine $\hat{\beta}$ en posant $\frac{\partial L}{\partial \beta'} = 0$. On obtient alors

$$\hat{\beta} = \left[\sum_{t=1}^T (x_t x_t' \otimes \psi_t'(\psi_t \Omega)^{-1} \psi_t) \right]^{-1} \left(\sum_{t=1}^T (x_t' \otimes y_t'(\psi_t \Omega)^{-1} \psi_t)' \right)$$

Afin de déterminer Ω on pose

$$\frac{\partial L}{\partial \Omega} = -\frac{1}{2} \sum_{t=1}^T \left\{ \frac{\partial \log(|\psi_t \Omega|)}{\partial \Omega} + \frac{\partial u_t'(\psi_t \Omega)^{-1} u_t}{\partial \Omega} \right\} = 0$$

Or

$$\begin{aligned} \frac{\partial \log(|\psi_t \Omega|)}{\partial \Omega} &= \psi_t'(\psi_t \Omega)^{-1} \\ \frac{\partial u_t'(\psi_t \Omega)^{-1} u_t}{\partial \Omega} &= -\psi_t'(\psi_t \Omega)^{-1} u_t u_t'(\psi_t \Omega)^{-1} \end{aligned}$$

On obtient ainsi la condition suivante

$$\sum_{t=1}^T \{ \psi_t'(\psi_t \Omega)^{-1} (u_t u_t'(\psi_t \Omega)^{-1} - I_K) \} = 0$$

où $u_t = y_t - (x_t' \otimes \psi_t) \beta$.

La condition portant sur les coefficients des matrices de variance-covariance ne prend pas de forme analytique simple, cependant nous pouvons distinguer deux cas particuliers :

1. $\Omega^1 = \Omega^2 = \Omega^0$: dans ce cas les erreurs se comportent de la même manière dans les deux régimes ce qui nous amène à la simplification suivante, $\psi_t \Omega = \Omega^0$. On en déduit alors

$$\Omega^0 = \frac{1}{T} \sum_{t=1}^T u_t u_t'$$

Dans ce cas on retrouve l'expression habituelle de l'estimateur de la matrice de variance covariance pour un modèle VAR.

2. $g_t \in \{0, 1\}$: ce qui revient à considérer un modèle TVAR. Dans ce cas là nous avons $\psi_t = (I_K, 0)$ si $g_t = 0$ et $\psi_t = (0, I_K)$ si $g_t = 1$. On note alors $G_0 = \{t \in \{1, \dots, T\} : g_t = 0\}$, $G_1 = \{t \in \{1, \dots, T\} : g_t = 1\}$ et $T_0 = \mathbf{card}(G_0)$, $T_1 = \mathbf{card}(G_1)$. La condition d'optimalité se reformule alors de la manière suivante :

$$\sum_{t \in G_0} \left\{ \begin{pmatrix} I_K \\ 0 \end{pmatrix} (\Omega^1)^{-1} (u_t u_t' (\Omega^1)^{-1} - I_K) \right\} + \sum_{t \in G_1} \left\{ \begin{pmatrix} 0 \\ I_K \end{pmatrix} (\Omega^2)^{-1} (u_t u_t' (\Omega^2)^{-1} - I_K) \right\} = 0$$

Ainsi chaque terme s'égalise à zéro en posant respectivement

$$\Omega^1 = \frac{1}{T_0} \sum_{t \in G_0} u_t u_t'$$

$$\Omega^2 = \frac{1}{T_1} \sum_{t \in G_1} u_t u_t'$$

Procédure *Bootstrap*

Afin de construire les intervalles de confiance pour nos différentes estimations nous procédons comme suit :

1. Nous nous donnons les conditions initiales pour les variables endogènes : g_t, t_t, y_t, p_t .
Nous nous donnons également le seuil de la variable de transition.

2. Nous simulons le processus TVAR à partir des coefficients estimés en tenant compte du fait que la variable de transition est elle-même générée par le modèle étant donné qu'elle est une fonction de y_t et de ses retards. Selon que la valeur prise par la variable de transition est inférieure ou supérieure au seuil, nous appliquons les coefficients du régime correspondant permettant de générer le vecteur des variables endogènes en t à partir des variables endogènes retardées, des variables exogènes en t et d'un choc tiré aléatoirement parmi les erreurs du modèle estimé.
3. L'ajout du terme d'erreur tient également compte du régime dans lequel le processus TVAR se trouve. A partir des erreurs estimées nous formons deux ensembles : les erreurs estimées en régime de récession et les erreurs estimées en régime d'expansion. Le terme d'erreur est donc tiré aléatoirement dans l'ensemble correspondant. Ceci est nécessaire dans la mesure où la matrice de covariance des erreurs diffère selon le régime.
4. Nous réalisons 500 simulations et nous ré-estimons le modèle sur chacune d'entre elles (le seuil de transition n'est pas ré-estimé, nous conservons le même pour toutes les simulations bootstrap) afin de récupérer une distribution et réaliser les intervalles de confiance sur les différentes estimations.

Bibliographie

Ahrend, R., P. Catte and R. Price (2006), "Interactions between Monetary and Fiscal Policy : How Monetary Conditions Affect Fiscal Consolidation", OECD Economics Department Working Paper, No. 521.

Alesina A., and R. Perotti (1995), "Fiscal Expansions and Adjustements in OECD Countries", Economic Policy, n.21, 207-247.

Alesina A., and R. Perotti (1996), "Fiscal Discipline and the Budget Process", *American Economic Review*, Vol. 86, No. 2, 401-407.

Alesina, A. and S. Ardagna (2009), "Large Changes in Fiscal Policy : Taxes versus Spending", NBER Working Paper, No. 15438.

Ardagna, S. (2009), "Determinants and Consequences of Fiscal Consolidations in OECD Countries" in : *European Commission : European Economy 2009*, European Commission, Brussels.

Auerbach, A. and Y. Gorodnichenko (2012), "Measuring the Output Responses to Fiscal Policy", *American Economic Journal : Economic Policy*, Vol. 4, No. 2, 1-27.

Batini, N., G. Callegari, and G. Melina, 2012, "Successful Austerity in the United States, Europe and Japan," IMF Working Paper 12/190 (Washington : International Monetary Fund).

Baxter, M. and R. King (1993). "Fiscal Policy in General Equilibrium", *American Economic Review*, Vol. 83(3), pp. 315-334.

Bi H., Leeper E., Leith C., (2013), "Uncertain Fiscal Consolidation", *The Economic Journal*, Vol. 123, 31-63.

Biau, O. and E. Girard (2005), "Politique budgétaire et dynamique économique en France : l'approche VAR structurel," *Économie et Prévision* 169–171, 1–24.

Blanchard, O., and R. Perotti, 2002, "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output," *Quarterly Journal of Economics*,

Vol. 117, pp. 1329–1368.

Boussard J., de Castro F., Salto M. (2013) Fiscal Multipliers and Public Debt Dynamics in Consolidations. In : Paganetto L. (eds) Public Debt, Global Governance and Economic Dynamism. Springer, Milano

Caggiano G., Castelnuovo E., Colombo V., Nodari G., (2015), "Estimating Fiscal Multipliers : News From A Non-linear World", *The Economic Journal*, Vol. 125, 746-776.

de Castro, F and P. Hernández de Cos (2008), "The economic effects of fiscal policy : the case of Spain," *Journal of Macroeconomics*, 30, 1005-1028.

Christiano, L., M. Eichenbaum and S. Rebelo (2011), "When is the Government Spending Multiplier Large ? ," *Journal of Political Economy* 119(1), 78-121.

Cherif, R., and F. Hasanov, 2010, "Public Debt Dynamics and Debt Feedback," MPRA Paper No. 27918.

Cherif, R., and F. Hasanov, 2012, "Public Debt Dynamics : The Effect of Austerity, Inflation, and Growth Shocks," IMF Working Paper No. 12/230.

Davig T., E. Leeper, (2011), "Monetary-fiscal policy interactions and fiscal stimulus", *European Economic Review*, Volume 55, Issue 2, February 2011, pp. 211-227.

Denes M., Eggertsson G., Gilbukh S., (2013), "Deficits, Public Debt Dynamics and Tax and Spending Multipliers", *The Economic Journal*, Vol. 123, 133-163.

Eggertsson, Gauti B. (2006), Fiscal multipliers and policy coordination, Staff Report, Federal Reserve Bank of New York, No. 241

Eggertsson, Gauti B. (2011), "What Fiscal Policy Is Effective at Zero Interest Rates", NBER Macroeconomics Annual 2011 25 :1, 59-112.

Eyraud, L., and A. Weber, 2013, "The challenge of Debt Reduction during Fiscal Consolidation", IMF Working Paper.

Favero, C., and F. Giavazzi, 2007, "Debt and the Effect of Fiscal Policy," NBER Working Paper 12822.

Galí, J., D. López-Salido and J. Vallés (2007), "Understanding the effects of government spending on consumption," Journal of the European Economic Association, 5, pp. 227-270.

Giordano, R., S. Momigliano, S. Neri and R. Perotti (2007), "The effects of fiscal policy in Italy : Evidence from a VAR model", European Journal of Political Economy, 23, pp. 707–733.

Guichard, S., M. Kennedy, E. Wurzel and C. André (2007), "What Promotes Fiscal Consolidation : OECD Country Experiences", OECD Economics Department Working Paper, No. 553.

Hurlin, Christophe, and Valérie Mignon. Statistique et probabilités en économie-gestion. Dunod, 2018.

Luktepohl, H (2005), "New Introduction to Multiple Time Series Analysis", Springer-Verlag Berlin Heidelberg, 764 p.

Molnár, Margit (2012), "Fiscal consolidation : What factors determine the success of consolidation efforts ?", OECD Journal : Economic Studies, Vol. 2012/1.

Mountford, A. and H. Uhlig (2009), "What are the effects of fiscal policy shocks?," Journal of Applied Econometrics, 24(6), pp 960-992.

Perotti, R. (2004), " Estimating the effects of fiscal policy in OECD countries,". Proceedings, Federal Reserve Bank of San Francisco.

Von Hagen, J. and R.R. Strauch (2001), "Fiscal Consolidations : Quality, Economic Conditions and Success", Public Choice, Vol. 109.

Von Hagen, J., A. Hughes Hallett and R.R. Strauch (2002), "Budgetary Consolidation in Europe : Quality, Economic Conditions and Persistence", Journal of the Japanese and International Economies, Vol. 16.

Woodford, M., (2011), "Simple analytics of the government spending multiplier", American Economic Journal : Macroeconomics 3(1), 1-35.

Chapitre 3

Beta-convergence at municipalities' level: the French case ¹

3.1 Introduction

Since the seminal papers of Baumol (1986) and Barro and Sala-i-Martin (1992), an important literature has developed around the concept of economic convergence between territories. While the majority of studies have highlighted a convergence phenomenon, most of them have focused on relatively large territories: countries, American states, American counties or European regions (NUTS). Thus, the process of economic convergence remains largely unstudied at a fine scale such as municipalities. In order to fill this gap, this chapter investigates income convergence between French municipalities by exploiting a sample of nearly 30,000 municipalities whose median income is observed over the period spanning from 2001 to 2014.

The study of the convergence phenomenon at a fine scale is particularly relevant insofar as the

1. Une première version de ce chapitre est à paraître en tant que Document de travail : Egrou B. (2019), "Beta-convergence at municipalities' level: the French case", Working Paper EconomiX

aggregation of granular data can mask local heterogeneity. Indeed, the distribution observed on fine data may show much greater variability than that observed on aggregate data. For example, regions may all have the same income level while cities within these regions exhibit very different income levels. Furthermore, the preservation of granular information within a geographical space makes it possible to detect forms of spatial non-stationarity, both in terms of variables and relationships between them, that would be impossible to observe at a less granular scale. In addition, from a statistical viewpoint, relying on disaggregate data improves the accuracy of the estimates and avoids certain biases, particularly when there is a non-linear transformation of aggregate data.

The level of granularity chosen is also important regarding the theoretical justification for convergence. Indeed, Barro and Sala-i-Martin (1992) rely on neoclassical growth theory to understand convergence between American states, but it is difficult to apply it at the city level. At this level of granularity, there is a complete decoupling between production and income due to the high mobility of labour and capital: (i) a city can declare a median income even though no production activity takes place within it, and (ii) conversely a large number of production activities can take place in a city while the income from these production activities is declared elsewhere. The income declared within a municipality can therefore have a very weak link with local value added creation² and can have its origins in public wages, public transfers (unemployment, retirement), commuters, capital income... Finally, cities behave like very small open economies, which implies strong spatial dependence effects between them. Thus, the convergence phenomenon observed at this fine scale provides us with a better understanding of the dynamics of economic growth and how it spreads in space.

Beyond the understanding of the economic phenomenon, convergence between territories in terms of income also implies strong political stakes. On the one hand, economic convergence

2. See, in particular, the theory of the economic base (Hoyt, 1954; North 1955; Tiebout, 1956).

leads to better cohesion between territories because it implies that economic growth spreads across space in order to reduce inequalities, thus allowing each territory to benefit from overall economic growth. On the other hand, the means by which economic convergence is achieved may raise objections insofar as the fiscal policy deployed does not benefit all territories in the same way. Thus, the economic policies implemented in order to achieve convergence can undermine political cohesion between territories, with some territories feeling robbed to the benefit of others. We have recently seen an increase in requests for autonomy and regionalist movements in Europe, for example in Catalonia or Northern Italy. Davezies (2016) attributes the strengthening of these movements to the fact that the economic and public debt crises make solidarity between high-income and low-income territories increasingly difficult. In France, the metropolitan/provincial divide is often described as a source of political tensions. Indeed, deindustrialisation and globalisation have concentrated skilled jobs in metropolitan zones, and rural areas would then be destined to suffer from slower economic growth. Thus, the potential tensions that may exist between the territories of the same country make it crucial to assess and characterize the convergence phenomenon. This chapter tackles this issue and aims at testing the following hypotheses. First, do we observe a phenomenon of absolute convergence across French municipalities? Second, is there any growth spatial dependence between territories? Third, can we distinguish two convergence regimes based on the core/periphery distinction?

To the extent that these assumptions have already been addressed in the literature, our contributions are fourfold. First, we propose a study whose geographical unit is the municipality. This gives us a much higher level of granularity than the vast majority of previous studies. In addition, we have a large sample as it contains nearly 30,000 French municipalities. Second, no quantitative study has so far looked at the French case. Thus, to our best knowledge, the convergence of income levels between French territories has never been measured. Third, the geographical granularity of our observations as well as the fact that we observe almost all the French municipalities allow us to test the hypotheses mentioned above on subsets of various

areas of the French territory: is there convergence within "départements" ? within "régions" ? More generally, we will seek to assess the instability of the convergence phenomenon across the French territory. Finally, from a methodological viewpoint, we account for the spatial structure of the data using appropriate econometric models, allowing in particular to incorporate spatial autocorrelation as well as parameter instability across space.

Our main findings show that the β -convergence hypothesis is validated at the municipality level. Furthermore, we find evidence that this convergence phenomenon is non-linear and non-uniform on the territory, this result being robust to several methodologies.³

The rest of the chapter is organized as follows. Section 3.2 provides a review of the literature on how to assess convergence and the main findings regarding β -convergence. Section 3.3 details the various methodological tools we will need later on. Section 3.4 presents and describes our data. Section 3.5 display our results on absolute β -convergence and, finally, we conclude in Section 3.6.

3. It is worth mentioning that we do not seek to identify or study the determinants of local income growth. Indeed, many of our explanatory variables when studying relative convergence can be considered as endogenous. Thus, these variables are only useful as control variables, and we will not interpret the associated estimated coefficients. Identifying the determinants of convergence and explaining their reasons also go beyond the objective of this chapter ; our primary aim being to identify and characterize the phenomenon of β -convergence on French territory.

3.2 Economic convergence: scale, measure and literature review

3.2.1 From macro to micro

Economic convergence between territories is a relatively old subject of study. Early on, economists wondered why some territories had higher development rates than others, and whether we can expect convergence, or, at least, stability in levels of development across space. Originally, the interest for this issue lies mainly in its implications for social well-being and political stability. However, in the 1980s and 1990s, economists renewed their interest in the study of the convergence phenomenon as a means of separating competing economic theories: neoclassical growth theory and the new growth theory. Indeed, the neoclassical growth theory initiated by Solow (1956) and Swan (1956) predicts convergence of each economy towards its own stationary state due to the decrease in marginal returns. Initially, neoclassical growth theory applies to the study of an economy and does not directly imply conclusions in terms of convergence between economies. However, by adding the assumption of homogeneity of technological progress, it can be concluded that several economies will tend to converge towards a common growth rate. On the contrary, the new growth theory seeks to endogenize the long-term growth rate so that it depends on the structural parameters of the economy. The central idea of the theory of endogenous growth lies in the fact that technological progress is no longer considered exogenous but comes from the behaviour and interaction of economic agents. The aim is to eliminate the decline in marginal returns at the macroeconomic level in favour of constant returns. The literature then developed several ways of accessing constant returns: externality of production (learning by doing), existence of a sector producing technological progress (Romer (1986), Aghion and Howitt (1990))... These different methods have in common to be based on the effects of externalities between agents and market imperfections.

Growth theories apply to large economies such as countries, American states or large European regions and there is generally little interaction between economies. However, and since macroeconomic-level measures are only the result of a multitude of microeconomic behaviours and interactions, it is relevant to study economic development at smaller scales. This then makes more use of the notion of space and interaction between territories. The new geographical economy (Krugman (1991), Fujita and Thisse (1996)) then seeks to explain the distribution of factors of production in space in order to understand local economic growth. Economic agents seek to locate themselves in space strategically insofar as distance involves a cost. For example, in the event of high transport costs, it will be the interest of final goods companies to be close to final consumers, even if this means higher production factor costs (wages, rents, etc.). The suppliers of these final goods companies will have a similar logic leading to an agglomeration phenomenon due to spatial externalities. This agglomeration effect can be offset by rising input prices and congestion effects in areas where economic activity is too dense. From then on, a spatial balance can emerge. The new geographical economy therefore makes it possible to think of local development based on local production, which in turn depends on the location of economic agents in the area. This point of view makes it possible to explain in a natural way the concentration of productive activities as well as the emergence of poles of productivity. We should then expect economic development to diverge between the territories and, in particular, between their incomes.

However, we have seen that the smaller a territory is, the more we must expect a decorrelation between its income and its production. In this perspective, it is interesting to recall that one of the first theories explaining the development of regional and urban territories, the theory of the economic base developed in the 1950s by North (1955), Hoyt (1954) and Tiebout (1956), proposes to explain the income level of a territory by its ability to produce added value but also by its capacity to capture external income. Thus, according to this theory, the productive character of a territory is only part of the explanation of its wealth and other forces are at work.

Indeed, income from wages declared within a territory may originate from production outside the territory. In addition, property income (interest, dividend) also involves transfers between territories. In the case of a country, this corresponds to taking into account the income balance (primary income); the latter being generally low compared to domestic production, around 2.3% for France.⁴ In the case of a small, fully integrated economic territory, such as a city, this relationship can be very important. This is due in particular to the very high mobility of labour and capital at the local level. It should also be added that the formation of a budgetary union between several territories reinforces the decoupling between income and production. Indeed, the territories do not benefit and contribute in the same way, partly because of the eligibility of their population for certain taxes or transfers. For example, the fact that the retired population is not uniformly distributed among the different territories of a country creates a distortion between the distribution of value added production and the distribution of income. This is also the case for the distribution of the population eligible for unemployment benefits. More generally, we must expect that the decoupling between income and production will be all the more important as:

1. the geographical unit considered is small,
2. economic integration is important,
3. the pooling of income through budgetary policy is important,
4. the distribution of populations eligible for taxes and transfers is not uniform between territories.

While the new geographical economy provides a theoretical framework for understanding the location of production, this does not seem sufficient to explain the distribution of income at a fine scale. In particular, the polarization of value added creation does not imply a divergence of territories in terms of income within a country.

4. According to the 2017 report "La balance des paiements et la position extérieure de la France" produced by the "Banque de France", primary income amounts to 52.5 billion, i.e. 2.3% of GDP.

As stated above, the difference in economic development between economies can be seen from different points of view depending on the size of the geographical units, their level of economic integration and whether one considers production or income. The study of convergence is also modified. In the following, we will focus on a point that has not been widely studied until now: very small geographical units, very strongly integrated economically within a budgetary union whose mutualisation of income is high.

3.2.2 How to measure and test convergence ?

As we have seen, the study of economic convergence is politically decisive, but also has strong theoretical implications. However, we have not yet defined precisely the phenomenon of convergence and we will see that the literature has given rise to different concepts of convergence. Indeed, Islam (2003) distinguishes between several types of convergence:

1. Convergence within an economy (time dimension) versus convergence between several economies (individual dimension). In the first case, we try to check whether an economy is converging towards its own stationary state. In the second case, we try to check whether the different economies are tending towards a common stationary state.
2. Convergence in terms of growth rate *versus* convergence in level. Convergence can be thought in terms of level: for example, one may assert whether the level of wealth of countries tends to converge towards a common level, implying a reduction in inequalities between countries. On the contrary, the analysis may focus on growth rates, in which case countries will tend to share the same growth rate in the long term, but this does not imply a catching-up process in terms of wealth level.
3. β -convergence versus σ -convergence. β -convergence consists in testing whether the income growth rate depends negatively on the initial income, in that case we have a catching-up phenomenon to the extent that poor economies have higher growth rates on average than rich economies. If we have the income of several economies at two different

dates separated from T years, then economically testing β -convergence is like estimating the following equation in cross section:

$$g_i = \alpha + \beta \ln(y_{i,t=0}) + \varepsilon_i$$

where $y_{i,t=0}$ is the initial income and $g_i = \ln(y_{i,t=T}) - \ln(y_{i,t=0})$ is the average income growth rate over the study period. A simple significance test on β then allows us to conclude that β is significantly less than 0 or not.

σ -convergence consists in verifying that there is a reduction in the dispersion of the income distribution between economies, thus reflecting a reduction in inequalities between them. Several dispersion measures can be used such as standard deviation, coefficient of variation or Gini index. It is important to note that β -convergence is not equivalent to σ -convergence as the latter is more restrictive. Indeed, β -convergence is a necessary condition for σ -convergence but it is not enough.

4. Absolute convergence against conditional convergence. Absolute convergence implies ignoring the control variables. In the case of β -convergence, this means that we are not trying to determine the effect of initial income on an economy's growth rate but simply to verify that poor economies have, on average, significantly higher growth rates than rich economies. Thus, in the case where β -convergence is verified we cannot say that a low initial income has a negative effect on the growth rate, we can simply deduce that economies with a low initial income have higher average growth rates. On the contrary, conditional convergence implies taking into account the other factors influencing growth. In the event that conditional convergence is verified, it is no longer possible to say that there has been catching-up over the study period, but only that, all other things being equal, a low initial income is associated with a high growth rate, or that initial income has a negative effect on the growth rate. It is therefore important to note that the conclusion in favour of conditional convergence can be verified even though rich economies have experienced higher growth rates on average than poor economies.

5. Global convergence versus local convergence. This distinction occurs when testing convergence between several economies. Rather than assuming that economies converge towards a common stationary state, it is possible to suppose that these same economies form subgroups where within each subgroup a long-term equilibrium is shared.

We can then test convergence by combining different choices, for example, testing the absolute convergence in level between several economies. Various methodologies can be used, as highlighted by Islam (2003): cross-section, panel, time series, and distribution. In the following, we will test absolute β -convergence, between several economies in terms of income level. We will also allow the existence of convergence between subgroups. β -convergence will be tested from cross-section data. Despite the fact that β -convergence has been criticized, particularly by Quah (1990) and Friedman (1994) for not involving a reduction in dispersion, this concept is nevertheless relevant insofar as it is a necessary condition for σ -convergence. Moreover, we will not interpret β -convergence as evidence that economies are converging towards the same level of income in the long term. Indeed, this would imply that the process over the coming periods would be the same as that observed over the study period. In our opinion, this hypothesis is too strong since, in the case of an economy sharing a common budgetary system, the convergence process can be highly dependent on the political choices that make each period of study particular. The β -convergence hypothesis will simply be interpreted as highlighting a catching-up phenomenon over the period studied without implying anything else for future periods. This phenomenon of catching-up over the study period may be contingent on several political or historical elements that are difficult to measure in practice. Thus, we will refrain from concluding that the economies studied converge towards the same stationary state.

Concerning the methodology, we use a cross section analysis taking into account spatial autocorrelation as well as the instability of the parameters across the French territory. We will not use a panel approach, although this methodology allows us to release the hypothesis of homogeneity of economies through the introduction of fixed effects. Indeed, this would make it

possible to control for an omitted variable bias either constant over time or constant between individuals. We make this choice because our study focuses on French municipalities whose homogeneity can be reasonably assumed in terms of institutions, technological level or infrastructure. This assumption of homogeneity would have been clearly much more problematic in the case of a study involving European countries or regions. In addition, for each municipality, we have a very large number of control variables (see Section 3.4) to control for heterogeneity. Furthermore, the panel approach involves the "within" dimension in addition to the "between" dimension. This can be a disadvantage if the frequency of the data is high and spreads over a small time horizon. Indeed, the determinants of growth over a year will be much noisier than over a decade or so. This is all the more true when considering small economies. In our case, we have a study period spanning from 2002 to 2014 where we observe very small economies, so it is more appropriate to calculate the long-term growth rate in order to reduce dependence on short-term shocks and reveal the long-term determinants. Finally, studying convergence within subgroups (club convergence) can also be criticized as emphasized by Islam (2003). Indeed, it is not clear whether it is possible to differentiate conditional convergence from club convergence. If the definition of convergence clubs is based on control variables, it is similar to conditional convergence. It should be noted, however, that there is an important difference because in the case of conditional convergence, all economies share the same β conditionally with the other variables, whereas in the case of convergence per club each club has its own β . Thus, club convergence involves non-linearity to the extent that the effect of initial income depends on other variables. In some cases, clubs are not defined *via* control variables but according to the initial income level. The criticism that can be made regarding this practice is that there is no reason for rich economies to converge differently from poor economies insofar as the former have experienced income levels similar to the latter in the past. We can still weaken this criticism by the fact that while rich economies have experienced income levels similar to poor economies in the past, they have nonetheless remained richer than poor economies, there is thus an asymmetry in the relative position of economies. The economies which are located at the top of the

distribution are mainly those which generate technological progress and therefore long-term economic growth. On the contrary, other economies are at the bottom of the distribution and are more engaged in a catching-up process. The former may have taken a historical advantage over the latter that cannot be filled, but catching-up economies may converge towards a common level. Finally, as we will see in Section 3.3, club convergence takes on a different meaning when we integrate the spatial dimension. In this case, it will consist in defining spatial regimes allowing instability of coefficients in space.

3.2.3 A brief review of the literature on β -convergence

The first studies involving the concept of convergence date back to Baumol (1986) in the case of countries, and Barro and Sala-I-Martin (1992) in the case of American states and European regions. More specifically, Barro and Sala-I-Martin (1992) clearly highlight a negative relationship between initial income (income in 1880) and the average rate of income growth over the period from 1880 to 1988. This is valid for the American states as a whole, but also between states within the same region and between European regions within their respective countries. Strong evidence in favor of the β -convergence hypothesis is thus provided. These results were confirmed for the United States at a finer scale by Young, Higgins and Levy (2008), i.e., using income data at the level of American counties (3000 counties observed from 1970 to 1998). The authors conclude in favor of the β -convergence hypothesis for the whole country but also for each American state. In the context of Europe, Persson (1997) reproduces Barro and Sala-I-Martin's (1992) study on 24 Swedish regions observed from 1911 to 1993, and validates the β -convergence hypothesis. This result is also confirmed by Aronsson, Lundberg and Wikstrom (2001) again in the case of Sweden.

However, these first studies have an important flaw in that they ignore the spatial interde-

dependencies that may exist between geolocated observations. Including the spatial dimension makes it possible to take into account spatial externalities between observations, but also to introduce spatial regimes and thus allow the variation of coefficients in space. Several articles have overcome this weakness, in particular Rey and Montouri (1999), which clearly highlight a phenomenon of spatial convergence between American states and the existence of spatial interdependence between them. While the rate of convergence is slower when spatial interactions are taken into account, convergence remains very significant. All specifications tested within the article validate the β -convergence hypothesis. Baumont, Ertur and Le Gallo (2003) also seek to test the β -convergence hypothesis in the case of European regions by including spatial dependence. Here again, the authors show that there is spatial interaction between regions, and they also confirm the β -convergence hypothesis within this new econometric framework. Subsequently, Fischer and Stirbock (2006) and Le Gallo and Dall'Erba (2008) refined the analysis by including spatial regimes while maintaining spatial interactions. This econometric framework permits a variation of coefficients in space, thus allowing the estimation of different convergence speeds according to the territory under consideration (convergence per club). The two studies define a "core" regime corresponding to clusters of high-income regions and a "periphery" regime corresponding to clusters of low-income regions. Based on European data, the two articles show that poor regions converge significantly faster than rich regions. Gallo and Dall'Erba (2008) even show that the β -convergence hypothesis is not validated within the "core" regime. Lim (2016) reproduces a similar work to Le Gallo and Dall'Erba (2008) in the context of the USA and at a finer level of granularity. This sample is composed of the 177 US BEA Economic Areas observed from 1969 to 2008. The author strongly highlights the spatial dependence between these territories and validates the β -convergence hypothesis. In line with the results of Fischer and Stirbock (2006) and Le Gallo and Dall'Erba (2008), the rate of convergence within the "periphery" regime is much higher (and significantly different) than that estimated within the "core" regime. Still concerning European regions, Artelaris (2015) compares different methodologies in the evaluation of β -convergence: global convergence, "club" convergence as

well as local convergence based on the GWR method.⁵ The author validates the β -convergence hypothesis and also highlights a spatial instability of the coefficients.

To date, very few articles have studied convergence at the city level. Glaeser et al. (1995) focus on the determinants of average income and population growth in cities, using a sample of 203 American cities observed from 1960 to 1990. Initial income is included in their explanatory variables, the coefficient associated is significant and negative, suggesting a phenomenon of β -convergence. Lundberg (2001) carries out a study relatively similar to that of Glaeser et al. (1995) but based on Swedish data (271 municipalities observed from 1981 to 1990). The municipalities of Sweden are intermediate geographical units between the city and the county. The author confirms the β -convergence hypothesis, however this result is not significant for cities belonging to metropolitan areas. Lundberg (2003) extends his own 2001 paper by incorporating the spatial dimension into the analysis, the hypothesis of the existence of a positive growth externality between cities is well validated and income convergence is observed for cities outside the Stockholm region. Finally, Gonzalez-Val (2015) tests the β -convergence hypothesis, by incorporating spatial dependence, on a sample composed of American cities with more than 25,000 inhabitants (1152 cities) whose income is observed from 1990 to 2000. Here again, the β -convergence hypothesis is strongly supported.

The literature therefore provides us with a relative consensus regarding the β -convergence phenomenon. We generally observe convergence within geographical units with significant spatial dependencies, but this phenomenon is not uniform in space. In particular, the speed of convergence seems to be much higher in peripheral regions, defined as clusters of regions with lower incomes. On the contrary, the speed of convergence would be low or almost non-existent in the core regions. While convergence and spatial dependence have been demonstrated at different levels of granularity, there are few articles for which the observation unit is the city. When this

5. See Subsection 3.3.3 for a description of this method.

is the case, the cities are generally large, such as the the large American cities with more than 25,000 inhabitants and the Swedish municipalities. In addition, these samples are relatively small in size.

3.3 Methodology: accounting for spatial dependence

As we have seen, β -convergence can be evaluated by estimating the following equation in cross section:

$$g_i = \alpha + \beta \ln(y_{i,t=0}) + \varepsilon_i \quad (3.1)$$

In order to make such an estimation, income data must be collected on geographical units, for example countries, regions (American states, European NUTS-2 or NUTS-3 regions) or at a finer scale such as municipalities. A question then naturally arises: can the results from β -convergence on a certain scale be extended to other scales (more and less fine)? Dapena, Vazquez and Morollon (2016) discuss this issue in detail and show that the OLS estimator is not biased by aggregation of geographical units provided that no non-linear data transformation is required in the econometric study. Thus, the expected value of the estimator is the same regardless of the level of aggregation chosen. However, the OLS estimator on aggregate data is less effective than an estimate on disaggregated data. Indeed, aggregation leads to a lower number of observations in addition to a loss of information on the estimated relationship. In the case of the β -convergence estimation, the data aggregation problem is more preoccupying because the estimated equation includes a non-linear transformation of the explanatory variable to the extent that it is the logarithm of income that is considered. Under these conditions, Dapena, Vazquez and Morollon (2016) show that the loss in efficiency of the estimator is accompanied by a bias insofar as it is not equivalent to performing the transformation before or after aggregation. The study of β -convergence therefore benefits from being carried out at fine scales, which is the aim of the present chapter.

3.3.1 Spatial process and estimation

The estimation of Equation (3.1) by OLS requires restrictive assumptions about the error term such as homoscedasticity and non-autocorrelation. However, when we consider a set of economies, the assumption of non-autocorrelation is unlikely. For example, in the case of European regions or American states, we can expect that the growth rate of a region will be influenced by those of neighbouring regions. Similarly, a growth shock in one region may be correlated with shocks in neighbouring regions if unobserved variables display spatial dependence. Since this autocorrelation phenomenon is mainly underpinned by the location of observations in space, we can use the geographical relationships between observations to set up autocorrelation. This then requires modelling income growth through a spatial process.

A spatial process is a random process indexed by a spatial set: $Y = Y_i, i \in S$ (see in particular Gaetan and Guyon (2010)), in our case S is a non-regular network allowing to define a geometry of neighbourhood between observations. Each site i represents a municipality in France and the associated network can be represented by a neighbourhood graph where two communes i and j are said to be neighboring (a boundary links i to j) if a certain geographical criterion is verified, for example:

1. The distance between the two communes is less than a certain threshold. If necessary, the distance is used to set the intensity of the link between the two observations.
2. Both municipalities belong to the same region.
3. The commune j is part of the nearest K neighbours of the commune i for a certain distance.
4. The two municipalities share a border.

Thus, the structure of the neighbourhood graph is generated by the geography in which the communes are inserted. In this sense, we can say that the neighbourhood graph encodes the geography underlying the observations. A matrix of size $N \times N$, noted W , is associated with

the graph, where N is the number of nodes in the graph. The value of $W_{i,j}$ is used to measure the intensity of the relationship between i and j , $W_{i,j}$ is different from 0 as soon as i and j are neighboring, by convention we have $W_{i,i} = 0 \forall i \in S$. It is important to note that, unlike time series, spatial networks are non-causal since there is no order relationship on the S set. Thus, spatial dependence spreads in all directions across the edges of the network and not from the past to the future as in the case of time series. Finally, the non-regularity of the network, i.e., the fact that not all geographical units have the same number of neighbours, naturally leads to heteroscedasticity in the random process. In spatial econometrics, three types of spatial dependence are considered:

1. Spatial Moving Average (SMA) process:

$$Y_i = \sum_{j \in J_i} b_{i,j} \varepsilon_j + \varepsilon_i \quad (3.2)$$

The variable observed at the i location can be decomposed as the weighted sum of the error terms of all neighbours of i (noted J_i) plus their own error terms. This form represents the spatial counterpart of the MA form in time series, however here the sum is not made on the terms of past errors but on the terms of errors of the neighbours.

2. Spatial AutoRegressive (SAR) process:

$$Y_i = \sum_{j \in J_i} a_{i,j} Y_j + \varepsilon_i \quad (3.3)$$

The variable observed at the i location can be decomposed as the weighted sum of the endogenous variable observed at locations near i , to which an error term is added. Here again, this representation is reminiscent of the self-regressive process in a time series context but deploying dependence on all neighbours rather than from the present to the past.

3. Spatial AutoRegressive Moving Average (SARMA) process:

$$Y_i = \sum_{j \in J_i} a_{i,j} Y_j + \sum_{j \in J_i} b_{i,j} \varepsilon_j + \varepsilon_i \quad (3.4)$$

This process integrates the two previous types of spatial dependencies.

The error term ε is a white noise of variance σ^2 . In the following we consider the SARMA model, the two previous models being special cases. We can reformulate the model in matrix form. Let A be a matrix of size $N \times N$ such that $A_{i,j} = -a_{i,j}$ if $i \neq j$ and $A_{i,i} = 1 \forall i \in S$. B is a matrix of size $N \times N$ such that $B_{i,j} = b_{i,j}$ if $i \neq j$ and $B_{i,i} = 1 \forall i \in S$. The SARMA model is rewritten : $AY = B\varepsilon$, or $Y = A^{-1}B\varepsilon$. Thus, the variance-covariance matrix of the Y process shows autocorrelation as well as heteroscedasticity according to the coefficients of the A and B matrices:

$$V[Y] = \sigma^2 A^{-1} B (A^{-1} B)' \quad (3.5)$$

The A and B matrices are of size $N \times N$ and it is, obviously, not possible to estimate the coefficients that compose them. The idea is therefore to parameterize these two matrices using the matrix associated with the neighbourhood graph W which is considered exogenous. We then pose $A = (I - \rho W)$ and $B = (I - \lambda W)^{-1}$ which is equivalent to the following model:

$$Y = \rho W Y + u \quad (3.6)$$

$$u = \lambda W u + \varepsilon \quad (3.7)$$

This means that the error term and the endogenous variable are spatially dependent. The variance-covariance matrix of the process is then parameterized by the two parameters ρ and λ that will have to be estimated:

$$V[Y] = \sigma^2 (I - \rho W)^{-1} (I - \lambda W)^{-1} (I - \lambda W')^{-1} (I - \rho W')^{-1} \quad (3.8)$$

In this way we allow autocorrelation within the components of the Y vector *via* the spatial relationship of the observations. The SMA and SAR models are found by posing $\rho = 0$ and $\lambda = 0$ respectively. Assuming that the error term is normally distributed $\varepsilon \rightarrow \mathcal{N}(0, \sigma^2 I_N)$, the estimation of such a model can be done using the maximum likelihood procedure. We then have $Y \rightarrow \mathcal{N}(A^{-1} X \beta, \sigma^2 A^{-1} B (A^{-1} B)')$ and the following log-likelihood:

$$l(Y|\rho, \lambda, \beta) = \text{const} - \ln(\sigma) - \frac{1}{2} \ln(|A^{-1} B (A^{-1} B)'|) - \frac{1}{2\sigma^2} (AY - X\beta)' B' B (AY - X\beta) \quad (3.9)$$

We can concentrate the log-likelihood by determining the optimal β , denoted as $\hat{\beta}$, given the parameters ρ and λ :

$$l(Y|\rho, \lambda) = \text{const} - \ln(\sigma) - \frac{1}{2} \ln(|A^{-1}B(A^{-1}B)'|) - \frac{1}{2\sigma^2} (AY - X\hat{\beta})' B' B (AY - X\hat{\beta}) \quad (3.10)$$

With $\hat{\beta}(\rho, \lambda) = (X'B'B'BX)^{-1}X'B'B'BA Y$. At this stage, the log-likelihood is a non-linear function of the parameters ρ and λ and therefore an optimization algorithm must be used. In practice, this is only possible for values of N not too high. Indeed, the evaluation of log-likelihood requires calculating the determinant of the matrix $A^{-1}B(A^{-1}B)'$ which is of size $N \times N$. In our case, where we have nearly 30,000 observations, this is not achievable in a reasonable time even if the matrix $A^{-1}B(A^{-1}B)'$ is sparse. Kelejian and Prucha (1999) estimate the previous model using the method of moments, which avoids calculating the determinant of a matrix $N \times N$, so this method is feasible even for high values of N . Thereafter, we will adopt this estimation method.

3.3.2 Spatial diagnosis

A variable can be geolocated, or indexed by a spatial set, without presenting any spatial dependence in the same way that a variable observed over time does not always present temporal autocorrelation. In this case, the use of temporal process modelling is not necessary because the observations can be considered as identically and independently distributed. Thus, spatial diagnosis will involve measuring spatial autocorrelation using the Moran index:

$$\text{IM}(X) = \frac{N}{\sum_i \sum_j w_{i,j}} \frac{\sum_i \sum_j w_{i,j} (X_i - \bar{X})(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2} \quad (3.11)$$

Or in matrix form:

$$\text{IM}(X) = \frac{N}{\sum_i \sum_j w_{i,j}} \frac{x'Wx}{x'x} \quad (3.12)$$

where x corresponds to the size vector $N \times 1$ of the centered variable. The Moran index is well interpreted as a correlation but calculated only on neighbours, it measures the tendency

of an observation to deviate from the mean when its neighbours also deviate from it. A positive Moran index means that observations tend to be clustered, observations that deviate from the mean tend to be close to each other, as do observations that deviate from the mean. On the contrary, a negative Moran index means that observations that deviate from the mean are close to observations that deviate from the mean. The Moran index is significant when it is too unlikely that chance will generate such a disposition in space.

Of course, a Moran index calculated on a variable Y and significantly different from zero does not mean that this variable is at the origin of spatial dependence and that an interaction exists between observations at different locations for Y . Indeed, spatial autocorrelation can come from a second variable, noted X , on which the first depends. In this case, the variable Y inherits, in a certain sense, the spatial dependence structure observed on X . Thus, the spatial diagnosis will be performed on the residue resulting from the regression from Y on X . In the case where the residue still exhibits spatial autocorrelation despite the consideration of the X effect on Y , several cases are still possible: (i) the variable Y does indeed have its own spatial dependence and this spatial dependence must then be integrated *via* a SAR model; (ii) the residue of the spatial autocorrelation from omitted variables that are themselves spatially autocorrelated and this can be integrated by a SMA model; (iii) the two previous cases are both true and the use of a SARMA model is necessary. The calculation of the Moran index is general and does not allow to test the origin of the spatial dependence. Anselin (1988) develops two tests based on the statistics of the Lagrange multiplier. The first test considers the SMA specification and tests the H_0 null hypothesis: $\lambda = 0$ against the H_1 alternative hypothesis: $\lambda \neq 0$. The second test is placed in the SAR specification and tests the H_0 hypothesis: $\rho = 0$ against the H_1 alternative hypothesis: $\rho \neq 0$. The two test statistics are respectively calculated as follows:

$$\text{LM}(\text{err}) = \frac{(\varepsilon'W\varepsilon/s^2)^2}{T} \quad (3.13)$$

$$\text{LM}(\text{lag}) = \frac{(\varepsilon'WY/s^2)^2}{T + (WX\beta)'M(WX\beta)s^2} \quad (3.14)$$

With $s^2 = \frac{\epsilon'\epsilon}{N}$, $T = \text{tr}((W + W')W)$ and $M = I - X(X'X)^{-1}X'$. Under H_0 , the two test statistics follow a Chi-square law at one degree of freedom. These two tests are limited in that, as we have seen, the SAR specification can be combined with a SMA specification. It is therefore also necessary to be able to test the H_0 hypothesis: $\lambda = 0$ and $\rho = 0$ against the H_1 hypothesis: $\lambda \neq 0$ or $\rho \neq 0$. Anselin et al. (1996) have developed a test to this aim. In the following, the three test statistics will be systematically calculated in addition to the Moran index.

Despite the possibility of carrying out the tests mentioned above, it is still difficult to choose one specification over another. Insofar as the various tests may lead us to reject the associated H_0 hypotheses, Anselin et al. (1996) advise to decide in favour of the most significant test. We will therefore estimate the specification from the previous procedure, but for robustness reasons, we will always estimate the SARMA specification which allows to include the two potential spatial dependencies.

3.3.3 Spatial instability: non-linearities, spatial regimes and Geographically Weighted Regression

Instability from regimes

Spatial dependence can also take a more complex form than a simple correlation between neighbours. Indeed, the relationship described by Equation (3.1) may not be spatially stable. *A priori*, there is nothing to suggest that the effect of one variable on another is the same whatever the location. However, as a first approximation, we make such an assumption and therefore assume the stability of the coefficients across space. Nevertheless, the introduction of spatial regimes is possible, allowing coefficients to vary. This requires defining these regimes according to a third variable which may be one of the variables composing the model. The incorporation

of spatial regimes can be done while maintaining spatial process modelling and we will use this specification when we seek to test the existence of a core and a peripheral regime for which the convergence phenomenon differs.

In order to define the belonging of the observations to one or the other regimes, we follow the methodology of Fischer and Stirbock (2006) and Gallo and Dall’erba (2008), also used by Lim (2016). The first step is to calculate, for each observation, the Getis and Ord statistics defined as follows:

$$GO_i = \frac{\sum_{j=1}^N w_{i,j} y_j - \bar{y} \sum_{j=1}^N w_{i,j}}{S \left(\frac{n \sum_{j=1}^N w_{i,j}^2 - (\sum_{j=1}^N w_{i,j})^2}{N-1} \right)^{1/2}} \quad (3.15)$$

where

$$\bar{y} = \frac{1}{N} \sum_{j=1}^N y_j \quad \text{and} \quad S = \left(\frac{\sum_{j=1}^N y_j^2}{N} - \bar{y}^2 \right)^{1/2}$$

This statistic makes it possible to identify the locations where municipalities with high or low incomes are spatially grouped. When the value of the Getis and Ord statistics is negative, this indicates a concentration of municipalities with a low income. On the contrary, a positive value indicates a concentration of municipalities with a high income. For a municipality to belong to the core regime, it is not enough for it to have a high income. It must be surrounded by enough municipalities with a high income so that it is very unlikely that chance has produced this arrangement in space. The same applies to the municipalities belonging to the peripheral regime. Thus, municipalities with a high income may belong to the peripheral regime and *vice versa*, of course this will be the exception and not the rule. Finally, the rule of belonging of a municipality to a regime is simple: if its Getis and Ord statistics are positive, this municipality belongs to the core regime, if its Getis and Ord statistics are negative it belongs to the peripheral regime.

Instability from non-linearities

The simplest way to generate spatial dependence in the relationship studied is to introduce non-linearity into one or more explanatory variables. Therefore, the marginal effect of an explanatory variable depends on space to the extent that it depends on another explanatory variable whose values vary in space. Formally we have:

$$y_i = \alpha + \beta x_i + \gamma x_i z_i + \varepsilon_i \quad (3.16)$$

Thus $\frac{\partial y_i}{\partial x_i} = \beta + \gamma z_i$, this marginal effect depends on the space through the variable z_i . Eventually $z_i = x_i$, in the case of the convergence study this amounts to assuming that the income growth rate is a non-linear function of the initial income. As already noted in Section 3.2, this specification is close to the one where core/periphery regimes are defined from the income level.

Instability from local regressions

The spatial instability allowed by the definition of spatial regimes remains limited for two main reasons: (i) the number of regimes is limited; (ii) the definition of regimes is often *ad-hoc* and forces spatial instability to be expressed through the researcher's expectations. For example, in the case of the convergence study, spatial instability is generally studied through the existence of a core and a peripheral regime. Moreover, the introduction of non-linearity is also relatively arbitrary. In the case of β -convergence, we can assume that the effect of initial income is non-linear *via* its interaction with another variable (possibly itself). However many candidates are possible and the principle of parsimony prevents us from incorporating all the cross products of possible variables. In order to obtain spatially dependent marginal effects, more flexible models have been developed to explore the instability of coefficients in space. Caseti's (1972) approach consists in defining the marginal effects associated with the various explanatory variables as functions of space:

$$y_i = x_i \beta(p_i) + \varepsilon_i \quad (3.17)$$

Where p_i is the position of the observation i in space, for example $p_i = (\text{longitude}_i, \text{latitude}_i)$. Thus, unlike the ARMA spatial model, the spatial dimension is not achieved *via* a defined neighbourhood relationship through a network. The spatial dimension is used as a means of setting parameters for marginal effects. The $\beta(p_i)$ function can involve coefficients that must be estimated, as is the case in Caseti (1972), but this has the disadvantage of having to explicitly define the function linking marginal effects to space. This explicit definition is in some cases possible. For example, the definition of M spatial regimes from R_1, \dots, R_M spatial regions can be seen as a special case where we have $\beta(p_i) = \sum_{m=1}^M \beta_m \mathbb{I}(p_i)$ with $\mathbb{I}(p_i) = 1$ if $p_i \in R_m$ and 0 otherwise. However, most often the dependence on space can be complex and the need to find an explicit form is restrictive. In this perspective, Brunson, Fotheringham and Charlton (1998) propose a non-parametric estimate of the $\beta(p_i)$ function, called Geographically Weighted Regression (GWR).

The principle of the GWR method is as follows: An observation i is selected, then a sub-sample composed of the individuals geographically "closest" to the observation i is selected. Two methods can be used: either we select all observations whose distance to observation i is less than a given distance, or we select the nearest neighbouring K for a given K . Once the sub-sample is selected, the relationship between the explained variable and the explanatory variables is estimated locally using the weighted least squares method. Indeed, each observation j in the sub-sample is weighted according to its distance from the observation i . In order to perform this weighting, several kernels are possible:

1. uniform kernel:

$$\gamma_{i,j} = 1 \tag{3.18}$$

2. triangular kernel:

$$\gamma_{i,j} = \left(1 - \left|\frac{d_{i,j}}{h}\right|\right) \tag{3.19}$$

3. Gaussian kernel:

$$\gamma_{i,j} = (2\pi)^{-\frac{1}{2}} \exp \left\{ -\frac{1}{2} \left(\frac{d_{i,j}}{h} \right)^2 \right\} \quad (3.20)$$

Where $d_{i,j}$ is the distance between the observation j and the observation i . The uniform kernel is equivalent to applying OLS locally to the subsample. The Gaussian and triangular kernels decrease the weighting as the distance increases, the h parameter allows to adjust the rate of decrease. We construct the diagonal weighting matrix Γ^i of size $N \times N$ such that the element j of the matrix is equal to $\gamma_{i,j}$ if j is part of the subsample associated with the observation i and 0 otherwise. We can then estimate the coefficient vector β_i as follows:

$$\hat{\beta}_i = (X' \Gamma^i X)^{-1} X' \Gamma^i y \quad (3.21)$$

In the above equation, the X matrix and the y vector contain all the observations, but the Γ^i weighting matrix allows the selection of a sub-sample simply by weighting the observations outside the sub-sample associated with the i observation to 0. The previous procedure is repeated for all observations in the sample, so there are as many regressions and coefficients vectors as there are observations. We therefore have a matrix of estimated coefficients B where each column corresponds to an explanatory variable and each line corresponds to an observation. The values predicted by the model are therefore written

$$\hat{y} = \hat{B} \cdot X \quad (3.22)$$

With $\hat{B} = (\hat{\beta}_1, \dots, \hat{\beta}_N)'$ and where \cdot is the forward multiplication of the two matrices \hat{B} and X . In this way, we therefore have marginal effects that are functions of space insofar as they are calculated locally and therefore depend on the location of each observation. The vectors β_i form a surface, each location i is associated with a vector of coefficients.

In the following, we will use the nearest neighbouring K as the sub-sample selection method, this procedure has the advantage of always selecting the same number of observations for

each sub-sample, which facilitates inference and comparison of the results between the different regressions. Thus, the coefficient matrix \hat{B} depends on three parameters: the number of neighbours K , the kernel chosen (uniform, triangular or Gaussian) and the parameter h . In accordance with the methodology prescribed by Brunsdon, Fotheringham and Charlton (2002), the selection of these three parameters is carried out by cross-validation, seeking to minimise the following criterion:

$$CV(K, \text{kernel}, h) = \sum_i (y_i - \hat{y}_i(K, \text{kernel}, h))^2 \quad (3.23)$$

Where $\hat{y}_i = \hat{\beta}_i(K, \text{kernel}, h)x_i$. When estimating each coefficient vector β_i , the weighting of the i point is set to zero and is therefore excluded from the sub-sample to avoid overadjustment. Without this, a reduction in the number of neighbours would mechanically lead to a reduction in the sample error. Once the three parameters have been selected, we can estimate the B matrix as described above.

While the GWR method does not explicitly define the relationship between marginal effects and space and therefore allows potentially complex shapes, it should be noted that it assumes marginal effects are a relatively smooth function of space. Indeed, two close localisations will have relatively similar weighting matrices and therefore a similar coefficient vector β . The more the weighting system favours close observations, the more irregular the β_i function may be; however, this will be at the expense of lower accuracy due to the decrease in the number of estimates. There is therefore a trade-off between the irregularity of the β_i function and the precision related to its estimation. Of course, the larger the sample is and is composed of granular data, the higher the level of irregularity can be achieved with the same level of precision. Since we have a large number of observations at a fine geographical scale, we will also use this estimation method to test the instability of the convergence phenomenon in space without going through the regime definition. To our knowledge, Artelaris (2015) is the only article using the GWR method to evaluate β -convergence, comparing this method to "club"

convergence, he concludes that the latter is superior to the former. However, his sample is of low granularity and contains few observations compared to our, so we can expect different results.

3.4 Data and descriptive statistics

3.4.1 Data

We have the median income per commune over the period 2001-2014, which allows us to calculate the average growth rate of the median income over the period 2002-2014 for each commune in France while having the median income in 2002. These data come from INSEE, the calculation is based on the household tax revenues themselves established thanks to the exhaustive files of personal income tax returns and housing tax from the "Direction Générale des Impôts". This data is sufficient for our investigation on absolute convergence. Our data concern metropolitan France and, due to some missing values, we do not observe all the French municipalities. More precisely, our sample is composed of 29,317 municipalities, while metropolitan France had 36,552 municipalities on January 1, 2014.

When addressing conditional convergence, we add a number of control variables that we can classify into different categories: demography, socio-professional category, type of employment contract, work place, moving date, and variables linked to local fiscal policy.

We consider these different variables in level and in difference over the observation period, then we suppress the temporal dimension by taking the average for each of them (average on the variable in level and average on the variable in difference). Since we have a large number of explanatory variables but those relating to a particular category are strongly correlated with each other, we apply a dimensionality reduction by principal component analysis to each category. We recover as many dimensions as necessary to explain at least 70% of the total

variance of the group of variables. This allows us both to reduce the number of variables and also to obtain a set of control variables with very low correlation between them.

3.4.2 Global statistics

Based on the temporal evolution of statistics (average, median, quartiles, coefficient of variation) calculated for all municipalities, we observe (Figure 3.1) an upward trend in income between 2001 and 2014 with a sharp slowdown at the time of the 2008 economic crisis. We are also seeing a slowdown from 2013 onwards, marking the sovereign debt crisis. We therefore finally have a translation of the distribution of income over time without any deep deformation of it. Figure 3.1 highlights the continuous decrease in the income variation coefficient, with the standard deviation from nearly 20% of average income in 2001 to 17% of average income in 2014. This decrease therefore suggests a phenomenon of σ -convergence between French municipalities and indicates that low-income municipalities have caught up over the study period.

In 2002, the average income for all municipalities was 14,436 euros (Table 3.1). However, there is some heterogeneity since the standard deviation represents nearly 20% of the average. Moreover, the range is particularly high since the commune with the highest income has an income almost 7 times higher than the commune with the lowest income. On average, municipalities have experienced an average income growth of 3% over the period 2002-2014, but here again heterogeneity is very important. The standard deviation of the growth rate represents 25% of the average and the highest growth rate observed over the period is 64 higher than the lowest growth rate.

The cartographic representation (Figure 3.2) of the two variables illustrates a positive spatial autocorrelation. This is extremely clear in the case of the logarithm of income: high-income municipalities group together near metropolitan areas, coasts and borders. This is confirmed by calculating the Moran index which varies between 0.68 and 0.71 depending on the chosen

| stats | variable | |
|------------|-----------------|---|
| | $\ln(y_{2002})$ | $\ln\left(\frac{y_{2014}}{y_{2002}}\right)$ |
| count | 29,317 | 29,317 |
| mean | 14,436 | 0.031 |
| std | 2,821 | 0.008 |
| coef. var. | 0.195 | 0.258 |
| min | 5,269 | 0.002 |
| 25% | 12,578 | 0.026 |
| 50% | 14,010 | 0.030 |
| 75% | 15,843 | 0.035 |
| max | 35,689 | 0.102 |

TABLE 3.1 – Descriptive statistics

| Neighbourhood matrix | W_{Rook} | | W_{KNN} | | W_{Band} | |
|----------------------|-----------------|---|-----------------|---|-----------------|---|
| | $\ln(y_{2002})$ | $\ln\left(\frac{y_{2014}}{y_{2002}}\right)$ | $\ln(y_{2002})$ | $\ln\left(\frac{y_{2014}}{y_{2002}}\right)$ | $\ln(y_{2002})$ | $\ln\left(\frac{y_{2014}}{y_{2002}}\right)$ |
| Moran Index | 0.717 | 0.328 | 0.703 | 0.312 | 0.680 | 0.295 |
| Pseudo P-value | 0 | 0 | 0 | 0 | 0 | 0 |

TABLE 3.2 – Moran index. W_{Rook} : contiguity weights matrix. W_{KNN} : weights matrix based on K nearest neighbors. W_{Band} : spatial weights based on distance band.

neighbourhood matrix (Table 3.2). While the growth rate map is less clear-cut, the Moran index also indicates a very significant spatial autocorrelation of around 0.3.

The colorimetry of the maps in Figure 3.2 appears to be reversed, suggesting an inverse relationship between the logarithm of income in 2002 and the average growth rate. This is confirmed by Figure 3.3 where the scatter plot between the logarithm of income in 2002 and the average growth rate is represented. It is very clear that low income is associated with a high growth rate, the correlation coefficient being -0.45. This result could already lead us to conclude in favor of absolute β -convergence, but this conclusion would be hasty since the correlation coefficient does not take into account the spatial dependence structure of the data.

3.4.3 Descriptive statistics by regime

The literature has highlighted the distinction between core and periphery regimes within countries. In this perspective, the variable at the origin of the regimes is also the explanatory variable, i.e., the initial income. Indeed, the core regime corresponds to the regions where observations with a high income are concentrated, and generally includes the metropolitan areas and their surroundings. The periphery regime corresponds to regions where observations with low income are concentrated, generally including rural areas. We can visualize the location of the two regimes in Figure 3.4.⁶ We see very clearly, within the core regime, the main French metropolises as well as the entire Paris region.

As expected, the peripheral regime has a much lower average income than the central regime (Table 3.3). In addition, we note that the dispersion of income is more important for the central regime, the coefficient of variation amounting at 0.16 compared to 0.12 in the peripheral regime.

6. The definition of the two regimes is made in accordance with the method presented in Subsection 3.3.3

Thus, the incomes of the municipalities in the core regime are higher but also more unequally distributed. With regard to the rate of income growth, there is no difference apart from the fact that the peripheral regime experienced a higher rate of growth over the period 2002-2014. We also note that, for both variables, spatial correlation is more important for the core regime (Table 3.4). Thus in the core regime, incomes between municipalities are more unequal, but in addition, high-income municipalities tend to group together more than in the peripheral regime. Finally, the negative correlation between the logarithm of income in 2002 and the average growth rate over the period 2002-2014 is more important in the peripheral regime than in the core regime. This leads us to assume that the phenomenon of convergence in space is unstable.

3.5 Absolute convergence

3.5.1 Global absolute convergence

In this section we aim at testing the hypothesis of β -convergence globally on all French municipalities. As already mentioned in Section 3.3, we will first estimate the convergence equation by OLS in order to apply residue tests. Depending on the results of the latter, we will estimate a SAR or SMA model in addition to a SARMA model. We use the standardized contiguity matrix as the neighbourhood matrix each time. The tests carried out lead us to reject the hypothesis that the observations do not exhibit spatial dependence. Since the test statistic is much higher for the case where spatial dependency is incorporated in the error term, we prefer the SMA specification rather than SAR.

The results obtained (Table 3.5) very strongly confirm the β -convergence hypothesis since in all three specifications we obtain a negative and significant estimated value for β . In the OLS and SMA specifications, the coefficients obtained are very close (-0.0193 and -0.0207) and an

| regime | peripheral regime | | core regime | |
|------------|-------------------|---|-----------------|---|
| | $\ln(y_{2002})$ | $\ln\left(\frac{y_{2014}}{y_{2002}}\right)$ | $\ln(y_{2002})$ | $\ln\left(\frac{y_{2014}}{y_{2002}}\right)$ |
| count | 15,862 | 15,862 | 13,455 | 13,455 |
| mean | 12,767 | 0.033 | 16,403 | 0.0282 |
| std | 1587 | 0.008 | 2686.35 | 0.0065 |
| coef. var. | 0.124 | 0.243 | 0.164 | 0.23 |
| min | 5,269 | 0.0016 | 8421 | 0.0031 |
| 25% | 11,768 | 0.0276 | 14,655 | 0.024 |
| 50% | 12,811 | 0.0319 | 15,928 | 0.0276 |
| 75% | 13,773 | 0.0373 | 17,610 | 0.0316 |
| max | 35,160 | 0.102 | 35,689 | 0.073 |

TABLE 3.3 – Descriptive Statistics by regime

| regime | peripheral regime | | core regime | |
|----------------|-------------------|---|-----------------|---|
| | $\ln(y_{2002})$ | $\ln\left(\frac{y_{2014}}{y_{2002}}\right)$ | $\ln(y_{2002})$ | $\ln\left(\frac{y_{2014}}{y_{2002}}\right)$ |
| Moran Index | 0.404 | 0.207 | 0.573 | 0.365 |
| Pseudo P-value | 0 | 0 | 0 | 0 |

TABLE 3.4 – Moran index (W_{Rook}) by regime

increase in income in 2002 (in logarithm) of one standard deviation will be associated with a decrease in the average growth rate over the period 2002-2014 by about 0.4 percentage points. With regard to the SARMA specification, we observe a somewhat lower estimated value for β (-0.016), however it should be noted that in the case of the SARMA model and unlike the OLS and SMA models, the β coefficient does not correspond to the marginal effect. More precisely, in the SARMA model, the marginal effect of a variation of $\ln(y_{2002})$ on the i observation is given by the expression $\beta \sum_j A_{ij}$ where $A = (I - \rho W)^{-1}$. The effect is therefore potentially different according to the individuals because they do not all have the same number of neighbours. However, this is not the case here because we have normalized the W matrix so that the sum of the columns is equal to unity. Overall, the marginal effect is -0.0223, so slightly higher than what we obtained in the OLS and SMA cases.

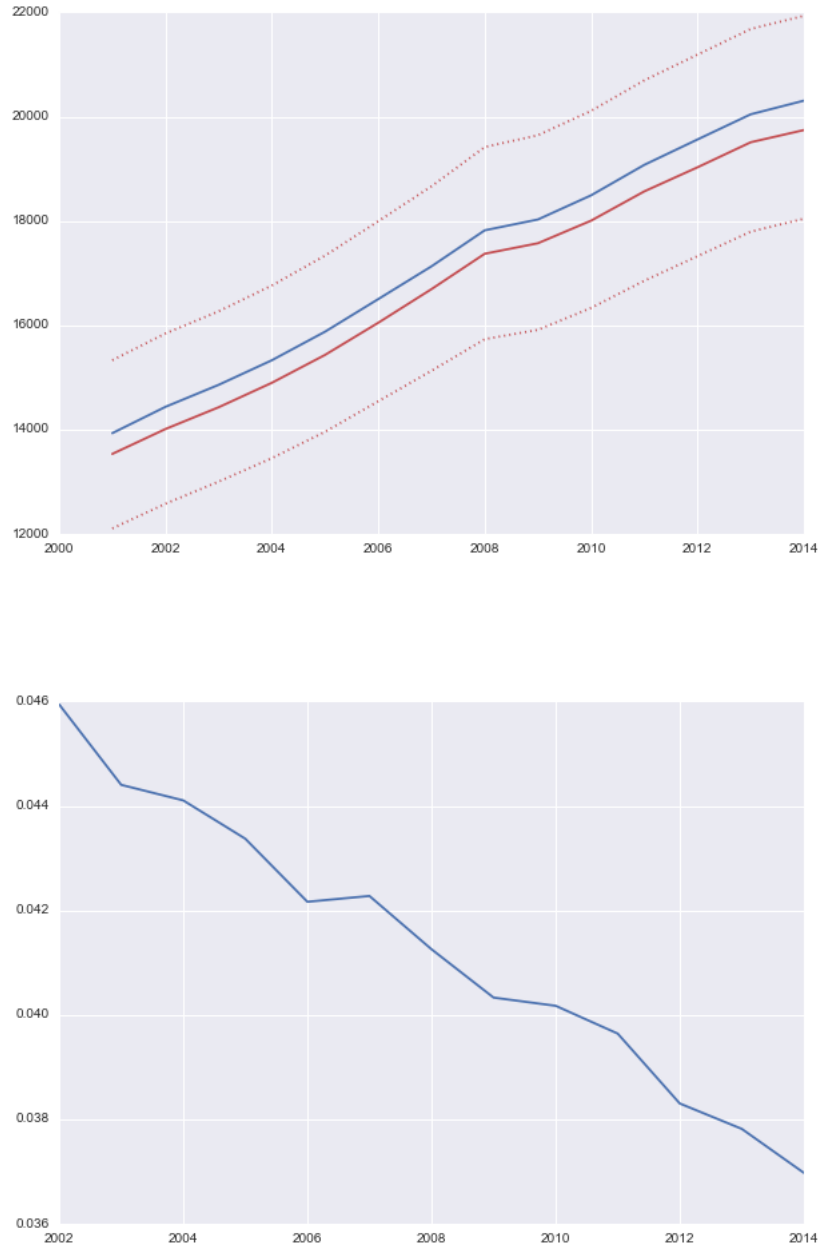
3.5.2 Convergence and spatial instability

Convergence with regimes

We are still testing for absolute convergence, but by distinguishing two spatial regimes: the core regime and the peripheral regime. We then apply the same procedure as before, again rejecting the hypothesis that there would be no spatial dependence between observations (Table 3.6), and retain the SMA specification in addition to the SARMA specification.

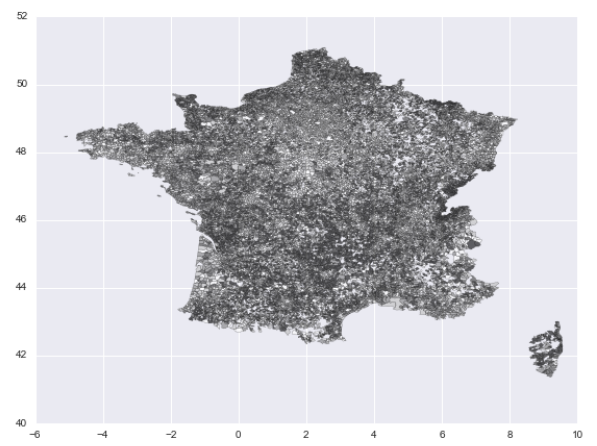
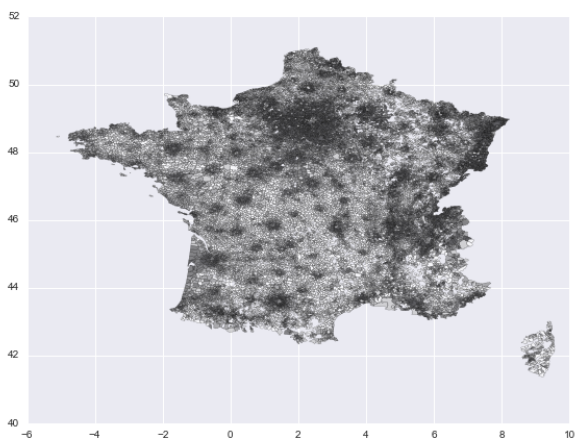
The results (Table 3.6) strongly support the β -convergence hypothesis within the two regimes. However, convergence seems to be stronger in the peripheral regime since the β coefficient varies around 0.30 depending on the specification chosen, while it is only 0.11 in the core regime. This is confirmed by a Chow test (Table 3.7), indicating that the two coefficients are significantly different between the two regimes. These results therefore corroborate the hypothesis that the convergence phenomenon is unstable across France.

FIGURE 3.1 – Temporal evolution of income distribution



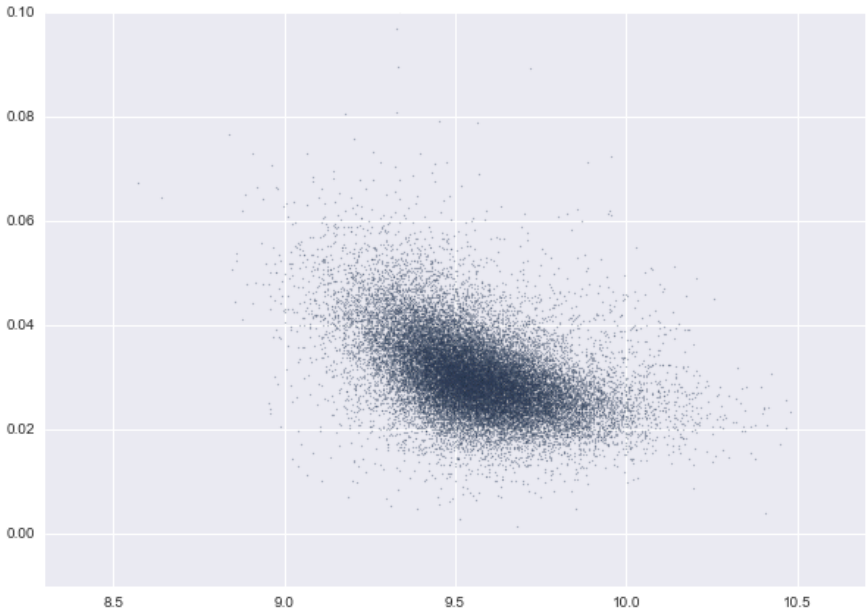
Up: temporal evolution of income mean (blue), mediane (red), quartile (dotted). Down: temporal evolution of income variation coefficient.

FIGURE 3.2 – Spatial distribution



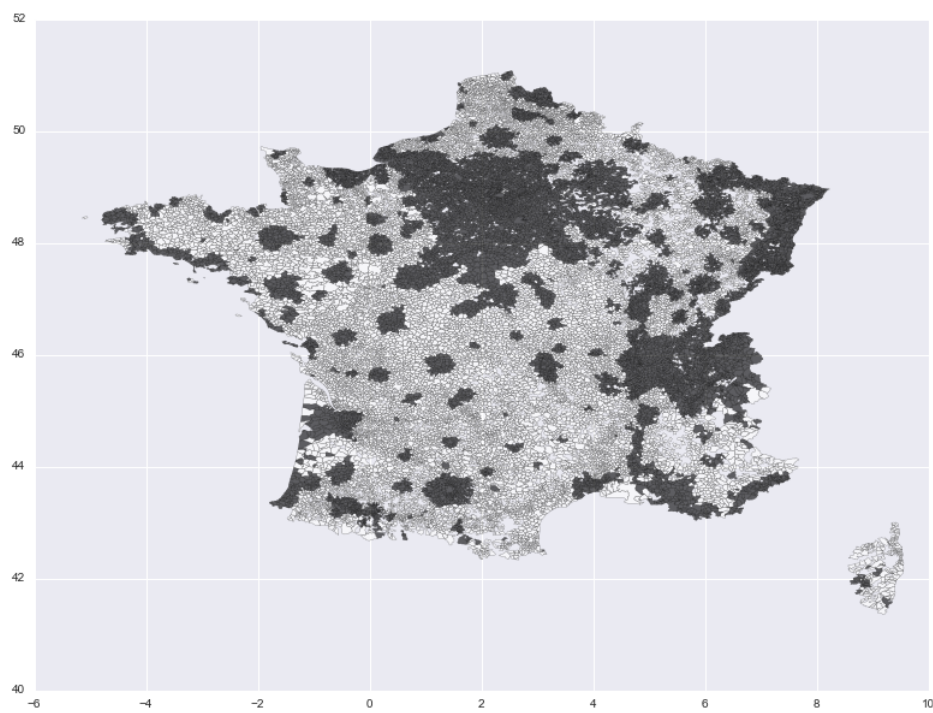
Left: logarithm of income in 2002. Right: income growth rate.

FIGURE 3.3 – Correlation between logarithm of income in 2002 and income growth rate.



x-axis: logarithm of income. y-axis: income growth rate.

FIGURE 3.4 – Spatial regimes



Black: core regime. White: peripheral regime.

| | model | | |
|---------------|-------------------|-------------------|-------------------|
| | OLS | SMA (Gmm) | SARMA (Gmm) |
| α | 0.215*** | 0.228*** | 0.175*** |
| β | -0.0193*** | -0.0207*** | -0.0161*** |
| λ | | 0.411 | 0.146 |
| ρ | | | 0.287 |
| R^2 | 0.217 | | |
| pseudo- R^2 | | 0.217 | 0.295 |
| N | 29317 | 29317 | 29317 |
| Moran index | 0.252*** | | |
| LM (lag) | 80.78*** | | |
| LM (error) | 1300.5*** | | |
| LM (SARMA) | 4713.9*** | | |

TABLE 3.5 – Estimation results of OLS, SMA and SARMA models. This table shows the results of the estimates according to three specifications: OLS, SMA, SARMA. The SMA and SARMA specifications are estimated using the generalized method of moments. ***: Significance at 1%. LM denotes the Lagrange multiplier tests as described in Subsection 3.3.2.

| model | OLS | | SMA | | SARMA | |
|-----------------------|------------|------------|-----------|------------|------------|------------|
| | periphery | core | periphery | core | periphery | core |
| α | 0.317*** | 0.137*** | 0.329*** | 0.141*** | 0.304*** | 0.126*** |
| β | -0.030*** | -0.0112*** | -0.031*** | -0.0116*** | -0.0292*** | -0.0105*** |
| λ | | | 0.404 | 0.404 | 0.273 | 0.273 |
| ρ | | | | | 0.145*** | 0.145*** |
| R^2 | 0.228 | 0.069 | | | | |
| pseudo- R^2 | | | 0.245 | 0.245 | 0.291 | 0.291 |
| N | 15862 | 13455 | 29317 | 29317 | 29317 | 29317 |
| Moran index (p-value) | 0.176*** | 0.356*** | | | | |
| Robust LM (lag) | 28.42*** | 2.43 | | | | |
| Robust LM (error) | 487.63*** | 966.6*** | | | | |
| Robust LM (SARMA) | 1094.82*** | 3844.77*** | | | | |

TABLE 3.6 – Estimation results of OLS, SMA and SARMA models by regime. This table shows the results of the estimates according to three specifications: OLS, SMA and SARMA, each time two regimes are introduced : core and periphery. The SMA and SARMA specifications are estimated using the generalized method of moments.***: Significance at 1%. LM denotes the Lagrange multiplier tests as described in Subsection 3.3.2.

| model | OLS | SMA | SARMA |
|--------------|------------|------------|--------------|
| α | 736.3*** | 958.4*** | 817.1*** |
| β | 739.5*** | 964.5*** | 836.66*** |
| Global test | 750.1*** | 978.3*** | 952.51*** |

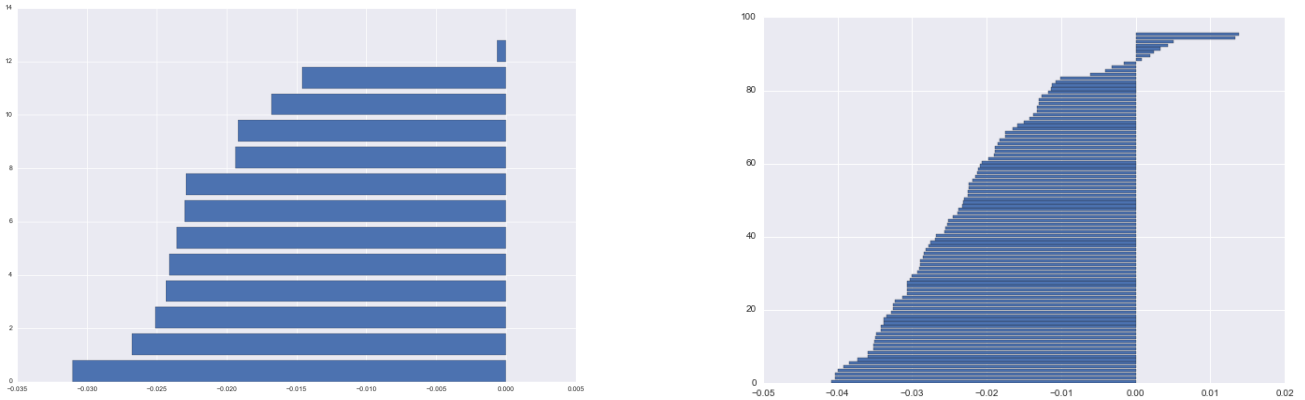
TABLE 3.7 – Chow test. ***: Significance at 1%.

Still with the objective of studying the instability of the β -convergence phenomenon, we can base the definition of the regimes on French administrative territories according to their own fiscal policies: "régions" and "départements". First, let us define as many regimes as "régions" and then as many regimes as "départements". Each territory has strong specificities in terms of spatial planning policy and amenities that are not easily observable, the introduction of regimes allows in particular to control for that. Figure 3.5 displays the value of the parameter β for each department or "région" and shows a certain heterogeneity, especially in the case of "départements". Indeed, if some "départements" present a strong convergence, others show a zero convergence, even present a phenomenon of divergence. Even if we note β -convergence on the majority of French sub-territories, here again, these results support the idea that the convergence phenomenon is spreading in a non-uniform way across the territory. Thus, even if this global study is necessary in order to assess the general trend over the whole territory, this is not sufficient and a more local study i.e., at a finer scale must also be carried out.

Convergence with non-linearities

In this section we estimate (Table 3.8) a model very close to that of the "absolute convergence" section, and incorporate the initial income squared within the explanatory variables. This allows us to recover different marginal effects according to individuals and, therefore, according to space. First, we note that introducing the square of the logarithm of income does not change

FIGURE 3.5 – Coefficient β by "région" and "département".



On the left are the β coefficients by "région" and on the right by "département".

the fact that observations are spatially dependent and we must once again use the SMA and SARMA models. The various specifications highlight a strong significance of the coefficient associated with the logarithm of squared income, which validates the hypothesis that the effect of initial income on the growth rate is non-linear. In this way we see that the marginal effect associated with initial income varies between -0.0345 and -0.0055 (quantile at 5% and 95%, Figure 3.6) according to the income level of the municipality. We therefore observe a certain degree of heterogeneity, confirmed by a coefficient of variation of 0.42. Obviously, the marginal effect inherits the spatial structure (Figure 3.6) of the logarithm of income since it is a linear function.

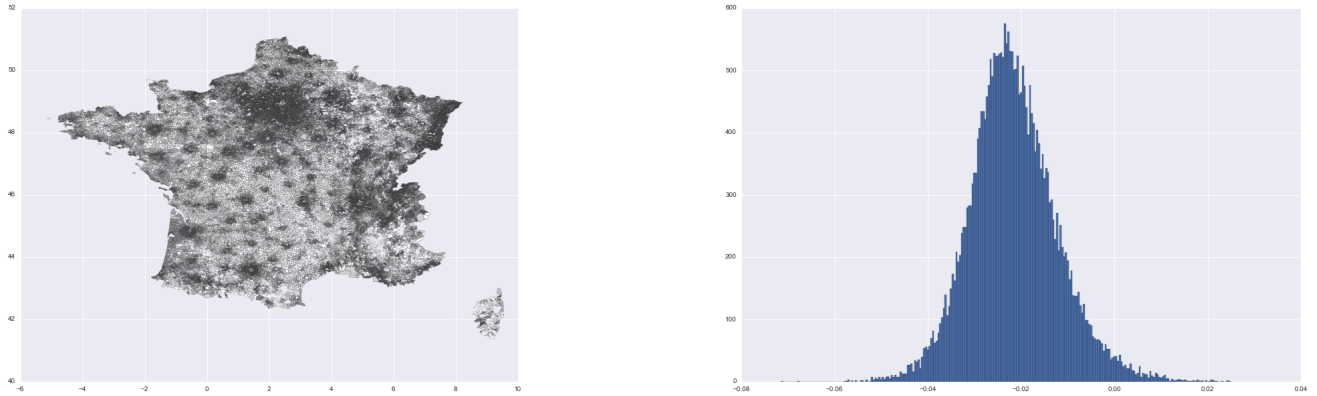
Convergence with local regressions

To carry out this local study and without having to explicitly define schemes from another variable, we estimate a GWR model. The smaller the number of neighbours, the more this allows for a large irregularity of β_i in space, however we lose in estimation accuracy. As we have already mentioned, the estimation of a GWR model requires the setting of certain parameters:

| | model | | |
|---------------|-------------------|------------------|------------------|
| | OLS | SMA (Gmm) | SARMA (Gmm) |
| α | 2.4*** | 2.53*** | 2.5*** |
| β | -0.4768*** | -0.503*** | -0.495*** |
| γ | 0.0238*** | 0.0252*** | 0.025*** |
| λ | | 0.405 | 0.467 |
| ρ | | | -0.055 |
| R^2 | 0.248 | | |
| pseudo- R^2 | | 0.248 | 0.228 |
| N | 29317 | 29317 | 29317 |
| Moran index | 0.246*** | | |
| LM (lag) | 29.4*** | | |
| LM (error) | 1216.6*** | | |
| LM (SARMA) | 4469.3*** | | |

TABLE 3.8 – Estimation results of OLS, SMA and SARMA models with non-linear effect. This table shows the results of the estimates according to three specifications: OLS, SMA, SARMA, each time adding a second-order effect. The SMA and SARMA specifications are estimated using the generalized method of moments (Gmm). ***: Significance at 1%. LM denotes the Lagrange multiplier tests as described in Subsection 3.3.2.

FIGURE 3.6 – Marginal effect resulting from the specification with non-linearity.



Left: spatial distribution of marginal effect. Right: distribution of marginal effect.

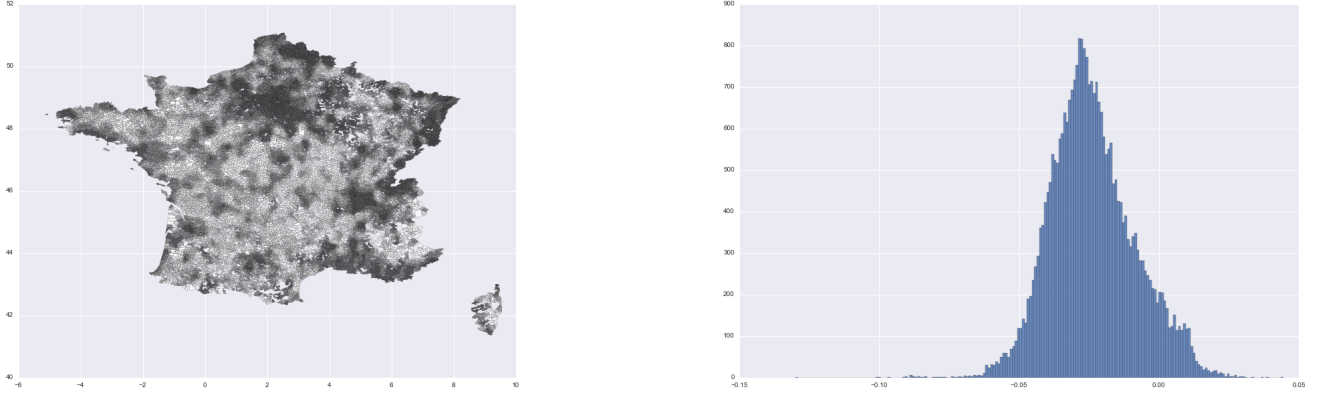
the number of neighbours, the kernel and the parameter governing the rate of decrease of the weighting. These three parameters are selected by cross-validation and we retain $K = 80$, a Gaussian Kernel and $h = 0.1$. The results of the estimates can be plotted on a map (Figure 3.7) where the colour of each commune corresponds to the value of the coefficient β estimated when the kernel is centred on it. We also represent in Figure 3.7 the distribution of the β coefficients in order to assess their dispersion. The fact that the values of β form geographical clusters is inherent to the calculation method. As we have already explained, two geographically close individuals will share a large number of common neighbours so their β will be calculated on similar samples and will therefore have similar values. If we calculate the Moran index on the errors from the GWR model we find a very low value (-0.0052) which is not significant. In this sense, the GWR approach makes it possible to control for spatial autocorrelation.

We test locally the significance (at 1%) of the β coefficient, it appears then on Figure 3.8 that for a large part of France we have a negative coefficient and significantly different from zero. However, it is important to note that there are still some territories whose coefficient is not significantly different from zero and others for which it is positive and significant. More broadly,

what is interesting is the large dispersion in the values taken by the convergence parameter β_i : 0.63. This is important insofar as the GWR method does not necessarily give values of β_i significantly different from each other, in that we characterize the great heterogeneity of the convergence phenomenon on the French territory. We can test the significance of the observed variability between the different β_i , using the method described in Brunson, Fotheringham and Charlton (2002). The idea is simply to compute a p-value for the standard deviation calculated on the distribution of β_i obtained in order to verify if the standard deviation of the marginal effect distribution is significantly different from zero. We have the following hypothesis set: $H_0 : \sigma(\beta_i) = 0$ against $H_1 : \sigma(\beta_i) > 0$. The procedure consists in switching observations and their location within the dataset and calculating each time the standard deviation on the distribution of the $\hat{\beta}_i$ obtained, this operation is repeated L times. So we end up with a standard deviation distribution, each calculated from a distribution of β_i from a different permutation. If the marginal effect does not vary significantly across space, then the loss of information on spatial structure caused by the permutation of locations should not affect the standard deviation of the distribution of $\hat{\beta}_i$. In this case, the probability that the standard deviation calculated on the non-switched data will be in the top 1 % of the standard deviation distribution is only 1%. The p-value is constructed as follows $p = \text{rank}(\sigma(\hat{\beta}_i^{\text{no perm}}))/L$, where $\text{rank}(\sigma(\hat{\beta}_i^{\text{no perm}}))$ is the rank of the beta's standard deviation estimated with the initial data. In our case we saw that $\sigma(\hat{\beta}_i^{\text{no perm}}) = 0.63$, after calculating 200 standard deviation we find that the largest standard deviation actually corresponds to the case where the locations have not been switched. Thus the null hypothesis is rejected and we conclude that $\sigma(\beta_i) > 0$. In this way, we fully justify the use of a GWR model.

We can also conduct a local inference by calculating the significance of each marginal effect for the different locations.

FIGURE 3.7 – Marginal effect resulting from the GWR specification.

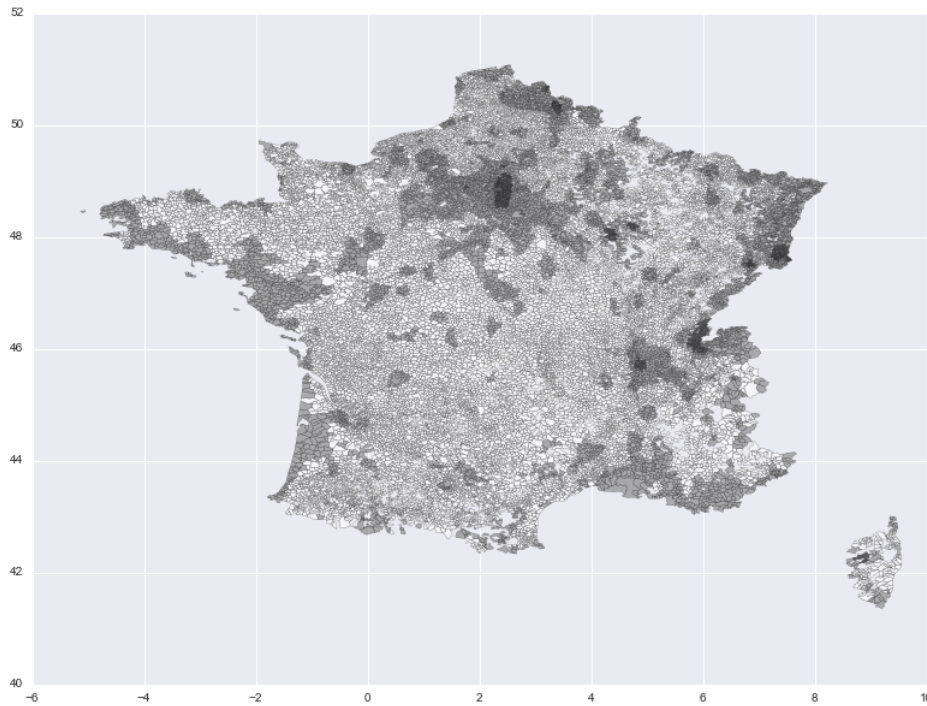


Left: spatial distribution of marginal effect. Right: distribution of marginal effect.

Summary and comparison of results

We have explored the instability of the convergence phenomenon through several methods, let us now compare the different results. The regression with regimes made it possible, in the first instance, to highlight a core/periphery structure based on the income levels of the various municipalities. We then confirmed through a Chow test the instability of the coefficients between the two regions, and obtain two marginal effects, one for each regime. We subsequently observe that the effect of the logarithm of initial income was much larger in the peripheral region. However, and as the literature has already noted, this method may ultimately be quite close to a classic β -convergence regression in which the square of the logarithm of income is added. We also estimated this specification, this time making the marginal effect directly dependent on the income level and therefore on location. The results confirm those obtained previously, insofar as the marginal effect decreases with income level. Thus, the poor municipalities do catch up with the rich municipalities but at a slower and slower pace as they become richer, so that the catching-up effect is almost non-existent between the rich municipalities.

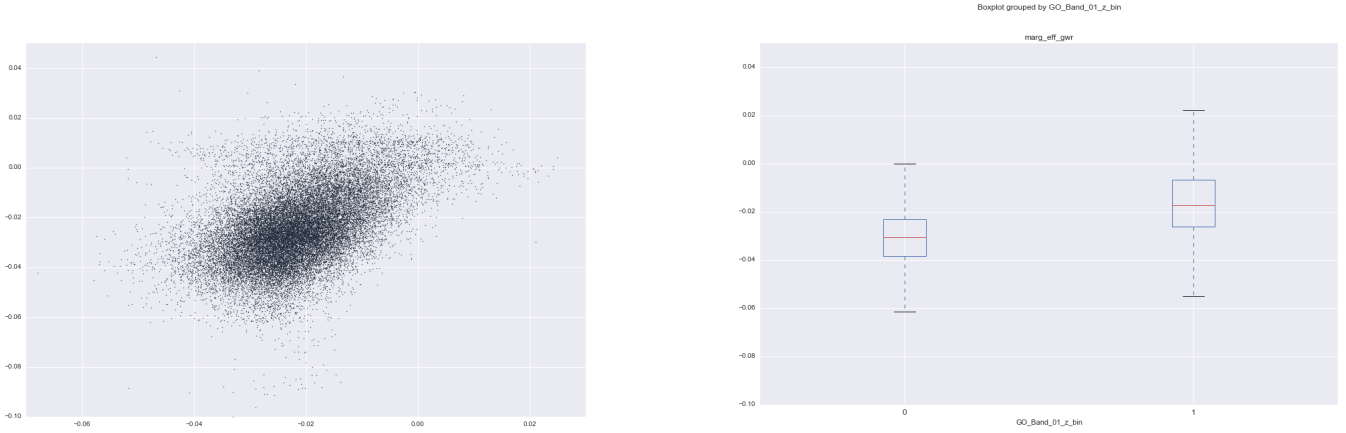
FIGURE 3.8 – Local significance test (spatial distribution)



We can see on Table 3.9 that the regime in which a municipality is located is well correlated with the magnitude of the marginal effect, confirming that these two methods provide relatively similar information. From the point of view of data adjustment, the two methods are also equivalent (Table 3.10) and share a pseudo R^2 around 0.24 in the case of OLS and SMA specifications. Although the introduction of non-linearity allowed for greater spatial variability in the marginal effect, the latter was in fact directly constrained by the spatial structure of the logarithm of income. In order to allow for greater flexibility, we therefore used the GWR method. While this does not directly provide a theoretical basis for explaining the variation in the marginal effect on the territory, it allows the spatial instability of the marginal effect

to be best characterized. Indeed, the latter depends on space in a non-parametric way and its variation is not constrained by any explicit function. We then obtained very different marginal effects depending on the spatial location, clusters of municipalities where convergence was strong and others where it was very weak. Interestingly, we find to a certain extent the arrangement of income clusters highlighted by the Getis and Ord (1992)'s method to define the core/periphery regimes. However, the map of the core/periphery regimes does not overlap perfectly with those of the various estimates of the area of β : the correlation between the regime and the value of the convergence coefficient does not exceed 0.5 (Table 3.9). It should be noted, however, that the initial income of a commune i seems to be a good indicator in determining the value of β_i , thus indicating a strong non-linearity between the growth rate and the initial income. Accordingly, even if the study of instability of convergence on the territory through the core/periphery vision is relevant, the fact remains that it does not cover all the irregularity of the β surface that the GWR method updates. While the core/periphery analysis summarized the convergence in two values, $\beta = -0.03$ for the periphery and $\beta = -0.011$ for the core, we see here a much larger extent as 25% of them have a β coefficient below -0.034 and also 25% of the municipalities have a convergence coefficient above -0.015 . Similarly, we can see in Figure 3.9 that the marginal effect estimated from the non-linear regression does not fully explain the marginal effect highlighted by the GWR method. Catch-up rates can therefore vary very strongly from one location to another without the variation in initial income being able to fully explain this evolution. Thus, the first two methods did not exhaust all the spatial complexity inherent in the β -convergence phenomenon. On the contrary, the GWR method incorporates additional relevant information insofar as we see that the pseudo- R^2 is greatly increased by the use of this method, going from 0.24 to 0.49 (Table 3.10).

FIGURE 3.9 – Link between marginal effects



Left: scatter plot between marginal effects from non-linear regression and the GWR. Right: distribution of marginal effects from the GWR by regime.

| model | regime | non-linear | GWR |
|------------|--------|------------|-----|
| regime | 1 | | |
| non-linear | 0.65 | 1 | |
| GWR | 0.47 | 0.49 | 1 |

TABLE 3.9 – Correlation between the marginal effects of the 3 different specifications

| | simple | | regime | | non linear | | GWR |
|-------|--------|-------|--------|-------|------------|-------|-------|
| model | OLS | SMA | OLS | SMA | OLS | SMA | GWR |
| R^2 | 0.217 | 0.215 | 0.245 | 0.245 | 0.248 | 0.247 | 0.489 |

TABLE 3.10 – Comparison of the explanatory power of the different specifications.

3.6 Conclusion

Our objective was to characterize the phenomenon of convergence in income at a fine scale, considering a sample of nearly 30,000 French municipalities. Through the estimation of equa-

tions of β -convergence and according to different specifications (global, by regime, with non-linearity, with local regressions) accounting for spatial dependencies, two robust results can be drawn from our investigation.

First of all, we observe over the period 2002-2014, a catching-up process in terms of income but it follows a non-linear dynamics. On average, the increase in the logarithm of income in 2002 by one standard deviation is associated with a decrease in the average growth rate over the period 2002-2014 by about 0.4 percentage point. Specifically, a municipality located in the first quartile (12 578 euros) regarding its income level has an average growth rate (0.0326 %) higher than that of a municipality belonging to the first quartile (15843 euros, 0.0278 %).⁷ Thus the income ratio goes from 1.26 in 2002 to 1.19 in 2014, highlighting a catch-up. On the other hand, the income of the second municipality still increased more than the income of the first commune, despite a lower growth rate because the latter applies to a higher level of income. It is worth mentioning that this reasoning cannot be extended to future periods for two main reasons. First, the catching-up process is not immutable in time and it can be contingent on public policies, either in terms of redistribution or spatial planning, as well as on the choice of location of economic agents. Secondly, we have highlighted a non-linear effect, so that the higher a municipality is in the distribution of income, the less it catches up with the preceding municipalities. Thus the previous interpretation can only be valid for a sufficiently short period of time so that income does not vary too much. Otherwise, the second-order effect no longer becomes negligible. When considering non-linear effects, we find that the municipality with an income equal to the first quartile shows a growth rate of 0.5 percentage points (2.74 % against 2.34%) higher in 2002 than the municipality with an income equal to the third quartile. However, in 2014, due to the increase in income, the difference in growth rate falls to 0.017 percentage point (2.18 % versus 2.01%).⁸ Thus, while the phenomenon of catching up is real, it essentially concerns the

7. We use here the results of the global regression with the SMA specification, we have $\hat{y}_i = 0.228 - 0.0207\log(x_i)$.

8. We use here the estimates on global convergence with non-linearity and MA specification: $\hat{y} = 2.53 -$

municipalities located at the bottom of the income distribution and it is unlikely that, in the long term, the poorest municipalities catch up with the richest. On the other hand, on the basis of our results, it is also unlikely that a gap can be created between rich and poor municipalities.

Secondly, we show that the convergence process is non-uniform across the territory. In a sense, this instability is a natural consequence of the non-linearity of the process. Indeed, since the marginal effect depends on initial income, mechanically the former varies across the territory in the same way as the latter. However, as highlighted by our GWR estimation results, the variation in the level of convergence across the territory could not be fully explained by the non-linearity mentioned above. The convergence phenomenon observed in France over the period 2002-2014 can therefore be characterized as follows. We do observe a convergence of income levels in general, but this is an approximation of a more complex phenomenon whose precise characterization is only possible through a study with a small geographical unit: the municipalities. We then find evidence of a strong effect of non-linearity and instability across space. While a part of the spatial instability can be explained by the non-linear effect, another part seems to escape this explanation.

This chapter has characterized the phenomenon of spatial convergence in France at a very fine scale. Our main conclusions are robust, and the spatial instability we highlighted provides an opportunity to further investigate the causes of convergence. A promising extension of the present study would be to explain, on the basis of the characteristics emphasized in this chapter, why some clusters of municipalities show a high level of catch-up while others do not. Our preliminary results therefore pave the way for future work to understand the reasons for local convergence.

$0.503\log(x_i) + 0.0252\log(x_i)^2$.

3.7 Bibliography

Aghion, Philippe, and Peter Howitt. A model of growth through creative destruction. No. w3223. National Bureau of Economic Research, 1992.

Anselin, Luc. "Lagrange multiplier test diagnostics for spatial dependence and spatial heterogeneity." *Geographical analysis* 20.1 (1988): 1-17.

Anselin, Luc, et al. "Simple diagnostic tests for spatial dependence." *Regional science and urban economics* 26.1 (1996): 77-104.

Aronsson, Thomas, Johan Lundberg, and Magnus Wikström. "Regional Income Growth and Net Migration in Sweden, 1970-1995." *Regional Studies* 35.9 (2001): 823-830.

Artelaris, Panagiotis. "Local versus regime convergence regression models: a comparison of two approaches." *GeoJournal* 80.2 (2015): 263-277.

Barro, Robert J., and Xavier Sala-i-Martin. "Convergence." *Journal of political Economy* 100.2 (1992): 223-251.

Baumol, William J. "Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show." *The American Economic Review*, vol. 76, no. 5, 1986, pp. 1072-1085.

Baumont, Catherine, Cem Ertur, and Julie Le Gallo. "Spatial convergence clubs and the European regional growth process, 1980-1995." *European regional growth*. Springer, Berlin, Heidelberg, 2003. 131-158.

Casetti, Emilio. "Generating models by the expansion method: applications to geographical research." *Geographical analysis* 4.1 (1972) : 81-91.

Dall'Erba, Sandy, and Julie Le Gallo. "Regional convergence and the impact of European structural funds over 1989–1999 : A spatial econometric analysis." *Papers in Regional Science* 87.2 (2008): 219-244.

Dapena, Alberto Díaz, Esteban Fernández Vázquez, and Fernando Rubiera Morollón. "The role of spatial scale in regional convergence: the effect of MAUP in the estimation of β -convergence equations." *The Annals of Regional Science* 56.2 (2016) : 473-489.

Davezies, Laurent. *Le Nouvel Égoïsme territorial. Le grand malaise des nations : Le grand malaise des nations*. Le Seuil, 2016.

Fischer, Manfred M., and Claudia Stirböck. "Pan-European regional income growth and club-convergence." *The Annals of Regional Science* 40.4 (2006): 693-721.

Fotheringham, A. Stewart, Martin E. Charlton, and Chris Brunsdon. "Geographically weighted regression : a natural evolution of the expansion method for spatial data analysis." *Environment and planning A* 30.11 (1998): 1905-1927.

Fotheringham, A. Stewart, Chris Brunsdon, and Martin Charlton. *Geographically weighted regression: the analysis of spatially varying relationships*. John Wiley and Sons, 2003.

Friedman, Jerome, Trevor Hastie, and Robert Tibshirani. The elements of statistical learning. Vol. 1. No. 10. New York: Springer series in statistics, 2001.

Fujita, Masahisa, and Jacques-François Thisse. "Economics of agglomeration." *Journal of the Japanese and international economies* 10.4 (1996): 339-378.

Gaetan, Carlo, and Xavier Guyon. *Spatial statistics and modeling*. Vol. 81. New York: Springer, 2010.

Getis, A. and Ord, J. K. (1992), The Analysis of Spatial Association by Use of Distance Statistics. *Geographical Analysis*, 24: 189-206.

Glaeser, Edward L., JoséA Scheinkman, and Andrei Shleifer. "Economic growth in a cross-section of cities." *Journal of monetary economics* 36.1 (1995): 117-143.

González-Val, Rafael. "Cross-sectional growth in US cities from 1990 to 2000." *Journal of Geographical Systems* 17.1 (2015): 83-106.

Hoyt, Homer. "Homer Hoyt on development of economic base concept." *Land Economics* 30.2 (1954): 182-186.

Islam, Nazrul. "What have we learnt from the convergence debate ?." *Journal of economic surveys* 17.3 (2003): 309-362.

Kelejian, Harry H., and Ingmar R. Prucha. "A generalized moments estimator for the autoregressive parameter in a spatial model." *International economic review* 40.2 (1999): 509-533.

Krugman, Paul. "Increasing returns and economic geography." *Journal of political economy* 99.3 (1991): 483-499.

Le Gallo, Julie, Cem Ertur, and Catherine Baumont. "A spatial econometric analysis of convergence across European regions, 1980–1995." *European regional growth*. Springer, Berlin, Heidelberg, 2003. 99-129.

Le Gallo, Julie, and Sandy Dall'Erba. "Evaluating the temporal and spatial heterogeneity of the European convergence process, 1980–1999." *Journal of Regional Science* 46.2 (2006): 269-288.

Lim, Up. "Regional income club convergence in US BEA economic areas : a spatial switching regression approach." *The Annals of Regional Science* 56.1 (2016): 273-294.

Lundberg, Johan. "On the determinants of average income growth and net migration at the municipal level in Sweden." *The Review of Regional Studies* 33.2 (2003): 229-253.

Lundberg, Johan. *On the determinants of average income growth and net migration at the municipal level in Sweden*. 2001.

North, Douglass C. "Location theory and regional economic growth." *Journal of political economy* 63.3 (1955): 243-258.

Persson, Joakim. "Convergence across the Swedish counties, 1911–1993." *European Economic Review* 41.9 (1997): 1835-1852.

Quah, Danny. "Galton's fallacy and tests of the convergence hypothesis." (1990).

Rey, Sergio J., and Brett D. Montouri. "US regional income convergence: a spatial econometric perspective." *Regional studies* 33.2 (1999): 143-156.

Romer, Paul M. "Increasing returns and long-run growth." *Journal of political economy* 94.5 (1986): 1002-1037.

Solow, Robert M. "A contribution to the theory of economic growth." *The quarterly journal of economics* 70.1 (1956): 65-94.

Swan, Trevor W. "Economic growth and capital accumulation." *Economic record* 32.2 (1956): 334-361.

Tiebout, Charles M. "The urban economic base reconsidered." *Land Economics* 32.1 (1956): 95-99.

Young, Andrew T., Matthew J. Higgins, and Daniel Levy. "Sigma convergence versus beta convergence : Evidence from US county-level data." *Journal of Money, Credit and Banking* 40.5 (2008): 1083-1093.

Chapitre 4

Determinants of territorial inequalities

4.1 Introduction

Economic convergence is a crucial issue within the European Union, in particular for social and political cohesion. This phenomenon has been much analysed between the regions of Europe but few studies have been carried out to date on territories belonging to the same country and at a finer scale than the regions. However, in Chapter 3, we found that the phenomenon of convergence in terms of income between French territories was clearly at play at a global scale, but a large part of the complexity of the process was omitted. Firstly, the process is non-linear in that the catch-up rate of a territory depends on its position in the income distribution. Low income territories benefit from a higher speed of convergence. Secondly, convergence is highly spatially unstable without this being fully explained by its non-linear nature, and this instability cannot be reduced to a centre/periphery analysis as is often the case in the literature. We have even been able to highlight geographical areas where the municipalities diverge in terms of income over the period 2002-2014. Of course, this raises questions about the political and social sustainability of such territories and the possible public policies to be put in place. For these reasons, it is important to understand why not all territories converge and therefore to

identify the determinants of convergence. This is the aim of the present chapter.

Within this chapter our objective is twofold. First, we extend the analysis initiated in Chapter 3 and identify, on the basis of a number of socio-economic variables, the determinants of territorial incomes and thereby explain, in part, the reasons for their convergence or divergence. We focus on verifying the temporal stability of these determinants, by investigating whether it is always the same variables over time that determine income. Second, based on the determinants of income identified, we partly explain the differences in convergence observed between the territories. Our main contributions are fourfold. (i) We analyse the reasons for inequalities between territories at a small scale, the French municipalities (nearly 30,000 municipalities observed between 2001 and 2014). (ii) We assess the dynamics of these inequalities by an original method consisting in calculating local inequality measures for different years, which allows us to construct a variable to explain. (iii) We have a large number of explanatory variables from which we will be able to explain the spatial heterogeneity of the dynamics of inequality and therefore of the convergence phenomenon. Rather than arbitrarily choosing a subset of variables, and for robustness purposes, we use a variable selection method to isolate the most relevant variables. We show that the productive structure of a territory does not provide any information on its income level, which is largely related to the socio-economic characteristics of its population. (iv) Finally, we highlight an effect that can be observed mainly at the municipality level, namely the importance of commuters and, in particular, cross-border workers. Through this mechanism, we show the importance of value-added transfers from one territory to another and how a territory can increase its income through its ability to capture value-added produced within another territory. We will also see that this can be a source of increasing inequality and therefore a brake on convergence.

The income of a territory can be analyzed in two stages. First, given the distribution of economic agents (particularly firms and households) as well as public policy, what are the main determinants of a territory's income and how they interlink? Secondly, how are these main de-

terminants distributed within the territory and what forces are driving them ? The first point is therefore more of a short-term analysis in the sense that the mobility of production factors and households is very low in the short term. More generally, when the analysis focuses on a short time horizon, we can consider that the socio-economic structure of a territory is totally inherited from its past and history. Nevertheless, it is necessary to understand, first of all, how the territories' revenues are generated from the socio-economic structures in place. It is also a question of understanding how incomes interact with each other, since we must potentially expect spillover effects simply because territories exchange, among other things, goods and services. The second point focuses more on the long time horizon and the identification of the forces that form and distort these socio-economic structures over time, i.e., the evolution of the distribution of both firms and households within the geographical space. Here again, interactions are strong and the decision to locate economic agents depends, among other things, on the distribution already in place of other economic agents. For example, a household will integrate the distribution of firms as well as those of other households when choosing its location. It is only after studying these two economic phenomena that it is possible to understand the distribution of income in a territory, its dynamics and therefore the phenomenon of convergence, or divergence depending on the location.

Section 4.2 is devoted to the exposure of the main theoretical mechanisms that may impact convergence between territories. We present our data and methodology in Sections 4.3 and 4.4, respectively. Section 4.5 reports our results and related comments, and Section 4.6 concludes the chapter.

4.2 Literature review: the determinants of territorial inequalities

We can explain convergence by starting by stating the different determinants of income, the explanation of income convergence will then follow from the dynamics of its determinants. Then we proceed in two steps to explain the different levels of income across the territory. First, we review the different theories explaining the location of economic agents, then we assess how the spatial distribution of income is formed by taking as given the distribution of economic agents.

4.2.1 Location of economic agents and territorial inequalities

The phenomenon of territorial inequalities is old and the literature has proposed different sources of explanations. The simplest way to understand inequalities in income and/or production between territories is to highlight the heterogeneity of the geographical area in which economic activities take place. Thus, certain quantities are unequally distributed among the territories, for example natural resources or amenities, this determines the distribution of agents and subsequently generates a difference between the economic structures of the territories (allocation of production factors, production technology, means of transport, etc.). For example, the Heckscher-Ohlin-Samuelson (REF) model explains the emergence of international trade from the initial endowment difference leading to a difference in production and income. The explanation of justifying differences in income and production on the basis of geographical differences in the space in which production and consumption take place is simple, but its explanatory power can be important in some cases. The example of the presence of a natural resource is probably the most studied case in the literature (Stiglitz (1974), Gylfason (2000)). Even if the presence of a natural resource can allow certain territories to obtain higher incomes, it has also been shown that many other factors have an influence and some counter-intuitive situation could be highlighted (Sachs and Warner (2001), Van der Ploeg (2011)). In this context, it is

difficult to analyse the determinants of convergence insofar as the geographical characteristics of a territory are in the majority of cases given once and for all, and it is rare that convergence finds its origin in the modification of the geographical space itself, at least at reasonable time scales.

Territorial inequalities can also be explained by the existence of externalities, known as Marshallian. Externality, i.e., the fact that economic agents produce advantages or nuisances without this being the subject of monetary compensation, is in a lot of space-dependent situation insofar as the magnitude of the externalities effects decrease with distance. This is simply because two distant individuals generally interact less than two close individuals. Thus, the choice of location of some influences the choice of location of others, it can, in the case of a positive externality, lead to agglomeration or, on the contrary, in the case of a negative externality, to dispersion. These location externality effects have been studied in the literature through positive cases with agglomeration economies (Abdel-Rahman and Fujita (1990), Kelly and Hageman (1999), David and Rosenbloom (1990), Gauthier, Lapointe and Laurin (2003) or Gleaser (1994)) and through negative case with urban congestion effects (Mayer and Sinai (2003)). These mechanisms will therefore generate an unequal distribution of economic agents within the territory, which may partly explain territorial inequalities in production and/or income. Thus, it is possible to explain different levels of convergence within different territories by the fact that economic structures do not generate the same externalities and/or of different sizes.

Finally, more recently, the new geographical economy explains the heterogeneity of production without calling on either the heterogeneity of the geographical space or the Marshallian externality. This theory is essentially based on the existence of fixed production costs, transport costs and a preference for diversity on the part of consumers (Krugman, (1991)). Due to transport costs, companies will tend to spread throughout the country, but this trend is offset by the existence of fixed costs so that a limited number of companies can be present in the same place

to ensure a positive profit. Thus, companies will be encouraged to locate as close as possible to consumers in order to have access to a large market. On the other hand, consumers fall into two categories: skilled workers who can move freely within the territory and unskilled workers who cannot move. Skilled workers will choose their location in order to maximize their utility, which depends on the diversity of the product consumed, prices and income. Consequently, the location of workers depends on that of companies and *vice versa*, leading to a dynamic that cannot generally be resolved analytically even within the simplest models. As long as there is a positive utility differential from one region to another, skilled workers are encouraged to move. Based on numerical simulations, Krugman's (1991) model then highlights several cases where, when transport costs are high, skilled workers are fairly distributed between the two regions and there is therefore homogeneity within the geographical space. In the event of intermediate transport costs, we can witness, depending on the initial conditions, either a fair distribution or the emergence of a centre/periphery structure where the entire manufacturing sector and the skilled workers are grouped in a single region. Finally, if transport costs are low enough, the centre/periphery structure necessarily appears. Krugman's (1991) model makes it possible to explain the emergence of spatial heterogeneity simply by endogenizing the location of economic agents and introducing transport costs coupled with fixed production costs. We can note that, to the extent that workers are generally not mobile, Venables (1995) extends Krugman's (1991) model to the extent that it is intermediate goods firms that will seek to locate close to final goods firms. This theory can be used here again to explain the fact that convergence is not achieved at the same speed in different territories. This may, for example, be due to lower labour and capital mobility, in which case the speed at which the economy reaches the equilibrium distribution is slower.

It should be noted that trade liberalisation and economic integration are often perceived as sources of divergence within economic spaces (Brulhart, 2011); indeed some geographical spaces would benefit more from economic integration because of their characteristics. This heteroge-

neity would come from a difference in access to the various external markets (goods and services, labour, capital, etc.) or from a difference in the allocation of production factors. Thus, geographically isolated regions whose main factor of production is low-skilled labour would suffer from trade liberalisation while other regions would benefit from it. Several articles have sought to study theoretically the effects of economic integration and trade liberalisation on the phenomenon of spatial concentration. Henderson (1982) and Rauch (1991) study this relationship through a model where an economy consists of several cities generating economies of scale leading to concentration. This productivity advantage is offset by congestion effects and a balance occurs so that each city sees its size determined endogenously. It is possible within this framework to study the impact of liberalisation on spatial concentration, but the perfect mobility of workers leads to wage equalisation, preventing any study on spatial inequality. Krugman and Livas Elizondo (1996) analyse the problem of regional inequalities through the theoretical framework of the new geographical economy. Their model is composed of two domestic regions to which a third is added as the "rest of the world", they show that the reduction in the costs of trade with the rest of the world favours the dispersion of economic activities within the two domestic regions. Indeed, the drop in trade costs with the rest of the world makes firms and consumers indifferent to their location between the two domestic regions because of the increase in the share of imported and exported goods with the outside world. This result is valid only to the extent that both domestic regions have the same ease of exchange with the rest of the world. Alonso Villar (1999) extends the model of Krugman and Livas Elizondo (1996) by considering three domestic and two external regions. A domestic region has no access to the external regions while the other two domestic regions each have access to one of the two external regions. The author then shows that as soon as domestic transport costs are not too high, regions with access to foreign markets tend to capture more firms through export opportunities. However, competition is stronger in neighbouring regions, which can encourage firms to locate themselves within the region without access to external markets. Finally, the relocation of firms near borders is all the more likely given the high degree of liberalisation, the size

of foreign markets and the fact that foreign firms are complementary rather than competing with domestic firms. Thus, as Brulhart (2011) illustrates through a review of the literature, there is no clear theoretical prediction about the link between economic openness and regional inequalities. Finally, as Haaparanta (1998) shows, a difference in factor endowment can also influence how economic openness impacts regional inequalities.

4.2.2 Empirical evidence

Williamson (1965) is the first empirical study to analyze the determinants of regional inequalities. Based on the work of Kuznets (1955), the author hypothesizes that regional inequalities increase during the first phase of development but a reduction begins in a second phase. The hypothesis is confirmed on the basis of a sample of countries for which the author calculates a measure of inequality using regional production and Williamson (1965) therefore highlights an inverted U-shaped relationship between regional inequalities and levels of development. Subsequently, relatively few studies have tested this result from larger country samples, including articles by Amos (1988), Ezcurra and Rapun (2006) and Barrios and Strobl (2009), all three of which confirm the inverted U-shaped relationship. However, Amos (1988) suggests that once a high level of development has passed, regional inequalities increase again, thus an N-shaped relationship is highlighted. It should be noted that Lessman (2014) clearly confirms the existence of an N-shaped relationship. This result is again corroborated by Lessman and Seidel (2015) from a much larger sample of countries since the authors use the light emitted by economic activities to calculate regional inequalities for a majority of the world's countries, they also include a large number of explanatory variables that may impact regional inequalities. Indeed, Lessman and Seidel (2015) classify the determinants of regional inequalities into several categories, often inter-connected:

1. The economy: Regional inequalities may stem from growth itself because it does not

occur at the same speed across an economic territory. A phenomenon of diffusion then begins to take place so that, if at first regional inequalities increase, they decrease in a second time.

2. Geography: by influencing the distribution of economic agents, geography impacts regional inequalities.
3. Mobility of economic agents, factors of production and goods and services: as already discussed in the previous subsection, transport and installation costs involve forces of dispersion and concentration that can influence regional inequalities.
4. Economic openness: the heterogeneity of territories in terms of their access to the various external markets (goods and services, labour, capital, etc.) means that not all territories benefit from the same opportunities for trade and growth. However, this can also be accompanied by increased competition.
5. Natural resources: the non-uniform distribution of natural resources on a territory will mechanically contribute to the distribution of economic agents.
6. Transfers: the mobility of goods and services, as well as capital, will naturally generate cash flows between territories, thus impacting income distribution. In addition, the central state also has an influence through public levies and transfers. Some countries with more government intervention may then benefit from lower regional inequality through the existence of corrective mechanisms.
7. Institutions: not all countries benefit from the same institutions, so the way geography is divided into administrative territories and the powers given to these territorial administrative entities can influence regional inequalities.

Lessman and Seidel (2015) show the great importance of the degree of openness of countries. An increase in external trade is associated with an increase in regional inequalities. The authors also highlight the effect of mobility, measured *via* road infrastructure.

We also note, in the literature, several articles studying, more specifically, the link between regional inequalities and trade liberalisation. Rodriguez-Pose and Gill (2006) analyze 8 countries (America, Brazil, China, India, Germany, Italy, Mexico and Spain) and find a positive link between the increase in inequality and the increase in trade in goods and services since these exchanges are mainly composed of manufacturing products rather than primary products. Hirte and Lessman (2014) and Ezcurra and Rodriguez-Pose (2013) also find a positive link between the openness rate and regional inequalities.

Finally, to our knowledge, all studies seeking to identify the determinants of spatial inequalities have been carried out at the country level by calculating inequality measures for each country from the regions that make up the components. In this context, the two strong results emerging from the literature are, on the one hand, the inverted U-shaped relationship between spatial inequalities and the level of development and, on the other hand, the fact that trade liberalisation as well as economic integration promote the increase in spatial inequalities. However, we have seen that this inverted U-shaped relationship is not entirely valid since for high levels of development inequalities are beginning to increase again. The literature therefore already provides us with two possible explanations to explain the heterogeneity of the convergence phenomenon across the French space. Indeed, France being a developed country, the difference in convergence between geographical areas could be linked to a difference in income dynamics and/or a difference in access to foreign markets.

We then study the phenomenon of spatial inequality at a much finer scale than the articles mentioned above. However, we will see that at this scale the location of economic agents is no longer the only determinant of the spatial distribution of income and that small economic entities such as municipalities interact very strongly with each other through several channels.

4.2.3 Income formation

We assume that the socio-economic structure of territories is given and we now seek to explain the emergence of the spatial distribution of income from the spatial distribution of economic agents. In this context, we will see that the spatial distribution of income is not limited to the spatial distribution of production. What characterizes a territory as an economic space is the economic structure formed by the population of companies located within the territory as well as the population of households living there. These two populations have unique characteristics that may differ from one territory to another and will have an impact on income. For example, a territory may have a large number of firms related to a particular sector and/or be composed of a significant portion of a category of households. More generally, and to the extent that a territory is part of a larger economic entity, the added value produced within a territory will interact with the added value produced by the other territories. Moreover, the income declared within it will depend not only on its ability to produce value added but also on its ability to capture external value added. These two facts are all the more important as the geographical units considered are small, we will explain these two points in more detail.

Interaction between value added

The value added produced on a French scale originates in several territories, each of which has a particular production structure, which necessarily leads to imports and exports between territories. These exchanges of goods and services will generate an interdependence of the territories' production and therefore of incomes. We simply want to show here that income itself is a determinant of income but through its "spatial delay". We can simply formalize this idea from a simple Keynesian model consisting of N economies trading goods and services. We consider a territory i and we start from the accounting equation breaking down the value added (y_i) into five elements: private consumption (c_i), public consumption (g_i), investment (v_i), exports (x_i) and imports (m_i):

$$y_i = c_i + g_i + v_i + x_i - m_i \quad \forall i \quad (4.1)$$

We assume that each region j has a certain propensity to import goods and services from the region i , then m_j is the total quantity imported by the region j . We assume that a share $\lambda_{ij} \in [0; 1]$ is imported from the i region. It is likely that the parameter λ_{ij} is dependent on the geographical distance between the two regions, but not only. We have to set the constraint $\sum_j \lambda_{ij} = 1$ so that we have $\forall j \quad m_j = \sum_i \lambda_{ij} m_j$. The total quantity exported by the region i will therefore be equal to the sum of imports from the other regions weighted by their propensity to import from the region i . So we have:

$$x_i = \sum_j \lambda_{ij} m_j \quad \forall i \quad (4.2)$$

We can reformulate equation (4.1) using equation (4.2):

$$y_i = c_i + g_i + v_i + \sum_j \lambda_{ij} m_j - m_i \quad \forall i \quad (4.3)$$

We simply assume that consumption and imported quantity are income functions: $c_i = c_i(y_i)$ and $m_i = m_i(y_i)$. We then get:

$$y_i = c_i(y_i) + g_i + v_i + \sum_j \lambda_{ij} m_j(y_j) - m_i(y_i) \quad \forall i \quad (4.4)$$

We can reformulate this equation system in matrix form:

$$\mathbf{y} = \mathbf{c}(\mathbf{y}) + (\Lambda - I_N)\mathbf{m}(\mathbf{y}) + \mathbf{a} \quad (4.5)$$

Where Λ is a matrix such that $[\Lambda]_{ij} = \lambda_{ij}$ if $i \neq j$ and $[\Lambda]_{ij} = 0$ otherwise. The vectors are such that $[\mathbf{y}]_i = y_i$, $[\mathbf{c}(\mathbf{y})]_i = c_i(y_i)$, $[\mathbf{m}(\mathbf{y})]_i = m_i(y_i)$ and $[\mathbf{a}] = g_i + v_i$. It is then very clear that

the added values of the different territories influence each other through the Λ matrix which forms an externality network between territories *via* the propensities to import. The multiplier produced by a modification of the autonomous demand is naturally modified:

$$d\mathbf{y} = (I - L(\mathbf{y}))^{-1}d\mathbf{a} \quad (4.6)$$

where $L(\mathbf{y}) = \mathbf{c}'(\mathbf{y}) + (\Lambda - I_N)\mathbf{m}'(\mathbf{y})$. The matrix $L(\mathbf{y})$ takes direct effects into account. Indeed, an increase in the value added produced by the region j of a unit will have the direct consequence of increasing the value added produced by the region i by $[L(\mathbf{y})]_{ij}$ units. The matrix $K(\mathbf{y}) = (I - L(\mathbf{y}))^{-1}$ takes into account not only the fact that an increase in the autonomous demand of the region j will increase its import demand from the region i but also all indirect effects. The increase in the value added produced by the region j will have an impact on several regions, which will also have an impact on other regions and thus more... In total, an increase in the value added produced by the region j of a unit will increase the value added produced by the region i by $[K(\mathbf{y})]_{ij}$ units, taking into account all interdependence effects. The $K(\mathbf{y})$ matrix therefore corresponds to the multiplier, only now does the latter take into account interactions between regions *via* imports and exports. An exogenous production shock is now spreading through the network formed by geographical units, so we have local multipliers that can be more or less important depending on the characteristics of the economies. In particular, if the exogenous shock takes place within a territory whose propensity to import is high, a large part of the surplus production will be generated by its main trading partners. If the territory has many trading partners the shock will be strongly dissipated and the effects on the partners will be negligible unless the shock is of a very large size. Thus, the greater the rate of territorial opening, the greater the interaction effects between productions. Knowing that the smaller the territory, the greater the rate of opening up, this simple model justifies the use of econometric modelling that takes into account the interdependencies between income in the case of the study of municipalities.

If we now make the simplifying assumption of linear consumption and import function, $c_i(y) =$

$c_i y_i$ and $m_i(y) = m_i y_i$, the model is resolved analytically and we obtain:

$$\mathbf{y} = (I_N - C - (\Lambda - I_N)M)^{-1} \mathbf{a} \quad (4.7)$$

Where C and M are diagonal matrices such that $[C]_{i,i} = c_i$ and $[M]_{i,i} = m_i$. We then see that revenues depend on all autonomous demands *via* the $(\Lambda - I_N)M$ matrix and the variance of revenues depends on the variance of autonomous demands but also on the interdependence relationships between the territories. Thus, interdependencies can directly impact convergence, as can be seen simply by taking the borderline case where a perfect equalization of autonomous demands does not produce a perfect equalization of revenues.

Interaction between income and value added

We have just seen that the added value produced within one territory can be highly dependent on the production of the other territories. However, we will see that the territories' incomes can interact through other channels than simply the exchange of goods and services. As early as the 1950s, one of the first spatial analyses of income, the theory of the economic base (North (1955), Hoyt (1954) and Tiebout (1956)) had already outlined the main mechanisms for transferring added value between territories. According to this theory, the income of a territory depends mainly on its ability to capture external value added. Historically, the theory of the economic base has focused essentially on the production and export capacity of territories, so interdependence between territories is achieved through the exchange of goods and services and it is through this channel that a territory is able to have a high income, as explained in the previous subsection. Within each territory, the theory distinguishes two sectors: the basic sector and the support sector. The basic sector is the productive sector, almost all of whose production is dedicated to exports and it therefore depends to a large extent on external demand from the territory. The support sector is a sector whose production is supposed to satisfy domestic demand. This sector exists essentially thanks to the core sector, which ensures

the presence of a labour force and a capital stock generating domestic demand. A multiplier effect then appears insofar as an increase in the external demand of a unit will have a greater effect on the territory's income because the increase in production in the basic sector of a unit will immediately result in an increase in production in the support sector. Of course, this multiplier effect will be all the more weakened as the propensity to import from the basic sector as well as from the support sector is high.

Although trade in goods and services can be an important channel in the interdependence of territories, it is not the only one. Indeed, a territory's ability to capture external value added may depend on other elements that may be just as important, thus creating a decoupling between the territory's income and the value added created within it. First, the existence of commuters, i.e., inhabitants of one territory working in another territory, recover added value through their wages and repatriation to where they live. This can have a multiplier effect in terms of local demand. Second, the capital of one territory may be held by the inhabitants of other territories and here again the added value of one territory is fed into the income of other territories in the form of interest, dividends or rent. Third, if we consider a set of territories forming a fiscal union then redistribution aimed at correcting social inequalities can lead to income transfers between territories insofar as the population eligible for certain taxes or transfers is not uniformly distributed within the geographical space. For example, the retired population is not spatially distributed in the same way as the working population, or the unemployed population is not distributed in the same way as the employed working population due to certain economically affected areas. Finally, government expenditure, whether consumption or investment, is not uniformly distributed across the country in terms of public consumption or investment. However, public expenditure can support demand and therefore a local economic fabric allowing the payment of wages and/or dividends and therefore income. For these different reasons, we must expect that a territory's income will not depend solely on its ability to produce and export goods and services. The decoupling between the territories' incomes and their value-added production will be all the stronger as:

1. the geographical units considered are small, this favours the fact that households can work and hold capital outside their territory.
2. economic integration is important, promoting the existence of cross-border workers and the holding of capital outside their residential territory.
3. the pooling of revenues through fiscal policy is important, the more public administrations capture a large part of the value added before redistributing it and the more they can generate a spatial redistribution.
4. the distribution of populations eligible for taxes and transfers is non-uniform, so redistribution between different population categories implies a spatial redistribution.

The theory of the economic base has placed greater emphasis on a territory's ability to produce and export goods and services because in the 1950s the number of commuters and the distances they travel were much smaller due to technological developments in the field of transport and communication. Moreover, the role of the State in economic activity was much less important than it is today. In this sense, our societies have experienced a pooling of income through fiscal policy, making the territories' income much less dependent on their productive capacities. Finally, as we subsequently work on very small geographical units (the French municipalities) we must expect these effects to be very significant and we cannot limit ourselves to a simple analysis of production across the territory, on the contrary socio-demographic information may be essential.

We will study in detail these different mechanisms through the multi-regional Input-Output theory. This will allow us to formalize the interactions between territories by taking into account the different channels we mentioned earlier. We begin with a simple reminder of the Input-Output analysis and then present an extension involving several interacting territories.

Input-Output analysis

Input-Output analysis, introduced by Leontief (1936), provides a particularly suitable framework for studying the determinants of income at the local level. Indeed, first, it incorporates the diversity of the productive structure and its interdependencies *via* the matrix of technical coefficients and second, it naturally extends to the analysis of territories *via* the possibility of studying a system where an arbitrary number of regions coexist and interact (Isard (1951), Tiebout (1957), Moore (1955)). In such a context, the spatial dimension is based on the fact that regions can have very different production structures and that the inputs needed for production come from other regions. Naturally, these last two points are closely linked, as the specificity of the productive structure has the effect of generating exchanges between regions.

We will see later that this framework can be further extended by endogenizing household consumption while taking into account their diversity. Thus, each territory has specific characteristics both in terms of its productive fabric and the composition of its population.

The basic idea of input-output analysis is to deploy the accounting equation across the different sectors of the economy. If we indicate by i the sectors we then have, for every i , the following accounting equation:

$$x_i = \sum_{j \neq i} z_{ij} + f_i \quad (4.8)$$

where x_i is the production of the i sector, z_{ij} is the demand addressed to the i sector by the j sector and f_i is the final demand, assumed exogenous, addressed to the i sector. The latter therefore includes household consumption, public consumption, private investment, public investment and net exports. The hypothesis at the heart of the input-output analysis concerns the input demand function of the different sectors. For a j sector, the latter provides us with information on the quantity of each input required to produce a quantity x_j of output. It is

therefore a function, noted $d_j(x_j)$ defined in \mathbb{R} and valued in \mathbb{R}^N where N is the number of sectors in the economy:

$$d_j(x_j) = z_j = \begin{pmatrix} z_{1j} \\ z_{2j} \\ \cdot \\ z_{Nj} \end{pmatrix} \quad (4.9)$$

We assume that, for all sectors, the d_j function is linear so that we have:

$$d(a_j, x_j) = a_j x_j \quad (4.10)$$

Where $a_j = (a_{1j}, \dots, a_{Nj})^T$ is the vector containing the different technical coefficients. In other words, the input quantity i required to produce a unit of output j is fixed and equal to a_{ij} . Under these conditions we have $z_{ij} = a_{ij}x_j$ and equation (4.8) can be reformulated as follows:

$$x_i = \sum_{j \neq i} a_{ij} x_j + f_i \quad (4.11)$$

And since this is true for each sector, we have a linear equation system that can be written in matrix form:

$$x = Ax + f \quad (4.12)$$

Where x is the production vector, A the technical coefficient matrix and f the final demand vector. Each j column in the A matrix describes the demand generated by the j sector from other sectors. The A matrix gives us information on the interdependence between sectors but only in order 1 : indeed, the rise in total demand for the j sector will increase the production of the i sector by a_{ij} units, only this reasoning must not stop there because the increase in production of the other sectors will cause a rise in demand for the j sector but also between

them... A multiplier effect arises from this interdependence, we can calculate the final effect by solving equation (4.12) giving the output of each sector given an assumed exogenous final demand vector:

$$x = Bf \quad (4.13)$$

Where $B = (I - A)^{-1} = \sum_{k=1}^{\infty} A^k$ is the Leontief matrix. We do indeed find the first order effect which corresponds to the first term of the suite, but to this one is added an infinity of successive effects corresponding to the multiplier effects. This matrix allows for a simple economic interpretation : the element b_{ij} corresponds to the amount of additional i output when the final demand for the j sector of a unit increases. It follows that each element of the diagonal of the B matrix is greater than or equal to the unit to the extent that if the final demand for the i sector increases by one unit, it will necessarily require the output of the i sector to increase by one unit to satisfy this demand. In doing so, this sector will increase its demand for inputs, thus also causing an increase in production in other sectors, which in turn will rise their demand for inputs. This mechanism can therefore lead to a greater increase in production in the i sector than that induced by the simple augmentation in final demand. The effect on total production of a one-unit increase in final demand for the j sector is given by the sum of the elements in the j column of the B matrix:

$$\frac{\Delta(\sum_i x_i)}{\Delta f_j} = \sum_i b_{ij} \quad (4.14)$$

Each column of the B matrix therefore describes the effect of the increase in the corresponding sector on total production. In order for the model to be correctly applied, the total sum of intermediate consumption in a sector must not exceed the total value of its production. Otherwise, this sector would be unproductive insofar as the total value of its production would not allow it to pay for its intermediate consumption. We therefore impose the following condition:

$$\sum_i a_{ij} < 1 \quad \forall j \quad (4.15)$$

Otherwise, the sum of each column in the A matrix is less than one. So we have $x_j > \sum_i a_{ij}x_j$ and the difference between these two terms is the value added generated by the j sector. Thus, the share of value added in the j sector is equal to $1 - \sum_i a_{ij}$ (noted ν_j thereafter), by noting v the vector of value added generated by each sector, we have $v = Vx$, where $V = I - A^T$.

We can therefore endogenize household consumption, which until now has been a component of exogenous final demand. We assume that households capture a h_i share of the value added of each sector, so total household income, y , is given by:

$$y = h'v = h'Vx = \sum_j h_j \nu_j x_j \quad (4.16)$$

On the other hand, let us note c the vector of marginal propensity to consume for the different sectors so that the household consumption vector is given by cy . Finally, we have two equations, the first describes the equality of employment and resources for each sector and the second one describes the formation of household income from the production of the different sectors.

$$x = Ax + cy + f \quad (4.17)$$

$$y = h'Vx \quad (4.18)$$

This time, f corresponds to the exogenous demand and the final demand is given by $cy + f$. If we substitute the first equation within the second we get:

$$y = h'VB(cy + f) = h'VBcy + h'VBf \quad (4.19)$$

Thus, the line vector $h'VB$ reflects the effect of final demand on income without taking into account general equilibrium effects. The effect of an increase in final demand for the j sector of a unit (without taking into account multiplier effects) is given by

$$\frac{\Delta y}{\Delta(cy + f)_j} = [h'VB]_j = hVb_j = \sum_i h_i \nu_i b_{ij} \quad (4.20)$$

The results highlighted are very intuitive: the effect will be all the more significant if the j sector has a strong multiplier power with sectors whose share of value added is significant and whose share of this value added accrues to households. The scalar $h'VBc$ simply corresponds to the interdependence effect of income with itself. An increase in household income causes an increase in demand addressed to the different sectors according to the different marginal propensities to consume contained in the c vector, the income generated (in order 1, therefore without multiplier effects) is obtained by the weighted sum of the cy vector using the weighting vector $h'VB$ previously described. Of course, the previous reasoning does not take into account the multiplier effect of income, the increase in income leads to an increase in final demand and so on... It is then sufficient to solve equation (4.19) in order to obtain the income according to the exogenous demand:

$$y = \left[\frac{1}{1 - h'VBc} \right] h'VBf \quad (4.21)$$

or

$$y = \left[\frac{1}{1 - \sum_j \sum_i h_i \nu_i b_{ij} c_j} \right] h'VBf \quad (4.22)$$

From this result we can calculate the effect of an increase in exogenous demand addressed to the sector j on household income:

$$\frac{\Delta y}{\Delta f_j} = \frac{hVb_j}{1 - h'VBc} = \frac{\sum_i h_i \nu_i b_{ij}}{1 - \sum_j \sum_i h_i \nu_i b_{ij} c_j} \quad (4.23)$$

Thus, the simple input-output analysis already allows us to study the dependency links between sectors within the same territory and to investigate how an exogenous shock can modify income according to the characteristics of the local economic fabric. This simple framework does not allow us to study the effects of interaction between territories, however, we will see that it can easily be modified to include any number of interacting territories.

Input-output model à la Miyazawa (1976)

The previous input-output analysis can be extended in case several regions interact, we then use Miyazawa (1976) as a basis to explain the model. We assume that there are R regions and each of them is composed of N sectors, \mathbf{x} and \mathbf{f} are now vectors of size $[RN, 1]$. Each sector makes requests to all sectors within all regions. Thus, the matrix noted A^{rs} and size $[N, N]$, groups the technical coefficients describing the demands of the sectors in the region s towards the sectors in the region r . By posing:

$$A = \begin{pmatrix} A^{11} & \dots & A^{1R} \\ \dots & \dots & \dots \\ A^{R1} & \dots & A^{RR} \end{pmatrix} \quad (4.24)$$

We find the form already presented in the previous section: $\mathbf{x} = A\mathbf{x} + \mathbf{f}$. In order to endogenize household consumption, we note \mathbf{c}^{rs} the size vector $[N, 1]$ containing the marginal propensity to consume from the region s to the sectors of the region r and y^r the region's income r . By posing:

$$C = \begin{pmatrix} \mathbf{c}^{11} & \dots & \mathbf{c}^{1R} \\ \dots & \dots & \dots \\ \mathbf{c}^{R1} & \dots & \mathbf{c}^{RR} \end{pmatrix} \quad (4.25)$$

Here again, this allows us to find an expression similar to what has already been seen in the previous section: $\mathbf{x} = A\mathbf{x} + C\mathbf{y} + \mathbf{f}$, where $\mathbf{y} = {}^t(y^1, \dots, y^R)$. We note ν_j^r the share of

value added generated by the sector j within the region r and $V = I - A^T$. Then we have $V\mathbf{x} = \mathbf{v} = {}^t(\mathbf{v}^1, \dots, \mathbf{v}^R)$, with $\mathbf{v}^r = {}^t(v_1^r, \dots, v_N^r) = {}^t(\nu_1^r x_1^r, \dots, \nu_N^r x_N^r)$ the vector of added values from the sectors in the region r . Finally, we define the vector \mathbf{h}^{rs} size $[N, 1]$ describing the shares of value added generated by the sectors of the region s and captured by households in the region r . By posing:

$$H = \begin{pmatrix} {}^t\mathbf{h}^{11} & \dots & {}^t\mathbf{h}^{1R} \\ \dots & \dots & \dots \\ {}^t\mathbf{h}^{R1} & \dots & {}^t\mathbf{h}^{RR} \end{pmatrix} \quad (4.26)$$

The H matrix is $[R, RN]$ and a s column of this matrix is interpreted as the value added shares that the different regions recover from the N sectors of the s region. We can now describe the income formation of the different regions:

$$\mathbf{y} = HV\mathbf{x} \quad (4.27)$$

or

$$\mathbf{y}^r = \sum_s {}^t\mathbf{h}^{rs}\mathbf{v}^s = \sum_s \sum_i h_i^{rs} v_i^s \quad \forall r \in [1, \dots, R] \quad (4.28)$$

The latter equation is easily interpreted: the income of the region r is equal to the weighted sum of the added values generated by all sectors in all regions. The weighting scheme simply corresponds to the share that is captured by households in the region r . The HV matrix, which is $[R, RN]$ in size, allows us to transform the vector of production values into an income vector based on the shares of value added in each sector and the shares of value added obtained by households in the different regions for each sector. We note it $W = HV$ afterwards, the element $w_j^{r,s}$ is interpreted as the share of the sector's production j in the region s that contributes to the income of households in the region r . In total, we can represent the economic system by a two-equation (vectorial) system:

$$\begin{cases} \mathbf{x} = A\mathbf{x} + C\mathbf{y} + \mathbf{f} \\ \mathbf{y} = W\mathbf{x} \end{cases} \quad (4.29)$$

By substituting the first equation in the second to eliminate \mathbf{x} we have:

$$\mathbf{y} = WB(C\mathbf{y} + \mathbf{f}) = WBC\mathbf{y} + WB\mathbf{f} \quad (4.30)$$

Without taking into account multiplier effects, the increase in final demand in the j sector of the region s will increase household income in the region r by the following amount:

$$\frac{\Delta y^r}{\Delta(C\mathbf{y} + \mathbf{f})_j^s} = \sum_{i,s} w_i^{rs} b_{ij}^{rs} \quad (4.31)$$

The effect is simply the sum of the effects on each of the sectors in all regions, each time weighted by the share of value added captured by households in the region r . Note $L = WBC$, this matrix describes the interdependence relationships between the incomes of the different regions. If the income of the region s increases by one unit then the income of the region r increases by l^{rs} unit, always without taking into account the multiplier effects. The interdependence between incomes is achieved through three channels:

1. Households consume goods from other regions.
2. Sectors in one region use inputs from sectors in other regions.
3. Households capture value added from other regions.

This is why the regional input-output model in Miyazawa (1976) is relevant when studying income formation between several interdependent regions. It incorporates the fact that trade is carried out between regions both in terms of intermediate goods and final goods. In addition, it allows households in one region to capture value added from sectors in other regions. In practice, this may occur for several reasons, but in particular because households may work

and hold capital outside their region.

By solving equation (4.30) we obtain the following solution:

$$y = KVBf \quad (4.32)$$

where $K = (I - L)^{-1}$ is the matrix modelling the multiplier effects due to the interdependence of household incomes. If household income in the region increases by one unit, then household income in the region will increase by k^{rs} . The effect of an increase in exogenous demand is a three-step process: (i) this leads to an increase in the production of the different sectors within the different regions (Bf), (ii) then it leads to an increase in the value added distributed to households (VBf), (iii) which leads to an increase in household income by taking into account their interdependencies ($KVBf$). In order to better understand the effect of an increase in exogenous demand for the j sector in the region s on the region's income r , we have:

$$\frac{\Delta y^r}{\Delta x_j^s} = [KVB]_i^{rs} = \sum_{l=1}^R k^{rl} \left(\sum_{i,t} w_i^{ls} b_{ij}^{ts} \right) \quad (4.33)$$

In total, the effect of an increase in exogenous demand to the sector j in the region s on the region's income r depends on two distinct effects:

1. The ability of the j sector of the region s to influence the income of the different regions. This requires its ability to have a strong impact on the production of sectors generating a lot of value added and for which the share of value added captured by households is significant.
2. The region's ability to take advantage of the increase in income in other regions. This requires that households in other regions have a high propensity to consume goods from sectors in the region r and that the latter have a strong influence on the income of other regions.

We have therefore seen that the simple spatial distribution of economic agents does not provide us with complete information on the distribution of income, particularly when the territories

are small and highly integrated economically. In this case, it is important to take into account the interactions between income from trade in final and intermediate goods and services, value added transfers by commuters and capital ownership outside the region. These elements can therefore influence the convergence phenomenon without changing the location of economic agents. For example, a poor territory may converge to a richer territory simply because the latter will have a higher import demand and also because workers from the poor region can go to work in the rich region without changing their housing. Here again, the incomes of workers in the poor region will be largely spent within their own region, generating a multiplier effect.

4.3 Descriptive statistics and data presentation

Within this subsection we provide a set of descriptive statistics that allow us to characterize income inequalities and their dynamics between French territories and to explain our problems in the case of France. We therefore briefly recall some of the results already presented in Chapter 3.

We have the median income for a large majority of the municipalities in France (29,318 municipalities) and this last one is observed from 2001 to 2014. In 2001, French municipalities had an average income of 13,930 euros and a relatively high inequality, since the associated coefficient of variation was close to 20%. In order to cancel out the effect of very low or very high income municipalities, we observe that 90% of the municipalities have an income between 10,210 euros and 18,966 euros.

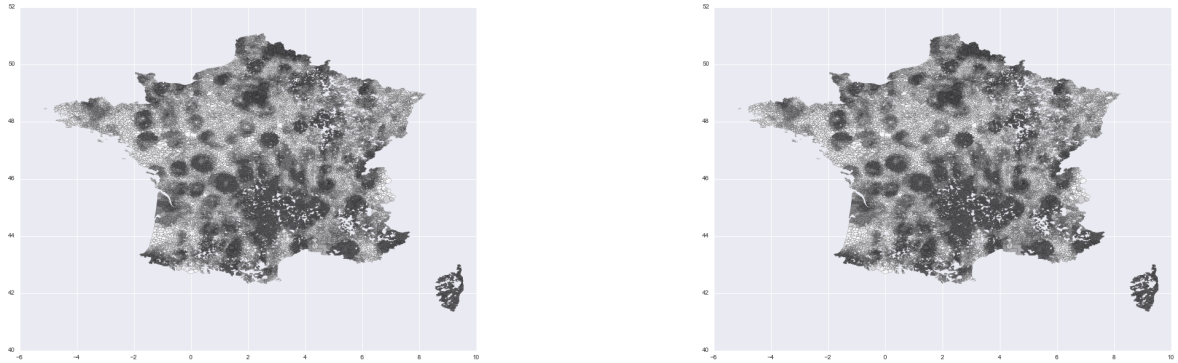
However, the analysis of income inequalities at the global level masks a possible heterogeneity between territories. In order to understand this, we choose two inequality measures, the coefficient of variation and the Theil index, which are insensitive to the unit of measurement, and then calculate these two inequality measures locally for each municipality i using a sample composed only of the K closest neighbours of the municipality i . We therefore have as many inequality measures as there are municipalities in the sample, so that we do not have to ar-

bitrarily partition the municipalities and maintain greater variability in the values that the inequality measure can take across the territory. Indeed, if we had partitioned the territory into $N < 29,318$ geographical areas, we would have calculated N inequality measures that may present strong discontinuities, moreover, the results obtained may depend strongly on the chosen breakdown, thus making the analysis unstable. Our method forces us to choose the number of closest neighbours in a relatively arbitrary way, knowing that a too small number makes the inequality measure irrelevant because it is calculated on a too small sample and that a too large number reduces its ability to capture geographical variability. However, this number can easily be modified to assess the robustness of the stylized facts obtained. Finally, it is important to note that measuring inequality locally by using sub-samples of geographically close municipalities is more economically relevant since we do not observe prices, and we can expect prices to display strong spatial autocorrelation. It is therefore more appropriate to limit ourselves to comparing neighbouring municipalities rather than remote ones.

Figures 4.1 present respectively the coefficient of variation and the Theil index for the different municipalities in France. These two maps show a large variability in the level of inequality across the territory. In particular, we can note (see Table 4.1) that the 25% most unequal geographical areas have an income variation coefficient at least 35% higher than the 25% of the most egalitarian geographical areas. It would seem that municipalities belonging to metropolitan areas have greater inequalities, but the two maps presented are not reducible to a simple metropolitan/province dichotomy. It should also be noted that the two measures of inequality are highly correlated and provide very similar information. Thereafter we will favour the coefficient of variation which has the advantage of being more easily interpretable.

The previous analysis was carried out for the year 2001 and it is interesting to study how inequalities between territories have evolved over time. In this sense, we are wondering about the possible convergence between the territories. This time we calculate the coefficient of variation and the Theil index globally but for each year from 2001 to 2014, their temporal evolutions are

FIGURE 4.1 – Spatial distribution of local inequality measures in 2001



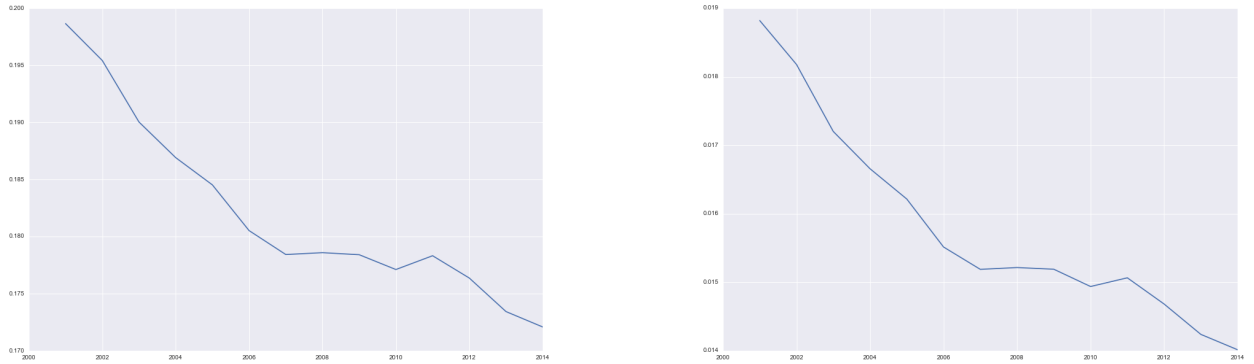
Left: coefficient of variation. Right: Theil index.

represented graphically on the Figure 4.2. Over the study period, the coefficient of variation went from 0.198 to 0.172, i.e., a decrease of 13.37%, the same is true for the Theil index with a decrease of around 25%. In this sense, we do have a decrease in inequalities and therefore a convergence between territories, in this case we are highlighting a phenomenon of σ -convergence. If convergence does take place over the study period, we note that it is not regular. Indeed, for the two selected inequality measures we observe a sharp decrease over the period 2001-2006 and then a slowdown over the period 2006-2012 before the convergence rate accelerates again. We can confirm these stylized facts by estimating β -convergence¹ for each year. Figure 4.3 shows the β obtained for each year according to the estimation method chosen. We do observe a negative *beta* each time, however, the latter increases between 2006 and 2012, reflecting the weakening convergence rate over this period.

As before, the global temporal analysis masks a great diversity of local evolution. But here again, we can measure local inequalities for each year and we calculate the rate of change in the local inequality measure between 2001 and 2014, so we evaluate the σ -convergence locally.

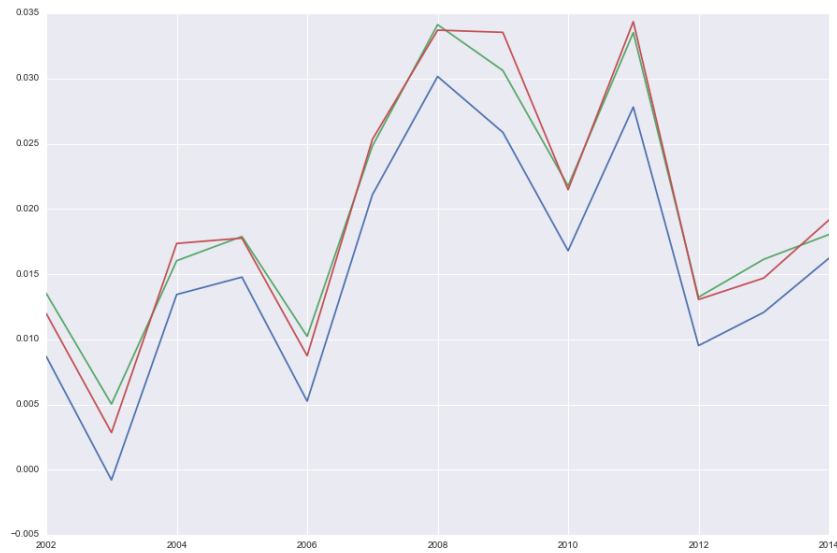
1. $g_i = \alpha + \beta \log(y_i) + \varepsilon_i$ where g_i is the income growth rate and y_i the initial income, see chapter 3 for a detailed exposure of the β -convergence

FIGURE 4.2 – Temporal evolution of income inequality



Left: coefficient of variation. Right: Theil index.

FIGURE 4.3 – Temporal evolution of beta-convergence



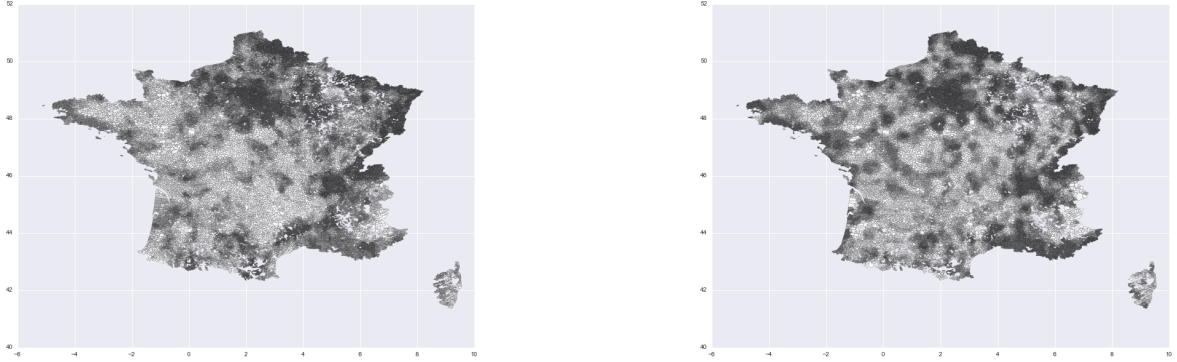
Blue line: OLS. Green line: SMA. Red line: SARMA

| stats | variable | |
|------------|----------|-------------------|
| | Local CV | Local Theil index |
| count | 29,318 | 29,318 |
| mean | 0.14 | 0.01 |
| std | 0.033 | 0.005 |
| coef. var. | 0.36 | 0.82 |
| min | 0.06 | 0.002 |
| 25% | 0.117 | 0.007 |
| 50% | 0.136 | 0.009 |
| 75% | 0.159 | 0.012 |
| max | 0.325 | 0.052 |

TABLE 4.1 – Descriptive statistics

Table 4.2 provides descriptive statistics on the rate of variation of the local coefficient of variation and the local Theil index. We do have an average convergence, however, for the two rates of variation of inequality measures, the coefficient of variation is greater than 80% indicating a strong heterogeneity between territories. We observe that, for 25% of the territories, the coefficient of variation of income has decreased by more than 25%, but there are also 25% of the territories for which the coefficient of variation has decreased by less than 9%. Figure 4.4 maps the value of the rate of variation, between 2001 and 2014, of the local coefficient of variation. We cannot identify a dichotomy between metropolitan areas and non-metropolitan areas, but Paris and Lyon metropolitan areas clearly show low convergence and, more generally, border

FIGURE 4.4 – Spatial distribution of inequality dynamics.



Left: rate of variation of the coefficient of variation. Right: beta coefficient from local β -convergence.

and coastal areas seem to show lower levels of convergence. It should be noted, once again, that the rate of change of the two inequality measures used are highly correlated (0.99) and using one or the other does not seem to make a difference. As before, we can complete the analysis based on the σ -local convergence with an analysis of β -local convergence. To do this we use the GWR² method to evaluate the β -convergence locally. The Figure 4.4 presents the map of the β coefficients obtained and Table 4.2 provides the associated descriptive statistics. We do have convergence on average, but the 53% coefficient of variation tells us, once again, about the great heterogeneity of the territories in terms of convergence. The results highlighted by the local β -convergence are therefore broadly similar to what we had obtained with the local σ -convergence.

At the end of this subsection, we emphasized the great spatial diversity of the convergence process: for some territories, income inequalities in municipalities have been greatly reduced, while for others, we do not observe a reduction in inequality. It is even possible to highlight territories for which inequalities have increased. This heterogeneity raises important economic

2. Geographically Weighted Regression method, see Chapter 3 for a detailed explanation of the method.

| stats | variable | | |
|--------------|--------------------|-----------------------------|------------------|
| | Local CV variation | Local Theil index variation | beta coefficient |
| count | 29,318 | 29,318 | 29,318 |
| mean | -0.164 | -0.281 | -0.356 |
| std | 0.136 | 0.244 | 0.189 |
| coef. var. | 0.83 | 0.87 | 0.53 |
| min | -0.508 | -0.752 | -1.148 |
| 25% | -0.257 | -0.447 | -0.485 |
| 50% | -0.181 | -0.329 | -0.376 |
| 75% | -0.088 | -0.166 | -0.246 |
| max | 0.582 | 1.470 | 0.309 |

TABLE 4.2 – Descriptive statistics

policy issues and at the same time gives us the opportunity to better understand the determinants of convergence by exploiting local convergence measures (variation rate of the local coefficient of variation, coefficient β from the β local convergence) as explained variables.

We have a large number of explanatory variables providing information on the age structure, Socio-professional categories (SPC), employment contracts, workplaces, mobility of inhabitants for each municipality in the sample.³ Many of these variables are highly correlated and it would be tedious to review the descriptive statistics for each of them. Then, we will select, from an

3. The list of explanatory variables is provided in the appendix.

algorithmic procedure, a subset of explanatory variables that are considered to be most relevant in explaining income as described below.

4.4 Methodology

Our ultimate objective is to understand why some geographical areas show high levels of convergence while others lack convergence. We saw in the previous subsection that we could construct a local convergence measure from the temporal variation in the coefficient of variation of income calculated locally. The same procedure is possible with other inequality measures such as the Theil index, but we have seen that the results obtained were very similar, we then prefer the coefficient of variation whose interpretation is more intuitive. Since we are trying to explain the evolution in the coefficient of variation of income over time, we will first identify the main determinants of income, then we can study the convergence of territories based on the dynamics of these determinants. Indeed, we assume that the income of a municipality i depends linearly⁴ on a certain number of variables, we have the following equation:

$$y_i = \alpha + \sum_{h=1}^H \beta_h x_{ih} + \varepsilon_i \quad (4.34)$$

Where ε_i is a random variable with a zero mean and a variance of σ_ε . Note R_i the geographical area containing the K nearest municipalities of the municipality i , μ_{y,R_i} , σ_{y,R_i} and C_{y,R_i} respectively denoting the average, standard deviation and coefficient of variation of incomes y on the geographical area R_i . Thus, we have

$$\begin{aligned} \mu_{y,R_i} &= \frac{1}{\#R_i} \sum_{j \in R_i} y_j \\ \sigma_{y,R_i} &= \left(\frac{1}{\#R_i} \sum_{j \in R_i} (y_j - \mu_{y,R_i})^2 \right)^{1/2} \\ C_{y,R_i} &= \frac{\sigma_{R_i}}{\mu_{R_i}} \end{aligned} \quad (4.35)$$

4. This assumption may seem strong but we will see later that it is reasonable.

Using equation (4.35) we can rewrite μ_{R_i} and σ_{R_i} as functions of the income explanatory variables:

$$\begin{aligned}\mu_{y,R_i} &= \alpha + \sum_{h=1}^H \beta_h \mu_{h,R_i} \\ \sigma_{y,R_i} &= \left(\sum_{h=1}^H \sum_{g=1}^H \beta_h \beta_g \rho_{h,g} \sigma_h \sigma_g + \sigma_\varepsilon \sum_{h=1}^H \beta_h \rho_{h,\varepsilon} \sigma_h + \sigma_\varepsilon^2 \right)^{1/2}\end{aligned}\quad (4.36)$$

Where μ_{h,R_i} , σ_h correspond respectively to the mean and standard deviation of the variable h calculated on the geographical area R_i , i.e., the nearest K municipalities of the municipality i . The correlation coefficient between the variables h and g is noted $\rho_{h,g}$. Thus, we can explain the mean income from the different means of the explanatory variables and the standard deviation of income from the standard deviations of the explanatory variables and their correlations. The coefficients linking income to other variables naturally occur within these expressions so that, all other things being equal, the lower the coefficient β_h is, the less the standard deviation of the h variable will impact the standard deviation of income. It is important to note that if the relationship between the means is linear, this is not the case for the relationship between the standard deviations, for two reasons. First, the standard deviation is the square root of the variance and second, a double sum of cross-products of the standard deviations of the explanatory variables appears because the variance is a bilinear form. Since the coefficient of variation is the standard deviation divided by the mean, we will therefore have a non-linear dependence relationship between the coefficient of variation of income, the mean and the standard deviation of the different explanatory variables. However, what we are trying to explain is the change in the coefficient of variation of income. If the latter is not too large, we can, from the previous results, make a first-order linear approximation to relate the variation in the coefficient of variation to changes in the means and standard deviations of the explanatory variables. Indeed, the coefficient of variation of income is modified either by the modification of the mean or the standard deviation and as a first approximation we have:

$$\Delta C_{y,R_i} = \Delta \sigma_{y,R_i} - \Delta \mu_{y,R_i} \quad (4.37)$$

However, always as a first approximation, we have:

$$\begin{aligned}\Delta\mu_{y,R_i} &= \sum_{h=1}^H \beta_h \Delta\mu_{h,R_i} \\ \Delta\sigma_{y,R_i} &= \frac{1}{2\sigma_{y,R_i}} \sum_{h=1}^H \frac{\partial\sigma_{y,R_i}}{\partial\sigma_h} \Delta\sigma_h\end{aligned}\quad (4.38)$$

With

$$\frac{\partial\sigma_{y,R_i}}{\partial\sigma_h} = \frac{1}{2\sigma_{y,R_i}} \beta_h \left(\sum_{g \neq h}^H \beta_g \rho_{g,h} \sigma_g + \sum_{g=1}^H \beta_g \rho_{g,h} \sigma_g + \rho_{h,\varepsilon} \sigma_\varepsilon \right) \quad (4.39)$$

By this way we can decompose the variation in the coefficient of variation of income from the variations in the means and standard deviations of its determinants. Assuming that we have a linear model that explains level income relatively well from a set of explanatory variables, we can then retrieve the coefficients β_h and calculate the correlation coefficients ($\rho_{h,g}$) and standard deviations (σ_h). Thus, we are able to trace the origins of the evolution in the coefficient of variation of income, however, there are two limitations to this method. First, the section on standard deviation variations involves a large number of cross-products. However, since we estimate the different parameters involved in the expression, the error increases very quickly with the number of variables due to the cross-products. Second, we make a first-order approximation, but we observe large variations in the coefficient of variation of income within our sample and we have seen, *via* the equations (4.38) and (4.39), that the dependency relationship is highly non-linear. We should therefore at least take into account second-order effects. For these two problems, we choose the following two-step methodology:

1. First, we apply a variable selection algorithm to determine the main determinants of the level of income. We are therefore simply looking for the "best" variables to explain the level of income, at this stage the variations do not occur.
2. In a second step, we explain the variation in the coefficient of variation of income ($\Delta CV_{y,R_i}$) over the period 2001-2014 based on the variation in averages ($\Delta\mu_{1,R_i}, \dots, \Delta\mu_{H,R_i}$)

and standard deviations $(\Delta\sigma_{1,R_i}, \dots, \Delta\sigma_{H,R_i})$ of these main determinants using a non-parametric method.

The first step allows us to sort within a large set of highly correlated explanatory variables, and it also makes it easier to interpret the results. The choice of a non-parametric method in the second step is crucial in order to take into account the non-linearity which, as we have seen, appears mechanically. In order to carry out these two steps, we will use only one method: random forest regression. Indeed, we will see in the following subsection, how this method allows us to select the most relevant variables but also to capture the effects of non-linearity and interaction between variables when explaining local convergence.

Variable selection

Selecting a subset of variables from a larger set has several advantages, it improves the interpretability of statistical modelling by focusing on a small number of really relevant variables and allows for better data visualization and a better understanding of the possible interactions between explanatory variables. Due to the increase in the amount of data available, variable selection is an increasingly active area of research, particularly in machine learning (Deng and Runger (2013); Genuer, Poggi and Tuleau-Malot (2010); Hapfelmeier and Ulm (2012); Gregorutti, Michel and Saint-Pierre (2015)), and there are currently many different methods that can be grouped into three categories, each based on a measure of variable importance:

1. Filter methods: These methods consist in selecting the explanatory variables before even estimating a regression model on criteria that relate them to the explained variable. For example, calculating the correlation coefficient or mutual information with the explained variable makes it possible to classify the explanatory variables and then choose the most relevant ones from this classification. These methods have a major limitation which is that they neglect the interactions between explanatory variables, two explanatory variables can be highly correlated with the explained variable while being highly

correlated with each other, so selecting these two variables can be redundant in terms of information. On the contrary, two explanatory variables with little correlation with the explained variable can be very relevant when associated as is the case for the XOR problem.

2. Wrapper methods: A prediction model is selected and the relevance of a subset of variables is assessed through its predictive performance. These methods therefore require a choice to be made about the model used and the performance criterion, if the model chosen is non-parametric and therefore more subject to over-fitting, it is recommended to evaluate the out-of-sample performance. If the total set of explanatory variables is large, testing predictive performance is not possible in practice for all subsets of variables and it is therefore also necessary to define an exploration method within all parts of the set of explanatory variables. For example, the model performance criterion can be optimized *via* a genetic algorithm, a simulated annealing algorithm...
3. Embedded methods: exist for some models, which in the first phase of model adjustment, operate a variable selection procedure. Thus, the model does not automatically use all available variables, this type of model is particularly adapted to the case where the number of explanatory variables is higher than the number of observations. Decision trees, lasso regression or ridge regression are among other things part of this type of methods.

One of the main challenges of selection methods is their stability, since it is important that a small change in the sample does not imply a large change in the subset of selected explanatory variables. This stability problem is all the more important as the number of explanatory variables is large and the latter are correlated with each other. One solution may be to construct the significance measure a large number of times on randomly selected sub-samples within the initial sample.

Then we use a selection procedure for variables belonging to both the wrapper and embedded methods, for which the regression model used is a random forest model and whose performance will be tested out of sample. But first we will explain why we do not use more parsimonious linear models. If we assume that the explained variable depends linearly on the explanatory variables we then have:

$$y = \beta_0 + \beta_1 x_1 + \dots + \beta_p x_p + \varepsilon \quad (4.40)$$

To the extent that all explanatory variables are centered in a reduced way, we can compare the coefficients β and the importance of a variable could be assessed by the absolute value of its marginal effect. However, we cannot decompose the unconditional variance of y in an additive way between the different coefficients, indeed we have:

$$\text{Var}[y] = \sum_{j=1}^p \beta_j^2 + 2 \sum_{j=1}^{p-1} \sum_{k=j+1}^p \beta_j \beta_k \rho_{jk} + \sigma^2 \quad (4.41)$$

Where ρ_{jk} is the correlation coefficient between the variables x_j and x_k . The linear model therefore poses the following problem: the more correlated the explanatory variables are, the more difficult it becomes to assess the importance of a variable from its marginal effect, and the greater the variance of the estimators of each of the coefficients, the greater the sensitivity of the selection procedure to a change in the sample. However, our sample presents several pairs of highly correlated variables, so a linear least-squares model is not an option. One possible solution would be to carry out a main component analysis (PCA) on all the explanatory variables, in which case we would have a set of perfectly uncorrelated variables and equation (4.41) would be reduced to its first term. However, this solution has two disadvantages, first, it leads to a loss of information due to the linear nature of the PCA and, second, we face a loss of interpretability. Indeed, this forces us throughout the rest of the chapter to work with main components calculated from a space of very large explanatory variables (total number of variables) and which may therefore be very difficult to interpret. Finally, the use of a linear

model does not make it possible to take into account the interactions between variables and the introduction of non-linearity is mainly done *via* the researchers' *a priori*. For these different reasons, we will favour a non-parametric model whose learning phase includes a variable selection step.

In order to select our variables we follow a procedure similar to that described by Gregorutti, Michel and Saint-Pierre (2015) which consists of the following steps:

1. estimate a random forest model.
2. calculate the variable importance.
3. eliminate the least important variable.
4. repeat steps 1 to 3 until all variables are eliminated.

Thus at each step of the procedure we obtain a subset of explanatory variables that are increasingly smaller and contained in the previous one. In order to select a subset of explanatory variables from this suite of subsets, we evaluate each of them by their out-of-sample predictive performance. We then choose the smallest subset of variables that does not cause a drop in out-of-sample performance, in this sense the procedure is based on wrapper methods. We therefore obtain a reduced number of explanatory variables while having an equally good performance outside the sample, we can consider that the elimination of the other variables does not cause us to lose relevant information. On the other hand, the procedure also uses embedded methods because the model chosen is a random forest model and the latter incorporates, during its learning phase, a variable selection method that allows us, subsequently, to construct a measure of variable importance. We will detail steps 1 and 2 of the variable selection procedure in order to explain the construction of a random forest model and the associated measure of importance.

Regression tree, random forest and importance of variables

We want to predict a continuous variable y from a set of explanatory variables \mathbf{x} , in general we can assume the following relationship:

$$y_i = f(\mathbf{x}_i) + \varepsilon \quad (4.42)$$

where f is any function. A regression tree is a non-parametric regression method whose objective is to approximate the f function by a T function taking a finite number of values, so the model requires to define M subsets of the feature space (R_1, \dots, R_M) forming a partition and to predict a constant on each of these subsets (c_1, \dots, c_M). The model is then written as follows:

$$T(\mathbf{x}_i) = \sum_{m=1}^M c_m \mathbb{I}(\mathbf{x}_i \in R_m) \quad (4.43)$$

where $\mathbb{I}_m(\mathbf{x}_i) = 1$ if $\mathbf{x}_i \in R_m$ and 0 otherwise. However, another restriction arises, the feature space partition must be accessible by recursive binary separation:

1. we choose a variable j and a threshold s .
2. we partition the feature space as follows $R_1 = \{\mathbf{x} : \mathbf{x}_j \leq s\}$ and $R_2 = \{\mathbf{x} : \mathbf{x}_j > s\}$.
3. Step 1 and 2 are repeated on each of the subsets obtained.

Finally, recursive binary separation can be interpreted graphically as a decision tree. Because of this recursive structure, regression trees capture interactions between variables extremely well and are able, for example, to solve the XOR problem. A regression tree therefore tries to approximate the f function by a T function taking a finite number of values from a feature space partition that is accessible by recursive binary separation. The method is non-parametric insofar as the subsets R_1, \dots, R_M and their M number are not defined *a priori* and it is within the learning procedure that these parameters are chosen. Although the subset of functions on

which a good approximation of the f function must be found may seem restrictive, it is nevertheless impossible to explore it exhaustively in order to obtain the best possible approximation under a given constraint (for example, a given number of M regions). Rather than choosing a sequence of variables and thresholds to optimize a certain criterion overall, we then use a gluttonous algorithm that consists of, at each step, selecting the variable and the threshold in order to optimize a certain criterion locally. Thus, we do not take into account the fact that the separation procedure continues after our choice and given a subset we look for the variable j , the threshold s and the two constants (c_1 and c_2) associated with the separation into two regions R_1 and R_2 which minimize the sum of the error squares. The program is therefore as follows:

$$\min_{j,s} \left\{ \min_{c_1} \left\{ \sum_{i \in R_1(j,s)} (y_i - c_1)^2 \right\} + \min_{c_2} \left\{ \sum_{i \in R_2(j,s)} (y_i - c_2)^2 \right\} \right\} \quad (4.44)$$

Where $R_1(j, s) = \{i : \mathbf{x}_{ij} \leq s\}$ and $R_2(j, s) = \{i : \mathbf{x}_{ij} > s\}$. First, it is easy to solve analytically the value of c_1 and c_2 for a given j variable and s threshold, in this case it is obvious that the best predictions on the two sub-samples will be the respective means:

$$c_k(j, s) = \frac{1}{\#R_k(j, s)} \sum_{i \in R_k(j, s)} y_i \quad (4.45)$$

The minimization program is therefore reduced to the following expression:

$$\min_{j,s} \left\{ \sum_{i \in R_1(j,s)} (y_i - c_1(j, s))^2 + \sum_{i \in R_2(j,s)} (y_i - c_2(j, s))^2 \right\} \quad (4.46)$$

At this step the algorithm tests all the couples (j, s) and then chooses the variable and the associated threshold producing the greatest error reduction. In this sense, regression trees incorporate a method for selecting variables within their learning phase. The learning algorithm

will then repeat this operation as many times as possible before encountering a constraint formulated by the researchers, indeed without constraint it would be possible to obtain a zero error in the sample simply by creating as many subset as observations. There are several possible constraints to avoid overfitting, such as limiting the M number of possible subsets or limiting the number of observations belonging to a subset. In addition to these constraints, a regularization procedure is applied as described in Hastie, Tibshirani and Friedman (2001).

We have therefore seen that during its learning, a regression tree must select at each step an explanatory variable from the available set and it chooses the one that leads to the greatest decrease in the sum of the error squares. We will therefore choose the variable that is most discriminating towards the explained variable and, hence, in a certain way most relevant given the initial subset. Due to the recursive nature of the process, a variable may not be relevant on the initial set but may become relevant on a subset. In this case, the tree highlights an interaction between variables, in fact, the second variable owes its relevance to the fact that the sample was separated into two subsets *via* another variable in the previous step. Since at each step a variable is selected and a decrease in the sum of the residue squares results, it is possible to simply measure the importance of a variable by summing the different error reductions obtained through it. Indeed, it is possible that this variable was chosen at different stages of the tree, it will then have strongly contributed to the reduction of the sum of the error squares. On the contrary, some variables may not have been chosen, in which case their measure of importance will be zero.

Although simple and intuitive, regression trees have important limitations. First and foremost, due to their construction, they lack continuity in their prediction and will therefore have great difficulty in capturing additive and linear shapes. On the other hand, the recursive process of tree construction is the source of a large variance in its predictions. Indeed, if the initial sample is somewhat modified and the first variable chosen is not the same, then the two subsets will

be different and all the subsequent steps will be affected, resulting in a potentially large modification of the predicted values. To fill this gap, the Random Forest method was introduced by Leo Breiman (2001). This method consists of estimating a large number of trees that were learned each time on a random sub-sample of the total sample. In addition, at each variable selection step, the variable is selected from a random subset of explanatory variables. The final prediction is simply the average of the values predicted by all the trees. This procedure minimizes the variance of the prediction while maintaining the bias constant. In addition, it also smoothes the prediction and thus allows to be better able to approximate the additive forms. It is always possible to construct a measure of importance for each of the variables based on the method described above but averaging over all trees. In general, and this will be the case in the future, the significance measure is normalized so that the sum on all variables equals 100.

Random forest models therefore have many advantages, first of all their non-parametric character allows them great flexibility and can thus take into account the effects of non-linearity and interaction between variables. To date, they are among the algorithms with the best predictive performance outside the sample. Second, their construction results in a variable selection sequence that can be used to construct a variable importance measure that is increasingly used in current research.

Measurement of marginal effects

Once our main determinants have been selected, we measure their effects in several ways, both from traditional spatial econometric models⁵ but we will also exploit the results obtained by the random forest model by calculating the associated partial dependence functions (Friedman, (2001)).

5. The reader is referred to Chapter 3 for a detailed exposure of these different models

Since the random forest model is non-parametric and algorithmic, it is not possible to obtain the marginal effect of a variable by a simple coefficient, the partial dependence functions make it possible to measure the modification of the predicted variable induced by the modification of a variable explained as follows. Note \hat{f} the function, obtained by learning a random forest, which has an explanatory variable vector associated with a prediction on the explained variable. Of course it is not possible to obtain a simple analytical form for this function and it is *a priori* difficult to evaluate the effect of a variable modification x_j on the prediction $\hat{f}(\mathbf{x})$, especially since the variables interact so that the effect of x_j on the quantity $\hat{f}(\mathbf{x})$ depends on the value taken by x_j but also on the values taken by the other explanatory variables. The principle of partial dependency functions is to select a variable x_j and consider the function $\hat{f}(x_j, \mathbf{x}_{-j})$ whose variables \mathbf{x}_{-j} are fixed. This function can be calculated numerically by varying the variable x_j and calculating the response obtained each time. This function therefore gives us graphically the link between the variables x_j and y for a given vector \mathbf{x}_{-j} , it is then sufficient to take the expected value on the vector \mathbf{x}_{-j} :

$$\text{PD}(x_j) = \int \hat{f}(x_j, \mathbf{x}_{-j}) p(\mathbf{x}_{-j}) d\mathbf{x}_{-j} \quad (4.47)$$

The empirical counterpart of equation (4.47) is simply to take the average within the initial sample:

$$\text{PD}(x_j) = \frac{1}{N} \sum_i \hat{f}(x_{i,j}, \mathbf{x}_{i,-j}) \quad (4.48)$$

This method therefore gives access to the average effect of the variable x_j on the predicted value $\hat{f}(\mathbf{x})$, this average effect is a function dependent on the variable x_j and will therefore be analyzed graphically. We will then be able to confirm where to invalidate the marginal effects identified by spatial models (SAR, SMA or SARMA).

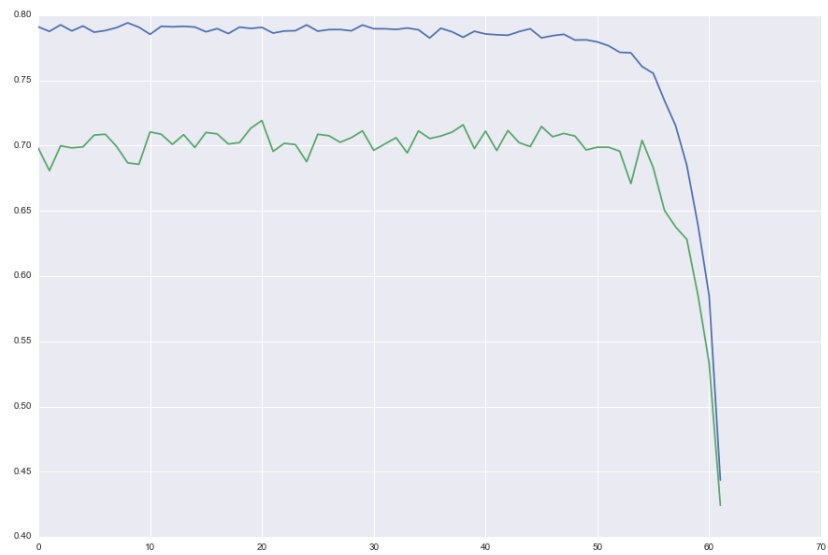
4.5 Results

As we mentioned in the methodological section, our approach consists of two steps. First of all, we identify the main determinants of income level using the variable selection method described above. Second, we regress the variation in the local coefficient of variation of income on changes in the means and standard deviations of the main determinants. The next two subsections therefore present the results obtained in step one and step two respectively.

The main determinants of income

All our explanatory variables are observed between 2006 and 2012, with the exception of variables relating to the sectors of activity (agriculture, construction, etc.) and the number of jobs in the export and basic sectors. Indeed, these variables are only available for 2009, so we choose this year to identify the main determinants of income in terms of level. We have 61 explanatory variables to which we add the endogenous variable, the spatially delayed income level. We therefore have 62 explanatory variables and as many regressions to perform from a random forest model in order to select the most important variables in determining income. As already explained in the previous section, at each regression, the variable with the lowest importance measure is deleted. The model parameters are set so as to allow a good fit while having a relatively short computation time since 62 models must be estimated. The number of trees in each forest is 5, the depth of the trees is limited to more than 9 and each subset should contain at least 10 observations. Figure 4.5 illustrates the importance of the explanatory variables at the initial stage of the procedure, i.e., when all the explanatory variables are present. A small number of variables has a major role (pop 15 years or more Executives and Intel Prof. ; pop 15 years or more Intermediate Prof. ; Employees 15 years or more permanent contract ; Non-Employees 15 years or more ; density), on the contrary, a large number of variables seem to have no importance. This is confirmed by Figure 4.6 which shows the performance of the

FIGURE 4.6 – R^2 evolution according to the number of variables

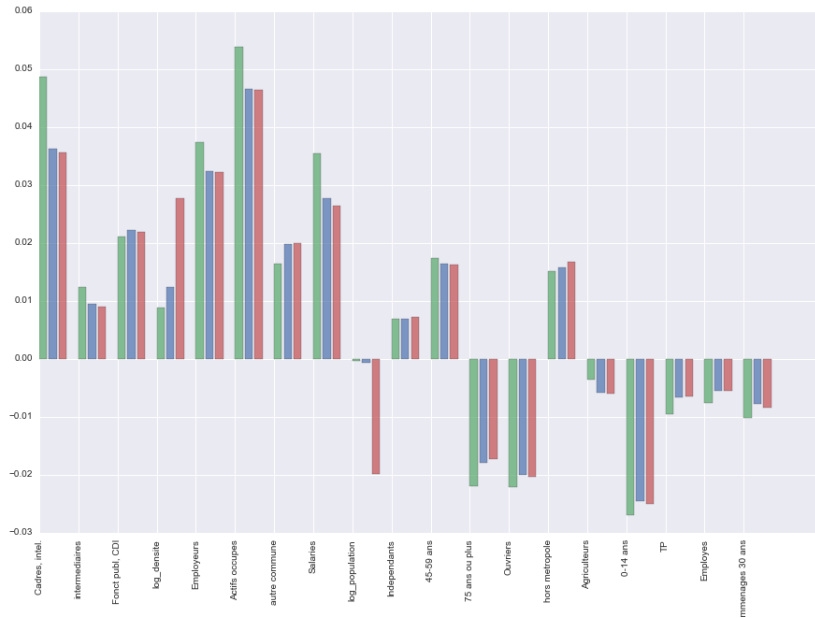


Blue: in sample. green: out sample.

the proportion of employees on permanent contracts also play a relatively important role. We also note that worker mobility plays a role in determining income *via* the proportion of employed workers working outside their municipality of residence and the proportion of employed workers working abroad. The demographic structure also appears within the variables retained through density, total population and age structure (population in 0-14 years, population between 45-59 years and population over 75 years). Finally, it is interesting to note the total absence of variables relating to the productive structure of the territory, whether in terms of sector or export. The position in terms of human capital seems to be very important without this interacting with belonging to a sector or an exporting territory. Thus, it does not matter whether you are a manager in logistics or in research as long as you are a manager. In addition, territories whose productive structure is mainly devoted to serving the local population have on average incomes equivalent to those of more exporting territories. We have already explained this phenomenon by the fact that the population does not necessarily declare the added value (*via* wages and capital income) where it was created as a result of commuters and capital mobility. Thus, a territory wishing to increase the income declared within it must not necessarily focus on its productive structure but rather on the socio-demographic structure of its population. In particular, we highlight the influence of human capital as an explanatory factor of income since the proportion of managers and intellectual professions refers to a population whose levels of education are generally high compared to the rest of the population. Thus, any socio-demographic convergence of territories should result in income convergence, however, the inertia of these determinants is significant in the short term. We will see later that the most important determinants in explaining the dynamics of inequality between 2001 and 2014 will not necessarily be the same.

The previous analysis is based on a snapshot of 2009, as we have already mentioned, this year's choice is due to the fact that we have a larger number of variables. However, we have seen that the variables related to the productive structure played no role in determining income and

FIGURE 4.8 – Marginal effects



Green: OLS. Blue: SMA. Red: SARMA

relationship between the dependent variable and the explanatory variables. While the random forest model had an out-of-sample R^2 of slightly above 0.70, we will see that the linear model achieves comparable predictive performance, although very slightly lower. We first estimate a simple OLS model to perform a spatial diagnosis from the residues, then we estimate SMA and SARMA models.⁶ Table 4.3 groups the results of the different specifications. Errors from simple regression are highly spatially correlated and we focus on the results from the SMA and SARMA specifications.

All variables are significant except for the proportion of self-employed. The explanatory variables are all centred down and the variable explained is log income, so the interpretation

6. See Chapter 3 for a detailed explanation of the methodology associated with spatial models.

| | model | | |
|---------------------------------|--------------|------------|-------------|
| | OLS | SMA (Gmm) | SARMA (Gmm) |
| Constant | 9.78*** | 9.78*** | 9.73*** |
| managers and intellectual prof. | 0.0488*** | 0.0363*** | 0.0356*** |
| intermediate prof. | 0.0412*** | 0.0094*** | 0.0090*** |
| permanent contract | 0.0211*** | 0.0222*** | 0.0219*** |
| log(density) | 0.0089*** | 0.0125*** | 0.0278*** |
| employers | 0.0374*** | 0.0324*** | 0.0322*** |
| employed workers | 0.0538*** | 0.0467*** | 0.0464*** |
| work another municipalities | 0.0164*** | 0.0198*** | 0.0200*** |
| salaried | 0.0354*** | 0.0277*** | 0.0264*** |
| log(population) | -0.0004 | -0.0006 | -0.0197*** |
| self-employed | 0.0069*** | 0.0070*** | 0.0072*** |
| 45-59 years | 0.0174*** | 0.0165*** | 0.0163*** |
| 75 years or older | -0.0220*** | -0.0178*** | -0.0173*** |
| workers | -0.0221*** | -0.0200*** | -0.0203*** |
| wokers abroad | 0.0151*** | 0.0158*** | 0.0168*** |
| farmers | -0.0035*** | -0.0058*** | -0.0059*** |
| 0-14 years | -0.0269*** | -0.0245*** | -0.0251*** |
| part-time workers | -0.0094*** | -0.0066*** | -0.0064*** |
| employees | -0.0075*** | -0.0055*** | -0.0054*** |
| moved 30 years or more | -0.0102*** | -0.0077*** | -0.0084*** |
| λ | | 0.0813 | 0.0814 |
| ρ | | | 0.0010*** |
| R^2 | 0.705 | | |
| pseudo- R^2 | | 0.70 | |
| N | 29419 | 29419 | 29419 |
| Moran index | 0.266*** | | |
| LM (lag) | 0.359 | | |
| LM (error) | 5585.57*** | | |
| LM (SARMA) | | 5586.35*** | |

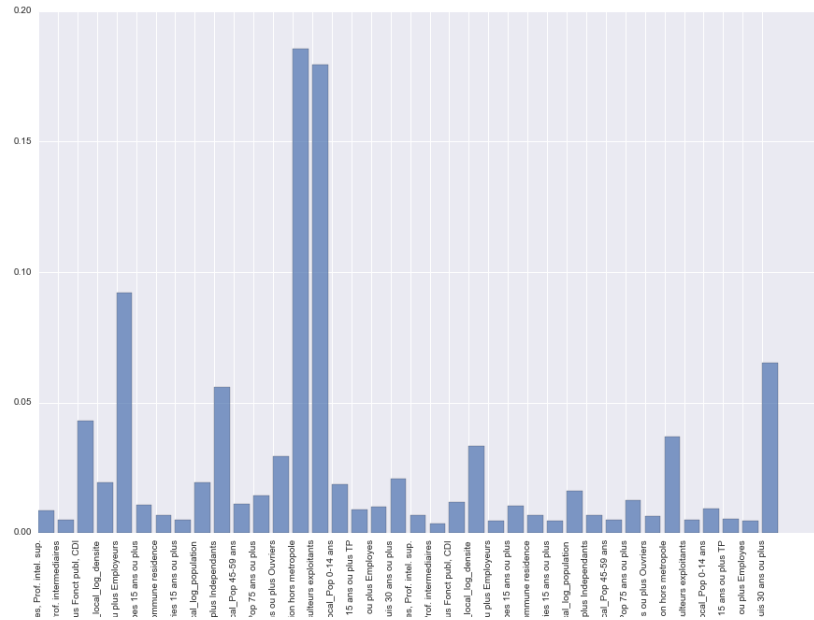
TABLE 4.3 – Estimation results of OLS, SMA and SARMA models. This table shows the results of the estimates according to three specifications: OLS, SMA, SARMA. The SMA and SARMA specifications are estimated using the generalized method of moments. ***: Significance at 1%. LM denotes the Lagrange multiplier tests as described in Chapter 3 Subsection 3.3.2.

of the coefficients is as follows: a deviation from the mean by one standard deviation of the variable k results in a higher income $\beta_k \times 100\%$, all other things being equal. So we see, for example, that if the share of managers and professionals increases by one standard deviation then the income is 3.69% higher. Figure 4.8 graphically illustrates the marginal effects obtained, the latter are relatively logical. Naturally, the proportion of executives, middle professionals, permanent employees and employed workers has a positive effect on income. On the contrary, a high proportion of workers and farmers is associated with lower incomes. The demographic structure also shows the expected results, with higher income in municipalities with a high proportion of 45-59 years old and lower income in municipalities with a high proportion of 0-14 years old and over 75 years old. It is also noted that income is higher for municipalities with a high population density and therefore within cities. Finally, it is interesting to note that the mobility of workers impacts income, the more inhabitants a municipality has working outside the municipality and the higher the income, the greater the effect is if its inhabitants work outside metropolitan France. In this sense, territories that are highly open to the labour market have higher incomes.

4.5.1 Determinants of convergence

We seek to explain local income convergence based on the variation in the mean and standard deviation of each of the explanatory variables highlighted in the previous section. We use both a linear model and a random forest model, the latter, as a non-parametric model, being much more flexible than a linear model. However, as we have explained in the methodology section, we must expect a highly non-linear relationship. We confirm this by the out-of-sample performance of the two models, in fact, the linear model shows a R^2 of 0.44 against a R^2 of 0.65 for the random forest model. We are therefore relatively good at predicting the level of local income convergence and are therefore able to explain, in part, why some geographical areas experience a high level of convergence between their municipalities while others do not. Since the random

FIGURE 4.9 – Variable importance



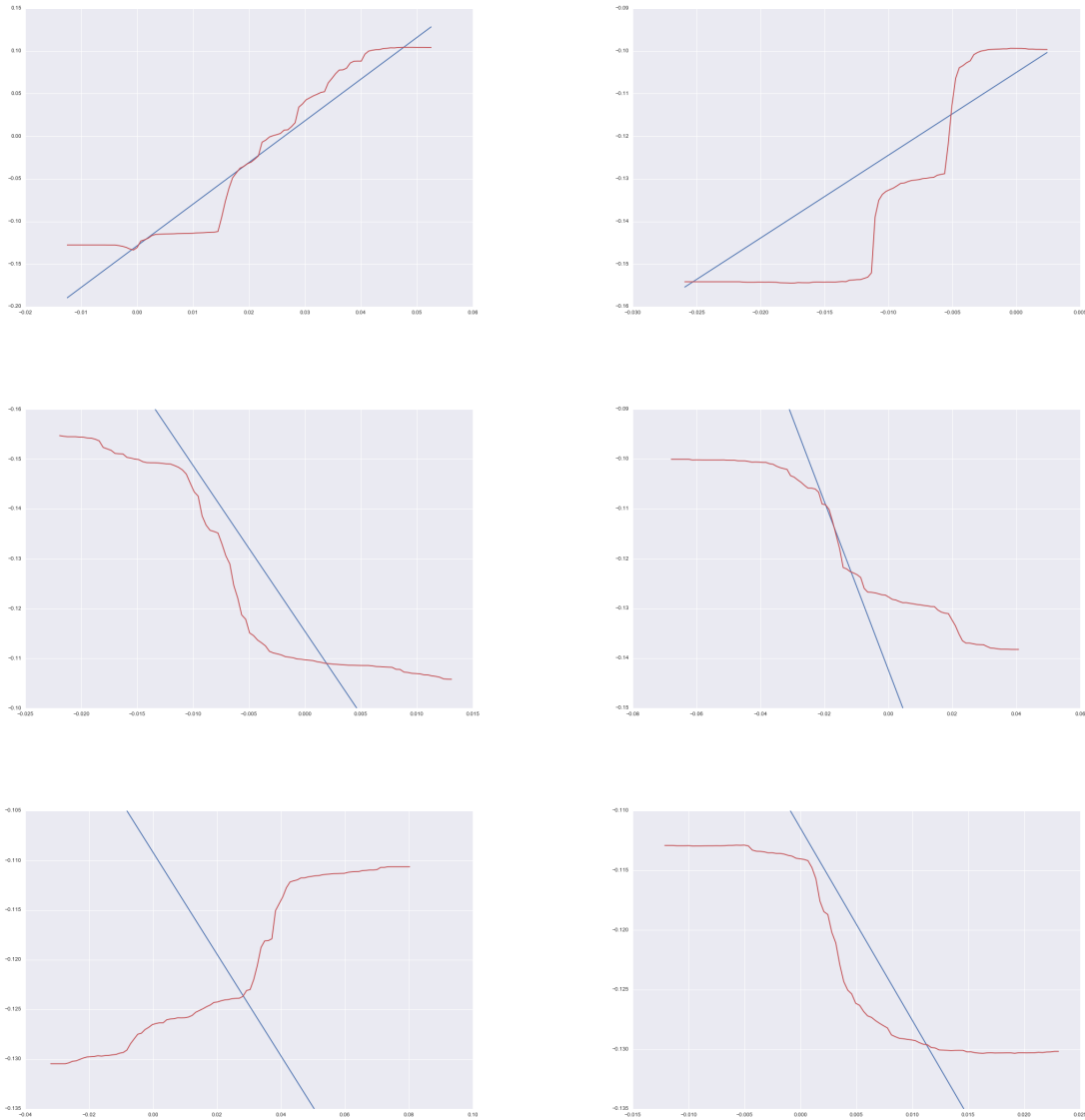
forest model is non-parametric, it is not possible to simply summarize the results obtained, but again we use the importance measure of variables to isolate the main determinants of convergence. We then use the partial dependency functions mentioned in the methodology section.

Figure 4.9 graphically illustrates the measure of importance of the variables and it can be seen that two variables stand out very clearly: the variation in the average proportion of the population working outside metropolitan France and the variation in the average proportion of farmers. We also note the importance of the variation in the average proportion of employers and self-employed workers, the variation in the standard deviation of the proportion of households that have been in place for 30 years or more seems to be an important variable too. It is interesting to analyse these levels of importance with Figure 4.10 where the partial dependency

functions are represented. This graphical representation allows us to evaluate marginal effects in terms of both magnitude and linearity, we review the six main variables:

1. We observe that the higher the variation of the proportion of people working abroad, the less the coefficient of variation has decreased over the period, reflecting a lower level of convergence. We have a relatively linear relationship and magnitude is very important: geographical areas whose proportion of inhabitants working abroad has not increased record, on average, a decrease in the coefficient of variation of more than 10% while an increase in the proportion of inhabitants working abroad of 5 percentage points is associated with an increase in the coefficient of variation of more than 10%. Thus we move from a situation of convergence to a situation of divergence when the proportion of inhabitants working abroad increases beyond 2.5 percentage points. A +5 differential in the change in the number of people working abroad leads to a +20 percentage point differential in the rate of change in the CV (coefficient of variation), i.e., an average effect of 4 percentage points less for each unit of change in addition to the number of people working abroad. Nevertheless, it should be noted that the effect is not totally linear and only begins with an increase in the ratio of inhabitants working abroad of more than 1 percentage point.
2. The change in the proportion of farmers is negatively related to convergence, i.e., geographical areas that recorded a decrease in the proportion of farmers also recorded, on average, a greater decrease in the CV. Figure 4.10 shows a strong non-linearity effect and we see that the explanatory variable acts at certain thresholds outside which the marginal effect is zero. We can still calculate the average effect on the $[-0.15, 0]$ interval, we note that a 1.5 percentage point decrease in the proportion of farmers results in a 5 percentage point decrease in the rate of change in the CV, or an average marginal effect slightly greater than 3. The magnitude of the effect is therefore half as large as the previous variable, and it is also valid over a much smaller interval.
3. The change in the proportion of employers is positively related to convergence, so terri-

FIGURE 4.10 – Partial dependence function



(1,1): cross-border workers mean variation. (1,2): farmers mean variation. (2,1): moved 30 years or more standard deviation variation. (2,2): employers mean variation. (3,1): self-employed mean variation. (3,2): permanent contract mean variation. Red: Random forest partial dependence function. Blue: Linear model partial dependence function.

tories that experienced a greater change in the proportion of employers also experienced a greater decrease in the CV. Here again, the effect is not completely linear, on average an 8 percentage point increase in the proportion of employers leads to a 4 percentage point decrease in the CV growth rate, i.e., an average effect of 0.5 percentage points. In addition, because of non-linearity, this average effect is approximately valid only on the interval $[-0.04, 0.04]$. The effect of this variable is therefore relatively small.

4. The change in the proportion of self-employed workers is negatively related to the level of convergence. The effect is also non-linear, but we can summarize it as follows: a 7 percentage point increase in the proportion of self-employed workers is associated with a 2 percentage point increase in the rate of change in the CV. The effect is therefore very small and only valid on the interval $[-0.02, 0.05]$.
5. We observe a positive relationship between the change in the proportion of employment on permanent contracts and the level of convergence. Here again, the relationship is non-linear since the effect of the explanatory variable occurs exclusively on the interval $[0, 0.015]$ and outside this interval the effect is nil. The average marginal effect on the $[0, 0.015]$ interval is -1.5 percentage points.
6. Finally, the variation in the standard deviation of the proportion of inhabitants who moved in more than 30 years ago has a positive relationship with convergence. That is to say, the territories where the municipalities have diverged in terms of the seniority of the inhabitants have experienced lower rates of change in the CV. But here again, the effect is relatively small and only valid over a limited interval (2.6 of percentage on average over the $[-0.015, 0]$ interval).

Our results show that one variable stands out very largely from the others in terms of marginal effect, namely the variation in the proportion of the number of inhabitants working abroad. This variable therefore appears to be decisive in order to understand the differences in convergence observed throughout France. Thus, even if our set of variables is relatively efficient in its predictive capacity, the marginal effects of the variables taken one by one are relatively small

compared to the effect of a change in the proportion of people working abroad. In addition, the majority of these effects are only valid over a sub-interval and cannot be extended to the full interval comprising the 99% of the sample. We will therefore subsequently focus on the main variable, in terms of marginal effect, highlighted in this subsection.

4.5.2 Interpretation of results

We have seen that territories that experienced an increase in the proportion of people working abroad over the period 2006-2012 also experienced lower levels of convergence. We found that an increase in the proportion of people working abroad by more than 2.5 points was associated, on average, with a positive CV growth rate, i.e., a divergence phenomenon. Thus, as we have already mentioned in the literature review, the location of economic agents is not the only determinant when it comes to explaining inequalities between territories and their dynamics. The fact that we work on small entities such as French municipalities implies other effects, in particular the fact that the income of a territory does not only depend on its ability to produce added value but also on its ability to capture the added value produced abroad. Our results therefore clearly highlight this last effect, since residents working abroad will capture added value produced outside the territory where they live. We then observe in Table 4.4 that territories whose number of inhabitants working abroad has increased have experienced higher income growth rates but have also further increased the standard deviation of incomes between municipalities within the territory. The increase in the rate of income growth tends to decrease the coefficient of variation while the rise in the standard deviation tends to increase it. Here, the second effect prevails over the first, although incomes that have increased on average, the increase in the standard deviation overcompensate for this first effect, leading to an increase in the CV and therefore to a divergence phenomenon for these territories.

The particularity of geographical areas that have seen a sharp increase in the number of people

| | cross-border workers | Δ income mean | Δ income std | Δ income CV |
|----------------------|----------------------|----------------------|---------------------|--------------------|
| cross-border workers | 1 | | | |
| Δ income mean | 0.376 | 1 | | |
| Δ income std | 0.491 | -0.016 | 1 | |
| Δ income CV | 0.351 | -0.288 | 0.961 | 1 |

TABLE 4.4 – Descriptive statistics

working abroad is that they have a better economic integration within the European area. However, we have found a similar effect in the literature, with countries with high rates of openness and economic integration showing greater spatial inequalities (Hirte et Lessman (2014); Ezcurra et Rodriguez-Pose (2013); Lessman and Seidel (2015)). Economic integration therefore offers new employment opportunities and therefore income growth. However, some municipalities may be better able to benefit from this economic integration because of the structure of the population that composes them or because of their geographical location, which makes it easier for them to access foreign jobs, thus increasing inequalities between municipalities located within geographical areas where the average proportion of inhabitants working abroad has increased. In this case, we find here a classic trade-off in development economics, openness and economic integration will generate territorial inequalities because not all of them have the same capacity to take advantage of the growth opportunities offered by economic integration. Thus, we will observe some zones of economic divergence between municipalities belonging to territories close to borders. In addition, multiplier effects can accentuate the initial effect insofar as municipalities capturing external value added by their inhabitants working abroad will benefit from greater domestic demand due to the increase in income, which will then stimulate local economic activity and once again impact the income of these same municipalities on the rise. This may even have a negative effect on municipalities that do not benefit from external income, within them the local economic activity may deteriorate due to the displacement of firms to

meet the new demand from municipalities benefiting from external income. It should also be noted that our sample contains the 2008 economic crisis, and we have seen that convergence was slowing down at the time of the crisis. We can therefore expect that these differences in the ability to capture external income between municipalities will be all the more significant in times of crisis. Indeed, the fact of having access to a larger labour market for the inhabitants of certain municipalities that are particularly well integrated within the geographical and economic space, gives them a greater capacity for resilience to recessions but contribute to increasing inequalities between municipalities.

4.6 Conclusion

At the end of Chapter 3 we showed that the convergence phenomenon had to be studied on several scales. Indeed, the global convergence between French municipalities masked very different situations at the local level where we observed both areas of convergence and areas of non-convergence. We also highlighted that this phenomenon of spatial heterogeneity of convergence could not be fully explained by the spatial heterogeneity of the levels of income and the fact that convergence was stronger for the municipalities at the bottom of the income distribution. These results in terms of spatial heterogeneity therefore gave us the opportunity to try to understand and identify the determinants of convergence. During this chapter, we have highlighted an important determinant that allows us to partly explain the spatial heterogeneity of convergence, namely the ability of a municipality to capture added value through its inhabitants working abroad. The importance of this variable also tells us about the importance of economic integration as a determinant of spatial inequalities. In this sense, we confirm, on a finer scale, a result already observed at the country level. Territories with better access to external markets benefit from higher growth rate of average income, however, on the other hand they face increasing inequalities leading to divergence between the municipalities making up them.

4.7 Bibliography

Abdel-Rahman, Hesham, and Masahisa Fujita. "Product variety, Marshallian externalities, and city sizes." *Journal of regional science* 30.2 (1990): 165-183.

Amos Jr, Orley M. "Unbalanced regional growth and regional income inequality in the latter stages of development." *Regional Science and Urban Economics* 18.4 (1988): 549-566.

Barrios, Salvador, and Eric Strobl. "The dynamics of regional inequalities." *Regional Science and Urban Economics* 39.5 (2009): 575-591.

Breiman, Leo. "Random forests." *Machine learning* 45.1 (2001): 5-32.

Brühlhart, Marius. "The spatial effects of trade openness : a survey." *Review of World Economics* 147.1 (2011): 59-83.

David, Paul A., and Joshua L. Rosenbloom. "Marshallian factor market externalities and the dynamics of industrial localization." *Journal of urban Economics* 28.3 (1990): 349-370.

Deng, Houtao, and George Runger. "Gene selection with guided regularized random forest." *Pattern Recognition* 46.12 (2013): 3483-3489.

Ezcurra, Roberto, and Manuel Rapún. "Regional disparities and national development revisited : The case of Western Europe." *European Urban and Regional Studies* 13.4 (2006): 355-369.

Ezcurra, Roberto, and Andrés Rodríguez-Pose. "Does economic globalization affect regional

inequality ? A cross-country analysis." *World Development* 52 (2013): 92-103.

Friedman, Jerome H. "Greedy function approximation: a gradient boosting machine." *Annals of statistics* (2001): 1189-1232.

Friedman, Jerome, Trevor Hastie, and Robert Tibshirani. *The elements of statistical learning*. Vol. 1. No. 10. New York: Springer series in statistics, 2001.

Gauthier, Bernard, Alain Lapointe, and Frédéric Laurin. "Les économies d'agglomération et la croissance des régions dans l'union européenne." *Revue d'Economie Regionale Urbaine* 2 (2003): 209-234.

Genuer, Robin, Jean-Michel Poggi, and Christine Tuleau-Malot. "Variable selection using random forests." *Pattern Recognition Letters* 31.14 (2010): 2225-2236.

Glaeser, Edward L. "Cities, information, and economic growth." *Cityscape* 1.1 (1994): 9-47.

Gregorutti, Baptiste, Bertrand Michel, and Philippe Saint-Pierre. "Grouped variable importance with random forests and application to multiple functional data analysis." *Computational Statistics and Data Analysis* 90 (2015): 15-35.

Gylfason, Thorvaldur. "Resources, agriculture and economic growth in economies in transition." (2000).

Haaparanta, Pertti. "Regional concentration, trade, and welfare." *Regional Science and Urban Economics* 28.4 (1998): 445-463.

- Hapfelmeier, Alexander, and Kurt Ulm. "A new variable selection approach using random forests." *Computational Statistics and Data Analysis* 60 (2013): 50-69.
- Henderson, J. Vernon. "Systems of cities in closed and open economies." *Regional Science and Urban Economics* 12.3 (1982): 325-350.
- Hirte, Georg, and Christian Lessmann. "Trade, integration, and interregional inequality." (2014).
- Hoyt, Homer. "Homer Hoyt on development of economic base concept." *Land Economics* 30.2 (1954): 182-186.
- Isard, Walter. "Interregional and regional input-output analysis : a model of a space-economy." *The review of Economics and Statistics* (1951): 318-328.
- Kelly, Morgan, and Anya Hageman. "Marshallian externalities in innovation." *Journal of economic growth* 4.1 (1999): 39-54.
- Krugman, Paul. "Increasing returns and economic geography." *Journal of political economy* 99.3 (1991): 483-499.
- Krugman, Paul, and Raul Livas Elizondo. "Trade policy and the third world metropolis." *Journal of development economics* 49.1 (1996): 137-150.
- Kuznets, Simon. "Economic growth and income inequality." *The American economic review*

45.1 (1955): 1-28.

Leontief, Wassily W. "Quantitative input and output relations in the economic systems of the United States." *The review of economic statistics* (1936): 105-125.

Lessmann, Christian. "Spatial inequality and development—Is there an inverted-U relationship?." *Journal of Development Economics* 106 (2014): 35-51.

Lessmann, Christian, and André Seidel. "Regional inequality, convergence, and its determinants—A view from outer space." *European Economic Review* 92 (2017): 110-132.

Mayer, Christopher, and Todd Sinai. "Network effects, congestion externalities, and air traffic delays : Or why not all delays are evil." *American Economic Review* 93.4 (2003): 1194-1215.

Miyazawa, Kenichi. *Input-output analysis and the structure of income distribution*. Vol. 116. Springer Science and Business Media, 2012.

Moore, Frederick T. "Regional economic reaction paths." *The American Economic Review* 45.2 (1955): 133-148.

North, Douglass C. "Location theory and regional economic growth." *Journal of political economy* 63.3 (1955): 243-258.

Rauch, James E. *Economic development, urban underemployment, and income inequality*. No. w3758. National Bureau of Economic Research, 1991.

Rodríguez-Pose, Andrés, and Nicholas Gill. "How does trade affect regional disparities ?." *World Development* 34.7 (2006): 1201-1222.

Sachs, Jeffrey D., and Andrew M. Warner. "The curse of natural resources." *European economic review* 45.4-6 (2001): 827-838.

Stiglitz, Joseph. "Growth with exhaustible natural resources : efficient and optimal growth paths." *The review of economic studies* 41 (1974): 123-137.

Tiebout, Charles M. "The urban economic base reconsidered." *Land Economics* 32.1 (1956): 95-99.

Tiebout, Charles M. "Regional and interregional input-output models : an appraisal." *Southern Economic Journal* (1957): 140-147.

Van der Ploeg, Frederick. "Natural resources : curse or blessing?." *Journal of Economic Literature* 49.2 (2011): 366-420.

Venables, Anthony J. "Economic integration and the location of firms." *The American economic review* 85.2 (1995): 296-300.

Villar, Olga Alonso. "Spatial distribution of production and international trade : a note." *Regional science and Urban economics* 29.3 (1999): 371-380.

Williamson, Jeffrey G. "Regional inequality and the process of national development : a description of the patterns." *Economic development and cultural change* 13.4, Part 2 (1965): 1-84.

Zhang, Xiaobo, and Kevin H. Zhang. "How does globalisation affect regional inequality within a developing country ? Evidence from China." *Journal of Development Studies* 39.4 (2003): 47-67.

4.8 Appendix

List of explanatory variables

1. Demography (total population, pop. 0-14 years, pop. 15-29 years, pop. 30-44 years, pop. 45-59 years, pop. 60-74 years and pop. 75 years or older). Observed from 2006 to 2014. Source: INSEE.
2. Socio-professional category (pop. 15 years or more farmers, pop. 15 years or more business managers, pop. 15 years or more managers and intellectual profession, pop. 15 years or more intermediate profession, pop. 15 years or more employees, pop. 15 years or more workers, pop. 15 years or more pensioners). Observed from 2006 to 2014. Source: INSEE.
3. Type of employment contract (employed workers 15 years or more, employees 15 years or more, non-salaried 15 years or more, employed workers 15 years or more part-time, employees 15 years or more part-time, employees 15 years or more public office, permanent contract, employees 15 years or more fixed-term contract, employees 15 years or more interim, employees 15 years or more assistant jobs, employees 15 years or more apprenticeship Internship, non-salaried 15 years or more self-employed, non-salaried earners 15 years or more employers, non-salaried earners 15 years or more caregivers). Observed from 2006 to 2014. Source: INSEE.
4. Work place (Working people 15 years or more work in municipalities residence, Working people 15 years or more work in another municipalities than in municipalities residence,

Working people 15 years or more work in another "départements", Working people 15 years or more work in another "région", Working people 15 years or more work in another country). Observed from 2006 to 2014. Source: INSEE.

5. Work sector (public administration, agriculture and fisheries, construction and public works, business-to-business trade, design and research, culture and leisure, distribution, education, maintenance, manufacturing, management, transport and logistics, intellectual services, health and social work, community services) Observed from 2006 to 2014. Source: INSEE.
6. Moving date (households moved in less than 2 years, households moved in between 2-4 years, households moved in between 5-9 years, households moved in between 10 years or more, households moved in between 10-19 years, households moved in between 20-29 years, households moved in between 30 years or more). Observed from 2006 to 2014. Source: INSEE.

Chapitre 5

Conclusion générale

Les objectifs définis en introduction étaient d'analyser les mécanismes économiques engendrant des disparités de revenu à la fois temporelles et spatiales et d'identifier les moyens d'y remédier. Nous avons vu que ces deux types de disparités de revenu impliquaient des risques en termes de cohésion politique entre territoires, en particulier lorsque ces derniers forment une union monétaire et budgétaire. Nous souhaitons alors expliquer l'émergence de ces disparités de revenu et proposer des politiques publiques dans le but de les atténuer.

Au sein du premier chapitre (Chapitre 2) nous avons mis en évidence, grâce à l'évaluation des multiplicateurs budgétaires, que les disparités de revenu temporelles pouvaient être contre-carrées en recourant à une politique budgétaire adaptée. Cependant, l'intervention publique n'est pas sans risque puisque selon le contexte économique au sein duquel la politique budgétaire prend place, l'effet de cette dernière peut-être contreproductif. En particulier, nous avons montré que le recours aux politiques de consolidation budgétaire en période de récession économique pouvait, vraisemblablement, conduire à une dégradation du ratio de dette publique.

L'analyse des disparités de revenu à échelle fine n'a fait l'objet que de très peu d'études au sein

de la littérature et aucune d'entre elles n'a été réalisée dans le cas de la France. Le deuxième chapitre (chapitre 3) fut donc consacré à la mesure et à la caractérisation du phénomène de convergence spatiale à une échelle fine dans le cas du territoire métropolitain français. Nous avons alors montré que s'il existait bien une convergence en moyenne sur l'ensemble des communes de France, ce processus révélait des propriétés plus complexes et ne pouvait pas se résumer à une simple vitesse de convergence partagée par l'ensemble des communes. Premièrement, la convergence s'effectue de manière non-linéaire en profitant davantage aux communes situées en bas de la distribution des revenus, et deuxièmement, le processus de convergence apparaît de manière très hétérogène sur le territoire français. Nous avons relevé des lieux où la convergence était forte alors qu'à d'autres endroits elle pouvait être très faible, nous avons même pu mettre en évidence des situations de divergence. Ainsi, malgré une convergence globale, il subsiste des zones géographiques au sein desquelles les inégalités entre les communes augmentent. Ce constat est préoccupant quant aux risques de cohésion sociale et politique que nous avons décrits en introduction, l'augmentation des inégalités à long terme au sein d'un territoire étant une source de tension à la fois pour les populations, mais également pour la politique budgétaire qui doit recourir de plus en plus à la péréquation. Ainsi, et contrairement à ce qui avait été produit jusqu'à présent au sein de la littérature, nous avons caractérisé le processus de convergence à une échelle fine, nous donnant accès à une plus grande précision. Cela nous a permis de mettre en évidence une hétérogénéité qui était difficilement observable à grande échelle. Ce résultat seul peut difficilement être à l'origine de politiques publiques car il suscite d'autres questions. En particulier, pourquoi observe-t-on des niveaux de convergence si différents à travers le territoire ? Et quels sont les déterminants encourageant ou freinant la convergence ?

Le troisième chapitre (chapitre 4) fut donc naturellement dédié à la résolution des questionnements soulevés par le deuxième chapitre. Nous avons dans un premier temps étudié les déterminants du revenu des communes et conclu à la grande pertinence des caractéristiques socio-

professionnelles d'un territoire plutôt qu'à ses propriétés en termes de structure productive. Nous avons ensuite mis en évidence que l'une des principales explications à l'hétérogénéité du phénomène de convergence au sein du territoire français était la différence d'accessibilité des zones géographiques aux différents marchés extérieurs. En effet, les territoires ayant enregistré un nombre croissant d'habitants travaillant à l'étranger ont également connu une plus faible réduction d'inégalités et, dans certains cas, une hausse de celles-ci. Cependant, ces mêmes territoires ont également connu, en moyenne, un taux de croissance de leur revenu plus élevé. Ces résultats confirment des constats déjà effectués à des échelles géographiques plus importantes dans la littérature et révèlent que l'arbitrage entre l'intégration économique et les inégalités spatiales est valable au sein même des pays. Là encore, nous révélons des enjeux de cohésion pouvant survenir au sein de l'Union Européenne car si le renforcement de l'intégration économique peut encourager la croissance économique et conduire à une réduction des inégalités entre les pays, cela ne garantit pas une diminution des inégalités à toutes les échelles. En particulier, l'ouverture économique peut exacerber les inégalités à échelle fine à l'intérieur des pays dans la mesure où elle renforce l'asymétrie des territoires dans leur positionnement géographique et leur capacité à profiter de l'intégration économique du fait des différences de caractéristiques en termes de population et de structure productive. S'il serait sûrement hâtif de vouloir prescrire des recommandations de politiques économiques à partir des résultats obtenus, nous pouvons tout de même mettre en avant le risque que représente une ouverture économique rapide et importante sans être accompagnée de politiques publiques afin de soutenir les territoires les moins à même de profiter de l'intégration économique.

Ainsi, nous avons produit au cours de cette thèse un certain nombre de résultats nous renseignant sur l'état actuel des disparités temporelle et spatiale de revenu en France. Nous avons pu dégager des recommandations de politiques publiques claires dans la gestion des disparités de revenu temporelles à travers l'identification des moments opportuns dans le recours aux différentes politiques budgétaires. Notre analyse des disparités spatiales s'est davantage concentrée

sur la caractérisation du phénomène de convergence à échelle fine et l'identification de ses déterminants dans le cas français, ces deux étapes étant essentielles avant toute analyse centrée plus spécifiquement sur l'évaluation des politiques publiques locales. En effet, la littérature nous offrait peu d'études sur l'analyse des inégalités entre villes et, à notre connaissance, aucune pour le cas français. Il était donc primordial de bien définir les propriétés du processus de convergence et les principaux facteurs impactant la dynamique des inégalités spatiales, ce à quoi nous avons dédié nos deux derniers chapitres de thèse.

Au-delà de ces contributions, ce travail ouvre la voie pour l'étude plus spécifique des politiques publiques, à travers les effets des politiques budgétaires conduites par les collectivités territoriales locales et des politiques de péréquation opérées par l'État. Il serait alors possible d'identifier des moyens d'action contre les inégalités spatiales et d'évaluer leurs effets afin de mieux gérer l'exposition des territoires aux conséquences, parfois néfastes en terme d'inégalités, de l'intégration économique et de l'ouverture des différents marchés intérieurs. De plus nous avons mis en évidence que la gestion défailante des variations de l'activité économique dans le temps, ayant souvent comme conséquence une mauvaise gestion de la dette publique, pouvait également détériorer la cohésion territoriale à la fois à l'intérieur des pays mais également entre les pays. L'objectif serait donc, à terme, de proposer des pistes en matière de gestion des disparités de revenu temporelles et spatiales afin de renforcer la cohésion au sein de l'Union Européenne tout en bénéficiant des opportunités de développement économique rendues possibles par l'intégration économique.