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TRÊS ENSAIOS SOBRE MUDANÇA DEMOGRÁFICA E SEUS IMPACTOS NAS ECONOMIAS BRASILEIRA E GAÚCHA

Porto Alegre
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Tese a ser submetida ao Programa de Pós-Graduação em Ciências Econômicas da Universidade Federal do Rio Grande do Sul, como requisito parcial para obtenção do título de Doutor em Economia, Área de Concentração: Economia Aplicada

Orientador: Prof. Dr. Marcelo Savino Portugal

Co-Orientador: Prof. Dr. Alexandre Alves Porsse

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"Old age is the most unexpected of all things that happen to a man."
- Leon Trotsky (1879-1940)

RESUMO

O presente estudo aborda a demografia e seus impactos na economia. A redução das taxas de fecundidade e de mortalidade, acompanhadas pelo aumento da expectativa de vida da população, tiveram como consequência a queda da taxa de crescimento populacional e mudanças na estrutura etária da população brasileira. Esse fenômeno também condiciona a chamada transição demográfica, processo no qual ocorre redução na proporção de crianças e aumento na proporção de pessoas idosas na população. A literatura supõe que esse processo esteja relacionado com o crescimento econômico, de forma que regiões com menor taxa de dependência (proporção de crianças e idosos na população) devem apresentar maior crescimento econômico. Utilizando-se técnicas de análise exploratória de dados espaciais (AEDE) para Áreas Mínimas Comparáveis (AMC) e de econometria para dados em painel, foi comprovada a relação inversa entre taxa de dependência e crescimento econômico com ambas as técnicas para o Brasil. A taxa de dependência indicou que o componente infantil predomina no Brasil e que as regiões do Brasil mais desenvolvidas em termos de mudança demográfica são as Sul e Sudeste. Tanto as taxas de dependência infantil e de idosos mostraram influenciar negativamente o modelo de crescimento econômico brasileiro, contribuindo para diminuir o caráter dúbio da última taxa mediante utilização de método econométrico que corrige para o problema da endogeneidade - Gmm-*System*. Foi também investigada a influência da demografia sobre o consumo utilizando-se dados da Pesquisa de Orçamentos familiares (POF) ano base 2002-2003 para o Rio Grande do Sul, indicando que os setores máquinas e tratores, material elétrico e eletrônico, material de transportes, outras indústrias, instituições financeiras, serviços prestados às famílias e às empresas, aluguel de imóveis, administração pública e serviços privados não-mercantis, possuem um efeito positivo do envelhecimento populacional no consumo, o que podemos chamar de quebra-cabeça ao contrário do consumo na aposentadoria. Ademais, o consumo total indicou ser estável, o que parece fazer sentido, uma vez que existem também setores cujo consumo diminui com a idade. Com isso, evidenciou-se a importância da demografia tanto no crescimento econômico quanto no consumo para o Brasil e o Rio Grande do Sul, respectivamente.

Palavras-Chave: Mudança demográfica. AEDE. Crescimento econômico. Gmm-*System*. Consumo por faixa etária.

ABSTRACT

This study addresses the demography and its impact on the economy. The reduction of fertility and mortality, followed by an increase in life expectancy of the population, has resulted in a decline in population growth and changes in the age structure of the population. This phenomenon also affects the so-called demographic transition process in which there is a reduction in the proportion of children and an increase in the proportion of aged people in the population. Literature assumes that this process is related to economic growth, so that regions with lower dependency ratio (proportion of children and aged people in the population) should have higher economic growth. Using techniques of exploratory spatial data analysis (ESDA) for Minimum Comparable Areas (MCA) and of econometrics for panel data, it has been proved the inverse relationship between the rate of dependency and economic growth with both techniques for Brazil. The dependency ratio indicated that the child component predominates in Brazil and that the more developed regions of Brazil in terms of demographic change are the South and Southeast. Both rates of child and aged dependency influenced negatively the model of Brazilian economic growth, helping to reduce the dubiousness of the last rate by using econometric method that corrects for the endogeneity problem - Gmm-System. It was also investigated the influence of demography on consumption using data of the Household Budget Survey (HBS) base year 2002-2003 for Rio Grande do Sul indicating that sectors of machinery and tractors, electrical and electronic equipment, transport equipment, other industries, financial institutions, services to families and business, property rental, government and private non-market services, have a positive effect from aging on consumption, what we could call an “unlike retirement consumption puzzle”. Moreover, the complete consumption indicated to be stable, which seem to make sense, since there are also areas which consumption decreases with age. With that, the importance of demographics in both economic growth and the consumption for Brazil and Rio Grande do Sul, respectively, has been evidenced.

Keywords: Demographic change. ESDA. Economic growth. Gmm-System. Consumption by age group.

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1 INTRODUÇÃO

A palavra demografia foi utilizada pela primeira vez em 1855 pelo francês Achille Guillard no livro *Élements de statistique humaine ou demographie comparée*, cujo objetivo foi estudar a estrutura e a composição da população. A ciência da demografia, contudo, surgiu com a publicação das primeiras tábuas de mortalidade – as quais mediam o risco de mortalidade segundo a idade - por John Graunt em 1962 na sua obra Observações Naturais e Políticas (BANDEIRA, 1996). As ideias de Graunt serviram de base para a formulação das principais teorias demográficas.

De acordo com as Nações Unidas, a demografia é atualmente definida como "uma ciência que tem por objeto o estudo das populações humanas, da sua estrutura, da sua evolução e dos seus caracteres gerais, encarados principalmente do ponto de vista quantitativo" (Instituto Brasileiro de Geografia e Estatística, 1969)[1]. Dentre essas características, o tamanho e a estrutura das populações são variáveis chave, uma vez que se buscam identificar os fenômenos que os determinam ou que os afetem ao longo do tempo, os quais são mensurados por indicadores tais como: taxa de natalidade, movimentos migratórios, taxa de fecundidade, taxa de mortalidade, entre outros (CERQUEIRA; GIVISIEZ, 2004).

A área de estudos desta pesquisa trata da mudança demográfica focada na estrutura etária da população, principalmente através do fenômeno chamado de *world population ageing*, isto é, o envelhecimento da população, que ocorre em diferentes graus em países desenvolvidos e subdesenvolvidos e procura avaliar seus impactos na economia utilizando diferentes técnicas de análise. Dado este cenário, a necessidade de informações e análises demográficas é crucial para auxiliar os *policymakers* a formular ou propor mudanças nas políticas públicas.

O tema chamou a atenção dos governantes e das comunidades internacionais através de uma publicação em 1956 das Nações Unidas (*The Ageing of Populations and its Economic and Social Implications, Population Studies*, n. 26) que teve foco no envelhecimento da população de países desenvolvidos. Em 1982, as Nações Unidas adotaram o Plano Internacional de Ação do Envelhecimento da População na Primeira Assembleia Mundial do Envelhecimento da População. Em 1994 foi realizada a Conferência Internacional de População e Desenvolvimento, que reconheceu o impacto econômico e social do envelhecimento da população como uma oportunidade e um desafio para a sociedade. A

[1] Versão brasileira do Dicionário Demográfico Multilíngue das Nações Unidas editado pelo IBGE.

Segunda Assembleia Mundial, em 2002[2], adotou o Plano de Ação Internacional do Envelhecimento da População de Madrid, representando um ponto de mudança de como o mundo trata os principais desafios de criar uma sociedade para todas as idades.

A população mundial, de acordo com o *censusclock* das Nações Unidas para 1° de julho de 2013[3], é de 6.187 milhões de habitantes, cerca de 2,5 vezes maior que em 1950. Deste total, cerca de 1.109 milhões pertencem a regiões mais desenvolvidas e 5.077 milhões pertencem a regiões menos desenvolvidas[4], representando um percentual de 18,1 e de 81,9%, respectivamente[5]. Em 1950, estes percentuais eram de 32,1 e de 67,9%, indicando que houve um crescimento populacional nas regiões menos desenvolvidas e um movimento oposto nas regiões desenvolvidas. Estima-se que em 2050 estas proporções continuem no mesmo processo, mudando para 13,9 e 86,1%, respectivamente.

Atualmente, a taxa de crescimento da população[6] mundial é de aproximadamente 1,14%[7], representando um tempode duplicação de 61 anos[8]. Esta taxa atingiu o pico em 1960 com 2% e estima-se que em 2050 a mesma deverá diminuir para uma média de cerca de 0,34%[9].

O Brasil, que, de acordo com as Nações Unidas[10], possuía em dezembro de 2012 cerca de 198.361 mil habitantes, teve aumento da sua representatividade na população mundial no período de 1950 a 2010[11] de 2,13 para 2,82%. Contudo, este percentual tende a diminuir em 2050 para 2,39%. Ainda segundo as Nações Unidas[12], a taxa de crescimento da população

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[2] Ano da primeira publicação das Nações Unidas sobre o envelhecimento da População. Demais atualizações desta publicação foram feitas nos anos de 2007 e 2009.

[3] http://unstats.un.org/unsd/demographic/sources/census/2010_PHC/default.htm

[4] As regiões menos desenvolvidas, segundo a Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2012) a incluem África, Ásia (exceto Japão), América Latina e Caribe e Oceania (exceto Austrália e Nova Zelândia) e as regiões mais desenvolvidas incluem Europa, América do Norte e os países excluídos da região menos desenvolvida (Japão, Austrália e Nova Zelândia).

[5] Estes dados foram obtidos da World Population Prospects: 2012 Revision do Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2012)

[6] A taxa média de crescimento exponencial da populacional é calculada, de acordo com Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2009a), através da expressão $\ln(P_t / P_0)/t$, onde t é a duração do período e P a população. A taxa é expressa como uma percentagem.

[7] Geography Home Page, 2011.

[8] A taxa de crescimento podeser usada para determinar o "tempo de duplicação" de um país, região ou até mesmo do planeta, isto é, quanto tempo vai demorar para que a população atual dobre. Esse tempo é determinado dividindo a taxade crescimento em 70 anos, uma vez que o número 70 vem do logaritmo natural de 2, que é 0,70. Assim, pode-se esperar que a população mundial de 6,5 bilhões para se tornar 13 bilhões até 2067 se o crescimentoa tual continuar.

[9] Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2009).

[10] http://unstats.un.org/unsd/demographic/products/socind/.

[11] Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (20012).

[12] http://unstats.un.org/unsd/demographic/products/dyb/dybsets/2009-2010.pdf

brasileira caiu de 3,04% ao ano desde o período de 1950-1960 para 1,00% ao ano em 2010, podendo alcançar -0,291% em 2050. O Instituto Brasileiro de Geografia e Estatística - IBGE também estima que a taxa de crescimento da população brasileira chegue ao valor zero em 2039. Assim, apesar de a taxa de crescimento no Brasil ter sido bastante superior à taxa de crescimento populacional mundial, hoje o Brasil já cresce a taxas inferiores que a mundial.

Constata-se, através dos dados acima apresentados, que existe um processo de desaceleração populacional que vem ocorrendo nas regiões mais desenvolvidas, e as estimativas indicam que o mesmo processo se verifica nas regiões menos desenvolvidas e no Brasil, porém iniciou-se tardiamente. Dentre os principais determinantes deste movimento, destacam-se a combinação da queda da taxa de fecundidade com a queda da mortalidade e com o aumento da expectativa de vida da população. Assim, existe uma redução na proporção de crianças da população e um consequente aumento na proporção de pessoas de grupos etários mais velhos.

Considerando os determinantes da mudança demográfica acima citados, a estrutura etária da população sofreu um processo de remodelação desde 1950 até 2009, e o mesmo deve continuar conforme projeções da United Nations (2012). Dessa forma, há uma alteração na proporção de crianças (0-14 anos), de pessoas em idade ativa (15-64 anos[13]), e de idosos (65 anos ou mais) na população, que se reflete na taxa de dependência[14]. O Brasil encontra-se hoje no estágio em que o número de pessoas em idade ativa está em ascensão e, consequentemente, existe uma queda da taxa de dependência. Esta situação é chamada de “janela de oportunidade” ou “janela demográfica”, uma vez que a maior parte da população pode estar no mercado de trabalho, proporcionando crescimento econômico[15]. Wong e Carvalho (2006) apontam para uma tendência de diminuição da pressão demográfica por novos empregos, gerando impactos sobre o mercado de trabalho.

Os dados mundiais da United Nations (2012) indicam que, atualmente, o Brasil apresenta um perfil de população por grupos de idade parecido com os dados estimados para o mundo. Comparando o Brasil a um país avançado no processo de mudança demográfica e a outro menos avançado, podemos ter como exemplo ilustrativo o Reino Unido e Zimbábue, respectivamente. O Gráfico 1 ilustra bem as diferenças, uma vez que é possível observar que

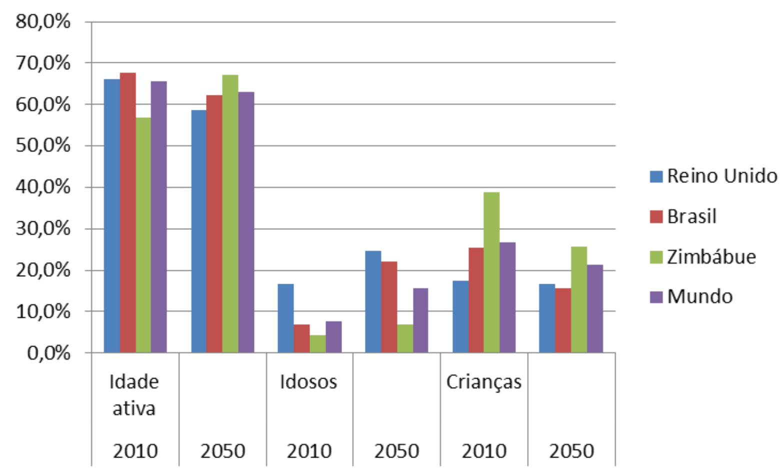
[13] Alguns autores utilizam a faixa de idade entre 15 e 59 anos, outros consideram dos 15 aos 64 anos. Neste estudo, optou-se por trabalhar com a faixa de 15 a 64 anos e, conseqüentemente, de 65 ou mais na faixa seguinte.

[14] Esta variável é calculada através da soma do número de crianças (pessoas até 15 anos de idade) e de idosos (pessoas acima de 65 anos) dividido pelo número de pessoas em idade ativa (de 15 a 64 anos)

[15] Brito (2007) salienta, contudo, que, dados os fortes desequilíbrios regionais e sociais no Brasil, os benefícios da transição demográfica são distintos segundo os níveis sociais, podendo ampliar as desigualdades sociais caso não sejam implementadas políticas que potencializem as transferências sociais de recursos.

o Reino Unido em 2010 possuía uma população idosa maior que os países em comparação e tenderá a possuir em 2050; o Brasil, que pode ser considerado hoje como um país em estágio moderado de envelhecimento populacional, possuía em 2010 e ainda possuirá em 2050 mais pessoas em idade ativa na comparação; e Zimbábue, lidera a comparação em termos de população infantil.

Gráfico 1 – População por grupo de idade



Fonte: Elaborado pela autora com base nos dados do *World Population Prospects: The 2012 Revision* das Nações Unidas (2012).

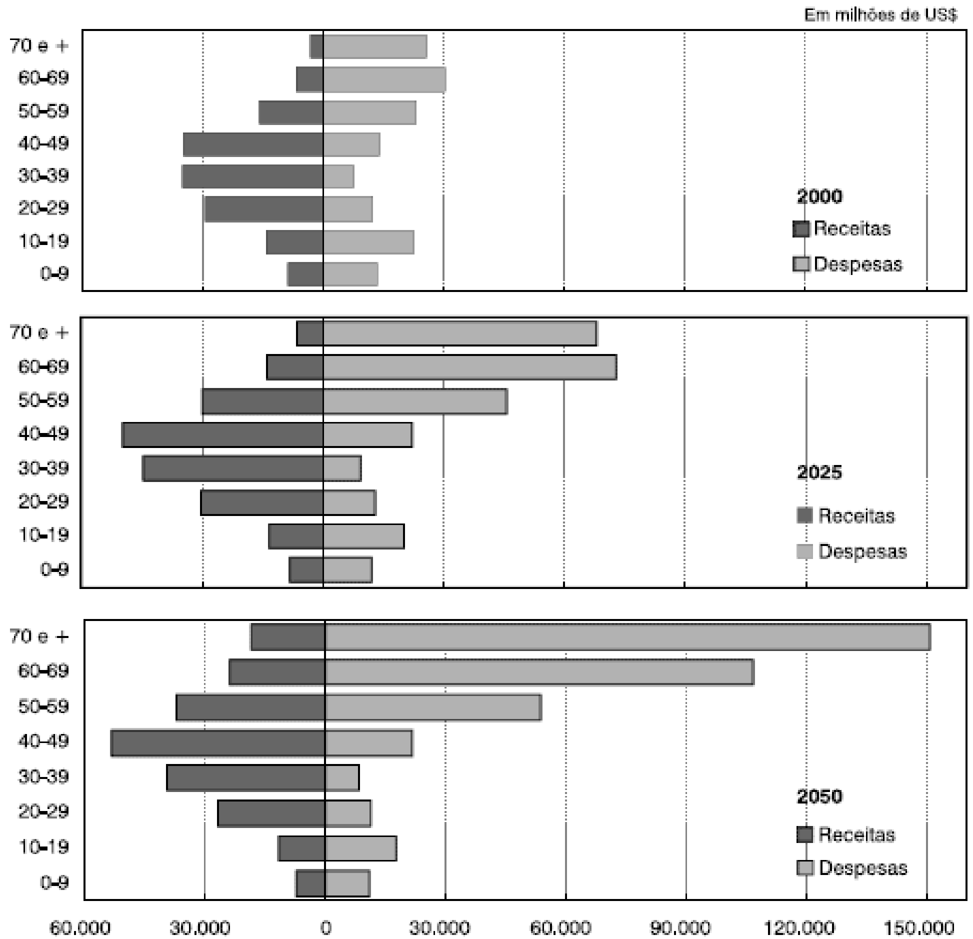
A mudança demográfica compreende uma alteração nas proporções de pessoas por grupos de idade. Percebe-se que quanto mais desenvolvido o país ou a região, maior a proporção de idosos e quanto menos desenvolvido menor o número de idosos. Este fato resulta de uma evolução, de forma que, num primeiro momento, existe uma proporção maior de população infantil (0 a 14 anos). À medida que as regiões vão se desenvolvendo, passa-se a ter uma proporção maior de jovens (15 a 24 anos), depois de adultos (25 a 64 anos) e, por fim, uma proporção maior da população idosa. E alterações nessas proporções terão implicações sobre a taxa de dependência, aumentando-a ou diminuindo-a conforme a proporção de pessoas por grupo de idade.

A publicação da United Nations (2009) sobre o envelhecimento da população identificou algumas características deste tema: processo sem precedentes, sem um paralelo na história da humanidade; processo persuasivo, uma vez que ele afeta praticamente todos os países do mundo; processo profundo, tendo consequências e implicações para a área econômica (crescimento econômico, poupança, investimento, consumo, mercado de trabalho, pensões, tributação e transferências intergeracionais), social (composição familiar, demanda por habitação, tendências de migração, epidemiologia e serviços de saúde) e política (padrões de voto e representação política); processo duradouro e irreversível, que vem ocorrendo desde 1950. Neste ano, a proporção de pessoas mais velhas era de 8%. Em 2009, passou para 11% e estima-se que em 2050 chegue a 22%. Uma vez que a mortalidade dos idosos continua em queda e que a fertilidade permanece baixa - e é improvável que volte a aumentar - a proporção de idosos continuará a crescer.

Em relação às implicações do processo de mudança demográfica para a esfera econômica, Miles (1999) cita como exemplo o impacto sobre a taxa de poupança, a formação de capital, a oferta de trabalho, a taxa de juros, e os salários reais. Wong e Carvalho (2006) consideram importante o impacto sobre a oferta de trabalho, uma vez que a população brasileira que está na idade ativa de trabalho (25 a 64 anos) deverá crescer ao menos até 2045. Contudo, essa oferta de trabalhadores só poderá ser aproveitada se a mesma tiver habilidades para desenvolver a sua produtividade, mantendo o equilíbrio entre o balanço econômico, social e intergeracional, de forma que se deve dar especial atenção à educação.

Além dos melhoramentos na qualidade da educação, o envelhecimento da população demanda mais recursos de saúde e de seguridade social, tendo como consequência o aumento dos gastos do governo nos grupos etários mais elevados (WONG; CARVALHO, 2006). De fato, quando se analisam as despesas do governo por grupo de idade para o Brasil (Gráfico 2), em 2000, a faixa etária de 60 a 69 anos já era a que representava a maior parte dos gastos do governo, devendo duplicar até 2015 e triplicar até 2050, sem contar que neste último ano os gastos estimados do governo com pessoas acima de 70 anos serão ainda maiores. Assim, com o avanço da mudança demográfica, a tendência é que os gastos futuros do governo irão crescer proporcionalmente mais do que as receitas. As projeções estimadas por Turra (2001) da relação entre receitas e despesas públicas para o Brasil apresentam um declínio considerável dessa relação para o período de 2000 a 2050, confirmando essa tendência. Como consequência, o déficit fiscal do governo tente a aumentar, sendo necessário tomar medidas de precaução que compensem essa demanda pública.

Gráfico 2 – Receitas (impostos) e despesas governamentais totais, por grupos etários. Brasil – 2000-2050



Fonte: Turra (2001[16] *apud* WONG; CARVALHO, 2006, p.16).

Além das implicações econômicas já citadas, cabe ainda lembrar que as estimativas populacionais constituem o principal parâmetro para a distribuição das cotas dos Fundos de Participação dos Estados[17] e dos Municípios[18] (Artigo 159 da Constituição Federal), os quais são formas de transferências intergovernamentais indiretas. Cada Estado ou Município recebe

[16] TURRA, C. M. Intergenerational accounting and economic consequences of aging in Brazil. In: Proceedings of the XXIV IUSSP General Conference. Salvador, Brazil, Aug. 2001.

[17] O Fundo de Participação dos Estados e do Distrito Federal (FPE) é composto por 21,5% da arrecadação do IPI (Imposto sobre Produtos Industrializados) e do IR (Imposto sobre a Renda), distribuídos de acordo com a população e a superfície e é inversamente proporcional à renda per capita da unidade federativa. Este fundo destina 85% de seus recursos às Regiões Norte, Nordeste e Centro-Oeste e 15% às Regiões Sul e Sudeste.

[18] O Fundo de Participação dos Municípios (FPM) é composto por 22,5% da arrecadação do IPI e do IR, com uma distribuição proporcional à população de cada unidade, sendo que 10% do fundo são reservados para os Municípios das Capitais, 86,4% aos Municípios de Interior e 3,6% aos Municípios com mais de 156 mil habitantes. No caso do FPM, a distribuição é dada da seguinte forma: Norte (8,52%), Nordeste (35,30%), Centro-Oeste (7,46%), Sul (17,54%) e Sudeste (31,19%).

as dotações em função direta de sua área geográfica e de sua população e em função inversa de sua renda per capita. Outro indicador que utiliza a população como um dos parâmetros na sua composição é o Índice de Retorno do Imposto sobre Operações relativas à Circulação de Mercadorias e sobre Prestações de Serviços de Transporte Interestadual e Intermunicipal e de Comunicação (ICMS) dos municípios, representando 7% do total do indicador.

O presente estudo investiga qual o impacto da mudança demográfica na economia brasileira sob uma perspectiva regional a partir de três ensaios. O primeiro ensaio avalia o padrão espacial da mudança demográfica utilizando a técnica de análise exploratória de dados espaciais (AEDE) e de regressão espacial para abrangência nacional mediante o uso dos dados dos censos demográficos de 1991 e de 2000 em nível desagregado de Áreas Mínimas Comparáveis[19], verificando se existe autocorrelação espacial global entre mudança demográfica e o crescimento da renda. O segundo ensaio avalia se a mudança demográfica possui um papel na convergência regional de renda utilizando regressão espacial com dados em painel com abrangência nacional em nível desagregado para os Estados brasileiros[20] (análise condicional aos fatores demográficos). E o terceiro ensaio irá analisar a relação de consumo entre os diferentes grupos de idade no Rio Grande do Sul utilizando dados da Pesquisa de Orçamentos Familiares (POF) referente aos anos 2002-2003. Anteriormente ao detalhamento de cada um desses ensaios, será feita uma revisão sobre os fundamentos da teoria da demografia e sua relação com a teoria econômica. Optou-se por apresentar separadamente esses fundamentos uma vez que eles servem de base para todos os demais estudos.

1.1 ECONOMIA E DEMOGRAFIA: UMA BREVE REVISÃO DE LITERATURA

A formulação das principais teorias demográficas teve por base as ideias de John Graunt, autor das primeiras tábuas de mortalidade:

> Com as tábuas de mortalidade de Graunt, a demografia define-se como ciência que, a partir da observação de dados, mede o *risco* dos fenômenos demográficos e que, a partir dos resultados dessas medidas, aspira a conhecer não apenas o presente e o passado, mas também a aventurar-se na prospecção do futuro. É esta ambição prospectiva que vai acionar a formulação de teorias universais da população, de que

[19] Este nível de desagregação possui correspondência territorial entre o período considerado, fato que não existe se considerarmos os municípios como referência, uma vez que muitos novos municípios são criados no período, modificando o contorno das áreas geográficas, dificultando a comparação ao longo do tempo.

[20] Optou-se por um recorte Estadual em função da disponibilidade de dados, a qual é contínua para os Estados Brasileiros e limitaria a utilização da técnica de dados em painel caso fossem considerados municípios, já que os dados de população municipais por idade só estão disponíveis nos censos demográficos.

> são principais expressões o malthusianismo e a teoria da transição demográfica (BANDEIRA, 1996, p. 2).

O primeiro estudo científico no campo econômico com enfoque para a demografia foi feito por Thomas Robert Malthus em 1798 com a obra "Um Ensaio sobre o Princípio da População". O autor propôs que, enquanto a população tenderia a crescer em progressão geométrica, os meios de subsistência (alimentos) cresciam em progressão aritmética - lei da população de Malthus (SANTOS, 2004; WELLINGTON, 2007). Logo, no futuro teríamos um contingente de famintos, uma vez que existia uma tendência de sobrepopulação. Apesar das críticas atuais, Malthus foi consagrado como "pai da demografia". Ele acreditava que a pobreza só poderia ser evitada diminuindo o número de nascimentos entre os pobres[21]. As críticas a esta teoria sugerem a redistribuição da riqueza como solução. Além disso, os avanços tecnológicos – que permitem produzir alimentos em maior quantidade, o uso de anticoncepcionais e a independência feminina são fatores que contribuíram para a redução do crescimento populacional.

Após a Segunda Guerra Mundial, com a nova aceleração populacional principalmente nos países do terceiro mundo, voltaram a surgir teorias e ideologias que tiveram por base o pensamento de Malthus. Assim, estas novas teorias foram denominadas de Neomalthusianas (WELLINGTON, 2007). De acordo com esses pensadores desta abordagem, a falta de controle do crescimento populacional é a causa do subdesenvolvimento e recomendam o uso de anticoncepcionais como solução, passando a responsabilidade do crescimento populacional para o Estado. Contudo, sabe-se que o problema da população não é quantitativo, e sim qualitativo, na forma com que ocorre a divisão dos recursos produzidos.

Opondo-se aos pensamentos anteriores, os Reformistas ou Marxistas (WELLINGTON, 2007) acreditam que é a pobreza que causa o elevado crescimento da população – causa inversa às teorias acima expostas. Dessa forma, as reformas sociais[22] (emprego, renda, educação) são a solução para o elevado crescimento da população. Mais especificamente Karl Marx (SANTOS, 2004) acreditava que a sobrepopulação não era um fenômeno absoluto e sim relativo uma vez que existe uma desadequação relativa entre subsistência e população, devido ao modo de produção capitalista. Na mesma linha de pensamento, existem os Ecomalthusianos, que acreditam que a população de baixa renda consome exageradamente recursos naturais e compromete gerações futuras. Outra corrente

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[21] Malthus nunca defendeu o controle de natalidade, mas reconhecia a sua necessidade para evitar uma catástrofe gerada pela fome.

[22] Para esta teoria, o Estado também é responsável pelo controle do crescimento populacional.

oposta à Malthusiana é a populacionista (SANTOS, 2004), que acredita que o crescimento da população é fundamental para o crescimento econômico, defendida no século XVI por Jean Bodin – que acredita que o valor de uma potência está na sua população (SANTOS, 2004) - e no século XX por A. Sauvy, que considera que o crescimento populacional é necessário para manter o dinamismo econômico, uma vez que a população jovem é aberta a mudanças e assegura o ritmo da inovação tecnológica, social e cultural.

Outra teoria aborda a transição demográfica, a teoria da transição demográfica de Laundry (SANTOS, 2004), impactando significativamente nas origens da demografia. A publicação *A Revolução Demográfica* em 1934 estabeleceu um regime demográfico através da relação entre natalidade (nascimentos/população total,) mortalidade (mortes/ população total) e crescimento da população[23]. A partir de situações sociais (sanitárias, econômicas e sociais) são definidas as taxa de mortalidade e de natalidade, que determinam o crescimento da população. Assim, são identificados três regimes demográficos: primitivo, intermediário e contemporâneo. No primeiro regime demográfico, o primitivo ou pré-industrial, não existe controle sobre a natalidade e a mortalidade é elevada. O crescimento populacional é regulado pelo nível de recursos disponíveis, de forma que quando há escassez de recursos, aumenta a mortalidade. A equivalência entre natalidade e mortalidade estabelece o equilíbrio. No segundo regime, o intermédio, existe controle sobre nascimentos sob a forma de celibato[24] e do adiamento do casamento. Apesar de serem inferiores ao regime primitivo, a natalidade e a mortalidade permanecem elevadas. Por fim, no terceiro regime, o contemporâneo, há uma restrição generalizada dos nascimentos e da mortalidade com a melhoria da qualidade de vida da população, de forma que o crescimento populacional permanece baixo. O autor define transição demográfica a passagem do regime primitivo para o contemporâneo, sendo que a taxa de mortalidade diminui antes da natalidade e o crescimento populacional se mantém. Na fase pós-transicional, o crescimento populacional diminui até tornar-se estável ou nulo.

[23] Diferença entre as duas taxas (natalidade e mortalidade).
[24] Esta prática condena membros da família a permanecer solteiros e foi comum em sociedades camponesas.

2 ARTICLE 1 - DEMOGRAPHIC CHANGE AND ECONOMIC GROWTH IN BRAZIL: AN EXPLORATORY SPATIAL DATA ANALYSIS

Abstract
The age structure of the Brazilian population has under gone changes due to the reduction in fertility and mortality rates, followed by the increase of the population's life expectancy, which resulted in a decrease in the population growth rate. This phenomenon also affects the so-called demographic transition process in which there is a reduction in the proportion of children and an increase in the proportion of aged people in the population. The literature assumes that this process is related to economic growth; therefore, regions with a lower dependency ratio (proportion of children and aged people in the population) should have higher economic growth. This study investigates the empirical evidence regarding the existence of this inverse relationship between dependency ratio and economic growth from a spatial perspective, using Exploratory Spatial Data Analysis (ESDA) techniques applied to demographic data and income per capita variation to the Minimum Comparable Areas (MCAs) of Brazil. Univariate MCA results indicate the existence of a high spatial correlation with the dependency ratio, and a relatively weaker correlation with the variation in income per capita. Bivariate ESDA results support the hypothesis of an inverse relationship between dependency ratio and per capita income growth, so demographic characteristics can also be an important component for understanding the pattern of regional income inequality and convergence in Brazil.

Keywords: Demographic change. Change in per capita income. Exploratory spatial data analysis.

2.1 INTRODUCTION

The word "demography" was first used by the French author Achille Guillardin 1855 in his book Élements de statistique humaine ou demographi e compare whose purpose was to investigate the structure and composition of the population. However, demography emerged as a science after the publication of the first mortality tables – which measured the risks of death associated with age – devised by John Graunt (BANDEIRA, 1996) in1662 in his work entitled *Natural and Political Observations Made Upon the Bills of Mortality*. Graunt's ideas were the cornerstone on which the major demographic theories were constructed.

This paper deals with demographic change, a phenomenon that started out in developed regions and which has had some impact on Brazil. It is concerned with the change in the age structure of the population and includes a web of factors. First of all, improvements in basic health conditions and the easy access to health services eventually dragged the mortality rate[25] down (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA - IBGE, 2008). There was a subsequent reduction in fertility rate because of family planning, of the widespread use of contraceptive methods and of the entry of women into the labor market. These factors, followed by the increase in life expectancy, led to a lower population growth rate (RIOS-NETO, 2005; ALVES, 2008b). According to IBGE, the Brazilian population growth rate dropped from 3.04% per annum since 1950-1960 to 1.05% p.a.in 2008, and it may be as low as -0.291% in 2050. IBGE also estimates that the Brazilian population growth rate will be zero in 2039. These results indicate that the population has grown in absolute numbers but, on the other hand, the decrease in growth rate points out that population growth has slowed down. Consequently, age groups changed and there exists now a reduction in the proportion of children and an increase in the proportion of aged individuals.

Age components make up the dependency ratio, which is calculated by adding the population of children and the population of age and dividing it by the total working-age population, and the change in this rate is known in the literature as demographic change. Initially, the rate is high due to the percentage of children in the overall population. When the demographic transition process begins, the dependency ratio drops because of the decrease in the number of children and of the increase in the number of working-age individuals. This transition period is known as "demographic dividend[26]" or "window of opportunity" as the larger proportion of working-age individuals may have a positive impact on economic growth (ALVES, 2004). A favorable demographic scenario alone does not guarantee such effect as it depends both on the capacity the economy has to absorb the labor force and on the existence of social conditions favorable to the skill development of individuals, causing economic productivity to rise (ALVES, 2008a; WONG; CARVALHO, 2006). Therefore, demographic dividend represents an opportunity for economic growth, but it does not guarantee that it will eventually occur. As the aging process advances, the working-age population decreases proportionately and the aged population increases in such a way that the dependency ratio is positive again. This change has an impact on the working population: either the tax burden or the social security contribution will be higher, given that the costs associated with health assistance are larger for the aged than for the children.

Worldwide, the dependency ratio was on the rise in 1950 (corresponding to 65), and started to decrease only between 1970 and 1975, when it reached 74. In 2009, the ratio

[25] It should be underscored that the long-term mortality rate tends to grow as the population gets older (ALVES, 2008b).

[26] More precisely, the first demographic dividend, which will be addressed in detail in the review of the literature (PRSKAWETZ; LINDH, 2007).

plummeted to 53, but it is expected to go up again by 2025. In more developed countries, the increase in the dependency ratio occurred earlier, from 2009 onwards, being lower than the world ratio (48), but one should recall that the peak ratio in developed countries is lower and relatively more stable. In such countries, the ratio may be around 58 in 2025 (UNITED NATIONS, 2009a). In Brazil, the dependency ratio has been dropping (it was 79.06 in 1950 and was estimated at 50.69 in 2010), as the number of working-age people is on the rise, but it is expected to drop further until 2022 (IBGE, 2008); after that, it may increase (according to BRITO, 2007, it is estimated to be 48.79 in 2020 and 57.87 in 2050) owing to the larger percentage of aged in the overall population. Currently, it is believed that the proportion of children is four times larger than that of aged and that these proportions will be the same in 2050. In this period, while the former decreases and the latter increases, the dependency ratio goes through drastic changes in its composition, but it remains relatively stable (BRITO, 2007). From 2050 on, the dependency ratio will increase more sharply due to the increase in the proportion of aged.

In this paper, we assess the spatial pattern of demographic change in Brazil, seeking to correlate this pattern with the variation in the regional Gross Domestic Product (GDP) per capita. Besides investigating the spatial characteristics of the demographic change process, the main goal is to determine whether dependency ratio and economic growth are closely related. To do that, we use Exploratory Spatial Data Analysis (ESDA) and spatial analysis of economic convergence for Brazil from 1991 to 2000, and split the Brazilian territory into Minimum Comparable Areas (MCAs). Aside from this introduction and from the conclusion, the paper is organized into four sections. Section 2.2 provides a brief review of the literature, focusing on the correlation between demographic change and economic growth. Section 2.3 presents the methodological procedures. Section 2.4 is devoted to the ESDA results whereas Section 2.5 deals with spatial convergence.

2.2 BRIEF REVIEW OF THE LITERATURE

The analysis of the correlation between demographic change and economic growth is quite recent in the literature. Before that, the population variable relied on the measurement of its overall growth, regarding the age structure as constant. The hypothesis of constant growth of the labor force in Solow’s model implies that, if the economy is at full employment, labor supply is inelastic at the wage level. According to Vasconcelos, Alves and Silveira Filho (2008), this simplifying hypothesis is the one used in neoclassical models, even though Solow

(1956) originally conducted two research studies on the possibilities of endogenous growth of the population variable, which were set aside by theoretician sat that time. Notwithstanding this assumption, many other models in the literature owe their inspiration to the classic models of economic growth. Thus, it is prudent to highlight the importance of Robert Solow's study, which turns out to be a hallmark in economic growth studies.

Solow (1956) concluded that, in the absence of technological progress, growth in a steady-state economy is determined by the labor force growth rate, which is regarded as an exogenous variable. Under this circumstance, each variable of the model (capital, labor, and output) grows at a constant rate. In the presence of technological progress, the growth rate of these variables is determined by the population and by technology, both of which are exogenous variables. However, capital and output per capita growths are determined by technology alone. Hence, the only way to increase capital or output per capita growth rates would be through technology, introduced into the model as an exogenous parameter and known as Solow residual, which is the driving force behind economic growth. Several other studies were conducted to assess economic growth under the perspective of endogeneity, since technology in Solow's model was exogenous. Therefore, other models were developed, such as the endogenous growth models.

The development of endogenous models gave rise to new endogenous growth theories that differ from Solow's original model due to the use of increasing returns to scale (MARTIN; SUNLEY, 1998; CLEMENTE; HIGACHI, 2000). These theories can be categorized into two groups: the first includes the models of Lucas (1988), Romer (1986), and Rebelo (1991), in which technology is considered to be a public good (except for Lucas's model), and the second one includes the neoclassical models of Schumpeterian endogenous growth, the models of Romer (1990) and of Aghion and Howitt (1993), in which technology is viewed as goods that are liable to appropriation, introducing the idea of imperfect competition.

According to Lucas (1988), an economy with larger human capital will grow faster. Interestingly, although investment in human capital begins in childhood, it may be regarded as a gate way to the labor market, since this variable has a positive impact on the wages of individuals. So, we assume that the impact of the "demographic dividend" on economic growth is larger when there is sizeable investment in human capital.

Rebelo's (1991) model is an example of linear models, which assumes that the basic sources of economic growth are physical capital, human capital, and research, adding these factors to a comprehensive measure of capital, such that production is a linear function of this measure of capital. The neoclassical models of Schumpeterian endogenous growth postulate that innovation plays a key role in explaining economic growth in the long run. Technological progress is explained by the search of larger profits. By taking imperfect competition into account, investment in research and development (R&D) allows creating a wide variety of new products with better quality, thus ensuring profit.

By introducing the idea of increasing returns to scale, endogenous models of economic growth deal with regional aspects of the economy, assessing spatial income distribution[27]. In this context, in the 1990s, an important economic development theory was proposed, the so-called New Economic Geography, which uses microeconomic logic to explain the concentrations of economic activity and of population in space, which originate and are maintained due to some sort of spatial clustering[28]. The mobility of factors, labor force, and capital explain clustering n such a way that producers choose to be closer to input suppliers, creating a cluster of producers, who, together with their employees, give rise to a large consumer market as a result of their own demands. These are the so-called backward and forward “linkages”, as designated by Fujita *et al.* (2002).The reasons for this understanding are related to cumulative processes rather than to the characteristics of the places *per se*, and so increasing returns to scale play an important role in the explanation of spatial irregularities.

Despite the fact that the ESDA technique is not usual for assessing the correlation between demographic change and the economy, the relationship between these variables has been the subject of study of different authors, especially from the 1990sonward, since there has been a more realistic approach to the population variable, given that its growth varies, leading back the original proposition made by Solow, set aside by the simplifying hypothesis (VASCONCELOS; ALVES; SILVEIRA FILHO, 2008). As to the implications of demographic change for the economy, Miles (1999) uses the impact on the savings rate, capital formation, labor supply, the interest rate, and real wages as examples. Wong and Carvalho (2006) believe that the impact on labor supply plays an important role, because the Brazilian working-age population (25 to 64 years old) is expected to grow at least until 2045. However, this labor supply can only be used if workers are skilled enough to increase their productivity, maintaining the equilibrium between economic, social and intergenerational balance.

On the other hand, the aging of the population requires more health and social security funds, increasing government spending on older age groups (WONG; CARVALHO, 2006).

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[27] See Krugman (1991), Porto Júnior and Jesus (2002).
[28] See Fujita *et al* (2002).

In fact, when we assess government spending per age group in Brazil (TURRA, 2001), we note that expenditures increase exponentially above the age of 49 years, and that the average expenditure per capita with individuals aged over 60 years reaches US$ 4,000.00 p.a., which is twice as high as the amount spent on the 30-39 age group. With demographic change, future government spending tends to rise proportionally more than do the revenues. Forecasts made by Turra (2001) for the difference between public revenues and expenses for Brazil show a remarkable decrease in this ratio for the period 2000 to 2050, thus confirming an uptrend. Consequently, the government's fiscal deficit tends to increase and it is necessary to take precautionary measures to offset this public demand.

Prskawetz and Lindh (2007) provide a recent review of the literature, linking the changes in demographic characteristics to economic growth and introducing three new empirical economic growth regressions for the European Union 15 member countries from 1995 to 2005, with the aim of conducting a prospective analysis of future demographic implications for economic growth for the current EU-25 until 2050. According to these authors, changes in age structure have been underway in the European Union since 1970, when the World War II baby boom generation entered the labor market, giving rise to a demographic dividend which led the population growth rate to be lower than the growth rate of the working-age population. This dividend has been recently denoted as the first demographic dividend (since a second one may occur when the population grows old), which can have two effects: an accounting one and a behavioral one. Whereas the former indicates differences in the growth rates of the economically active population and in the overall population, increasing the ratio between producers and consumers, the latter focuses on the role of demographic changes in output per capita (often referred to as the productivity component). Demographics may affect productivity due to its impact on savings, investment, human capital formation, technological innovations, among other factors. Although the first demographic dividend lasts for many decades, it has a temporary nature, as the increase of the economically active population owing to demographic transition cannot be sustained.

With the increase in the aged population, the first demographic dividend is negative, and then the second demographic dividend ends up influencing the economy[29]. This occurs when the growth rate of the economically active population is lower than the growth rate of the overall population. The second demographic dividend is akin to the analysis of the old-age dependency ratio, whose outcome for the economy is still obscure. The predicted outcomes

[29] See Prskawetz and Lindh (2007).

depend on to what extent capital accumulation is related to the aging of the population. Fukuda and Morozumi (2004) demonstrate that as the population growth rate falls, dissaving is expected to occur, negatively affecting the economic growth rate. Nonetheless, as the fertility rate also decreases, economically active people tend to save up more, causing a positive impact on the economic growth rate. If economically active people save more, the existence of a second demographic dividend depends on whether this saving is converted to investment in the domestic economy. Besides, foreign investments in this period may also contribute to increasing the income per capita. The results found by Prskawetz and Lindh (2007) indicate that it was only possible to exploit the growth potential offered by demographic change and saving in industrialized countries, in eastern, southeastern and southern Asia, as these countries had a higher economic growth rate than the sum of the first and second demographic dividends.

Most of the literature on the correlation between demographic change and economic growth applies to convergence models, where the growth rate per worker is treated as being proportional to the difference between the logarithm of the current and long-term output level per worker. This rate is assumed to be constant, while the steady-state equilibrium per worker is country and time specific, i.e., it relies on specific characteristics of countries/regions. The growing review of the literature on the empirical relationship between demography and economic growth, according to Prskawetz and Lindh (2007), implies that, even though the models (in terms of explanatory variables and time periods) and the estimation methods (often with the use of cross-sectional or panel data) are different, the results of several studies are usually compatible. An important finding is that the growth rate of the economically active population has a positive effect on the productivity growth rate per worker, i.e., not only does the growth rate of the economically active population determine the effect of the accounting component, but it also influences the behavioural component (term of productivity). Hence, a negative correlation is expected between the dependency ratio and economic growth when there are more economically active individuals.

Amongst the several demographic variables introduced in the economic growth models, the youth dependency ratio was significantly negative in most of the reviewed studies. In evaluating the role of demographics, Kelley and Schmidt (2005) found that the reduction in the youth dependency ratio in Europe had a strong positive effect on productivity growth rate per worker during the 1970s and 1980s.

Recent studies have used the internal demographic composition of the labor force instead of the dependency ratio. The conclusion of these studies show age groups associated with higher output. For example, Feyrer (2004) assessed 19 countries and observed that the percentage of workers aged 40 to 49 years is the one that contributes the most to the higher output per worker. The study of Prskawetz and Lindh (2007) for Europe indicates that the 50-64 year group is the one that most contributes to economic growth.

As pointed out by the review of several empirical studies, the growth rate of the economically active population is by and large one of the most robust demographic variables that is positive and significantly correlated with productivity growth per worker. Along with the fact that the growth rate of the economically active population also has a positive effect on the accounting component of the first demographic dividend, the global demographic role of the economically active population in economic growth is even greater. A similar finding, according to Prskawetz and Lindh (2007), was obtained for the youth dependency ratio which, if added as an additional demographic regressor, tends to be significant and negatively correlated with economic growth in most studies. The general conclusion from this analysis is that, regardless of the method and of the set of additional control variables used, the role of the growth rate of the economically active population and of the youth dependency ratio is a robust one. Many authors noted the importance of political and social aspects and their interaction with demographic changes as an important long-term determinant of economic growth.

2.3 METHODOLOGY

In this paper, we use ESDA and spatial regressions. We decided to use the first method because it seeks to describe the spatial distribution of the variable(s) under study, the patterns of spatial clusters and the type of clusters (stationary or not), in addition to the presence of atypical observations (outliers)[30]. Moreover, spatial autocorrelation is also important as the data from a location or region may influence the data from some other location through spatial spillover effects. The second method we considered important to reinforce and to deepen the analysis and we used convergence equations with Maximum Likelihood Estimation to correct for spatial dependency[31].

The inclusion of the regional dimension in the economic analysis allowed its use in econometric methods. Therefore, spatial econometrics is a subarea of econometrics that

[30] See Almeida (2008) and Anselin (1996).

[31] The Ordinary Least Square method was used for the no spatial regression analysis used to test the presence of spatial dependence.

utilizes spatial effects in econometric methods (ANSELIN, 1988a[32] *apud* ANSELIN; LE GALLO; JAYET, 2008), which can be derived from spatial dependence or heterogeneity. Spatial dependence establishes a correlation (or covariance) between random variable sat different locations, derived from a specific ordering determined by the relative position (distance, spatial arrangement) of observations in geographic space (or, in general, in the network space).

The scope of a spatial model for regional and urban science is extended by the inclusion of cross-sectional data in the space-time domain, and then spatial econometrics is defined as a subset of econometric methods concerned with the aspects found in cross-sectional observations and space-time (ANSELIN; SYABRI; KHO, 2006[33] *apud* ANSELIN, 2010). The variables related to location, distance and arrangement (topology) are dealt with explicitly in the specification, estimation, diagnostics, and model prediction, such that these treatments define the methodological scope of modern spatial econometrics.

The demographic variables used in the analysis are the overall dependency ratio[34] (child population + aged population)/(young population + mature population) and components of demographic change for the child population (overall population aged 0 to 14 years/overall population) and aged population (overall population aged 65 years or older /overall population). An income variable is also used, represented by the variation in household income per capita from 1991 to 2000. The study spanned the period from 1991 to 2000 and the space consisted of minimum comparable areas (MCAs) for Brazil[35]. This space limit was chosen as it was not possible to use municipalities for censuses between 1991 and 2000, because the changes over time would hinder the analysis. Furthermore, MCAs allow for a consistent analysis over time at a very disaggregated level. The demographic data were obtained from IBGE censuses, whereas household income per capita data were obtained from IPEA (Institute for Applied Economic Research) data and refer to those data used for calculation of municipal Human Development Index (HDI). Both databases were matched to the MCAs available from IPEA.

[32] Anselin, L. Spatial Econometrics: Methods and Models. Kluwer Academic Publishers, Dordrecht, The Netherlands, 1988a.

[33] Anselin L, Syabri I, Kho Y. GeoDa, an introduction to spatial data analysis. *Geographical Analysis* 38: 5–22, 2006.

[34] The definition of age of each element of the population structure (child, young, mature and aged) followed the criteria adopted by IBGE in its books on methodological notes and in its publications.

[35] It is intended to update this information with the inclusion of the 2010 income per capita after the publication of the 2010 census data.

2.3.1 Analytical Methods

The ESDA is univariate and bivariate, using Moran's I statistic (2.3.1.1) and LISA (local indicator of spatial association – 2.3.1.2). The former allows analyzing the existence of global spatial autocorrelation while the latter allows determining the presence of local spatial clusters around an individual location[36] and making inferences about the stationarity of global spatial autocorrelation.

The convergence analysis (2.3.1.3) conditional on income aims to check whether i) there is income convergence in the long run, ii) the dependency ratio has a negative effect on income. The regression analysis seeks to statistically test the relationship between these two variables. In addition, we estimate an absolute convergence model for the dependency ratio.

2.3.1.1 Univariate Analysis

Moran's I can be defined[37] for the univariate case as follows:

$$\Lambda = \frac{n}{S_0} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_{j=1}^{n}(y_i - \bar{y})^2} \quad (1),$$

where the variable y is expressed by its deviation from the mean ($y_i - \bar{y}$), w_{ij} is the spatial weights matrix that indicates the neighborhood relationship (ANSELIN; LE GALLO; JAYET, 2008), n is the number of observations of the sample (if the sample is based on MCA, as in this paper, n represents the number of MCAs) and S_0 stands for operation $\sum\sum w_{ij}$, meaning that all the elements of the spatial weights matrix need to be added up. When the matrix is row-standardized, the term S_0 yields n. Thus, equation 1 can be rewritten as follows:

$$\Lambda = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_{j=1}^{n}(y_i - \bar{y})^2} \quad (2)$$

[36] The identification of local spatial clusters is referred to in the literature as *hot spots*.
[37] The notation for Moran's I was used as shown in Anselin, 1995.

The spatial weights matrices w_{ij} indicate how observations interact in space through a variance-covariance matrix. Assuming that closer regions tend to be more intimately connected, the proximity of the regions can be estimated by a geographical criterion (contiguity matrix or distance matrix), or by a socioeconomic criterion[38] (e.g., human development index), such that each cell in the matrix represents the connection between two regions, which are given a spatial weight according to the selected criterion. Contiguity matrices regard regions as neighbours if they share a common boundary point. In the case of the Queen matrix, any region that shares a boundary with the region under study is taken as neighbor, regardless of whether the boundary occurs in a row, column, or diagonal. In distance matrices, the distance between points is regarded as k nearest neighbors, so there exists a cut off distance $d_i(k)$, such that all regions have the same number of k neighbours (ALMEIDA, 2011). The choice of the spatial weights matrix is arbitrary; however, the results are sensitive to this choice, and therefore it is interesting to test different specifications and observe Moran's I values given that the matrix with the highest value should always be chosen.

Moran's I values indicate how spatial autocorrelation occurs. Cliff and Ord (1981) demonstrate that the expected Moran's I value is given by $[1/(n-1)]$, so values below that indicate a negative autocorrelation while values above that indicate otherwise (ALMEIDA, 2011).

It is important to note that Moran's I only indicates whether there is spatial autocorrelation, but it does not show how the variable y correlates with its neighborhood. Hence, local analysis is necessary. An insight into the extent to which an individual set of data (z_i, Wz_i) influences the global measure is given by the Moran scatterplot, which contains the value of the variable (e.g., z) on the X axis, against the spatially lagged values on the Y axis (in this case, Wz), allowing us to assess the stability of spatial association. The global value of Moran's I statistic is given by the slope of the straight line of regression Wz on z. Moreover, it is also possible to identify outliers, i.e., when observations do not follow the same dependence process as the neighbors, with different values and points with more than two deviations from the origin (ANSELIN, 1995).

[38] Usually, the inverse distance is used for this criterion (ALMEIDA, 2011).

The local measure of Moran's I is given by LISA. In general terms, the LISA for a variable y_i, observed at i, can be expressed, according to Anselin (1995), by the L_i statistic as:

$$L_i = f\left(y_i, y_{Ji}\right) \quad (3),$$

where f is a function that may include additional parameters and y_i are the values of variable y observed in region i, and y_{Ji} are the values observed in the neighbourhood Ji of i. The values of y_i can be the original values of the observations or some standardization of them to avoid dependence on the local indicator (similar to global indicators of linear association). The neighbourhood Ji for each observation is formalized by the spatial weights matrix w_{ij}, as defined by Moran's I. The matrix w_{ij} can be row-standardized (the sum of the elements of each row is 1) to simplify interpretation. When this standardization is performed, the function $f\left(y_i, y_{Ji}\right)$ is weighted by the mean values of observations j of Ji.

The local indicator of spatial association allows determining the presence of spatial clusters, being directly linked to Moran's scatterplot. This result is shown on a map, where clusters and their values can be visually identified with ease. However, the latter can hinder data interpretation because a local Moran's I is computed for each region, with its respective significance level, generating a sizeable amount of data. Therefore, the maps are clearer and more efficient, as the significant are designated by colors, having up to four spatial associations, as occurs in Moran's scatterplot: High-High (HH), Low-High (LH), Low-Low (LL) and High-Low (HL). Each of these possible associations represents a quadrant on Moran's scatterplot, and the order corresponds to the sequence from the first to the fourth quadrant, respectively. The data can be interpreted in such a way that an HH cluster indicates that, for regions with this pattern of spatial association, region yields high values for the analyzed variable *z* and is in the neighborhood (represented by the spatial lag of variable *z*, *Wz*) of regions that also yield high values for this same variable. Thus, the other types of spatial association (LH, LL and HL) are interpreted likewise, where the first association refers to the variable under study and the second one corresponds to the spatial lag, representing the neighborhood. In addition, the sum of LISAs for all observations is proportional to the global indicator of spatial association (ANESELIN, 1995):

$$\sum_i L_i = \gamma\Lambda \tag{4},$$

where γ is a scalar and Λ is the global indicator of linear association (Moran's I).

2.3.1.2 Bivariate Analysis

The application of univariate LISA allows identifying the pattern of spatial association, taking each variable separately. Besides identifying this pattern, we are also interested in analyzing whether there exist a specific spatial association pattern between the dependency ratio and income per capita variation. To do that, we are going to use the same statistics of the univariate analysis, applied to the bivariate analysis.

The definition of multivariate spatial autocorrelation between two random variables follows Anselin (2002)[39] *apud* Chiarini (2008) and Almeida (2011). Let z_k and z_l be two random variables standardized to a mean equal to zero and to standard deviation of 1, such that $z_i = \frac{(y_i - \overline{y_i})}{\sigma_i}$, $i = k, l$. The multivariate spatial autocorrelation checks the linear association between the variable z_k in a region i (z_k^i) and the spatial lag of another variable $[Wz_l]$, such that the bivariate Moran's I for both random variables z_k and z_l is given by:

$$I_{kl} = \frac{z_k^{'} W z_l}{z_k^{'} z_k} \text{ or } I_{kl} = \frac{z_k^{'} W_{zl}}{n} \tag{5},$$

where n is the number of observations and W is the spatial weights matrix. Hence, we use this index here to verify whether there is some spatial correlation between the dependency ratio and the income per capita lag, and following the same logic, whether income per capita and the demographic change lag are also spatially correlated.

The multivariate local autocorrelation can be defined by following the same rationale behind the definition of the global statistic (ANSELIN, 2002[40] *apud* CHIARINI, 2008):

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[39] Anselin, L. Under the hood issues in the specification and interpretation of spatial regression models. **Agricultural Economics**, v. 27, n. 3, p.247-267, nov. 2002.

[40] Anselin, L. Under the hood issues in the specification and interpretation of spatial regression models. **Agricultural Economics**, v. 27, n. 3, p.247-267, nov. 2002.

$$I_{kl}^{i} = z_k^i \sum_j w_{ij} z_l^j \quad (6)$$

We can interpret the multivariate LISA as the degree of linear association between the value of a variable in each region i and the mean of another variable in neighbouring regions j.

2.3.1.3 Convergence Analysis

The convergence of a variable is usually estimated by the equation that defines β-convergence. By taking into consideration the absolute convergence equation for the income per capita variable, as defined by Porsse (2008), we have the following specification:

$$g_i = \alpha + \beta y_{0,i} + \varepsilon_i \quad (7)$$

where g_i is the log of the income per capita growth rate, $y_{0,i}$ is the log of the initial income per capita of State *i*, and ε_i is the error term with normal distribution, zero mean and constant variance $N(0, \sigma^2)$.

According to Baumol (1986)[41] *apud* Perobelli *et al.* (2007), if β is negative, there is convergence, indicating that countries with a higher initial income will have lower growth rates, so the incomes of the different regions analyzed tend to be the same over time.

At first, the equation is estimated by OLS. If convergence is observed, one should check whether there is autocorrelation. If so, tests are performed to determine whether there is spatial dependence, as OLS estimators are then biased and inefficient, and according to Porsse (2008), it is then necessary to assess the effects of neighborhood on the estimation process in order to obtain an unbiased and efficient income convergence measure. In this case, it is necessary to verify what the best econometric specification is by taking into account the presence of autocorrelation and what variables play a determinant role in explaining income convergence.

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[41] BAUMOL, W. ***Productivity growth, convergence and welfare: what the long run data show.*** American Economic Review, v. 76, n. 1, pg. 1.072-1.075, 1986.

Albeit similar to correlation in the time domain, the distinct nature of spatial dependence requires a specialized set of techniques rather than a mere extension of two-dimensional time series (ANSELIN, 2010). Thus, spatial dependence models may have different specifications, such as the lagged dependent variable model, in which correlation affects the dependent variable, and the spatial error model, in which correlation affects the error term. Since many aspects of heterogeneity can be dealt with by standard methods, the discussion will focus on spatial dependence models and will only contemplate heterogeneity when it is of relevance.

Florax, Folmer and Rey (2003)[42] *apud* Resende and Silva (2007) suggest an approach for choosing an appropriate specification of the model to be estimated using the Lagrange multiplier (LM) tests. Therefore, the selection of the specification of the model must follow the steps below:

a) estimate the absolute convergence model according to equation 7 using OLS;
b) test the hypothesis of no spatial dependence due to the omitted spatial lag of the dependent variable (LM_ρ), due to the omitted autoregressive spatial error (LM_λ) or due to the omitted spatial lag of the independent variable (LM_φ);
c) if none of the tests in item b is significant, use the specification according to item a (equation5); otherwise, follow step d;
d) if LM_ρ is significant, but LM_λ and LM_φ are not, estimate the spatially lagged model (2.3.1.3.1);
e) if is significant, but LM_ρ and LM_φ are not, estimate the spatial error model (2.3.1.3.2);
f) if the two or three tests are significant, estimate the specification whose test value is higher.

Following these steps, one should choose the most suitable econometric model for representing the income growth rate and for checking which variables can explain it. In the present study, our aim is to investigate whether the population dependency ratio is a significant variable for explaining income growth rate. However, other variables that influence income, specified earlier, will also be used. We follow the specification of other

[42] Florax, R. J. G. M.; Folmer, H.; Rey, R. J. Specification searches in spatial econometrics: the relevance of Hendry's methodology. **Regional Science and Urban Economics**, v. 33, p. 557-579, 2003.

spatial autocorrelation models which, according to Resende and Silva (2007), are estimated by maximum likelihood: spatial lag model, spatial error model and independent spatial model.

2.3.1.3.1 Lagged Dependent Variable Model or Spatial Lag Model

Autocorrelation occurs in the dependent variable, introducing a lag of the dependent variable in the specification of the model as explanatory variable:

$$g = \alpha + \beta y_0 + \rho W g + \varepsilon \qquad (8)$$

where ρ, according to Resende and Silva (2007), is a spatial lag coefficient that captures the spillover effects of the income growth rates on neighbors and W is a spatial weights matrix[43].

2.3.1.3.2 Spatial Error Model

Autocorrelation occurs in the error term, which is specified according to equation (9):

$$\varepsilon = \lambda W \varepsilon + \mu \qquad (9)$$

where λ is a scalar of the error coefficient, μ is normally distributed with zero mean and constant variance $N(0, \sigma_\mu^2)$, and W is a spatial weights matrix. Substituting equation 9 into 7, we have the functional form of the spatial error model:

$$g = \alpha + \beta y_0 + (I - \lambda W)\varepsilon \qquad (10)$$

Thus, when $\lambda \neq 0$, there is autocorrelation in the error. According to Rey and Montouri (1999, *apud* Perobelli *et al*, 2007), when $\lambda \neq 0$, a shock to a geographical unit spreads not only to the immediate neighbors, but also to all other units of the considered space.

[43] This matrix is the same one defined for calculation of the Moran's I on the first test.

2.3.1.4 Conditional Convergence

After determining the absolute convergence model that best suits the analysis, other factors will likely influence the income convergence process. The association of income convergence with other factors is known as conditional convergence and it can be obtained by inserting an X matrix of independent variables in equation 7:

$$g_i = \alpha + \beta y_{0,i} + X\gamma + \varepsilon_i \tag{11}$$

2.4 RESULTS

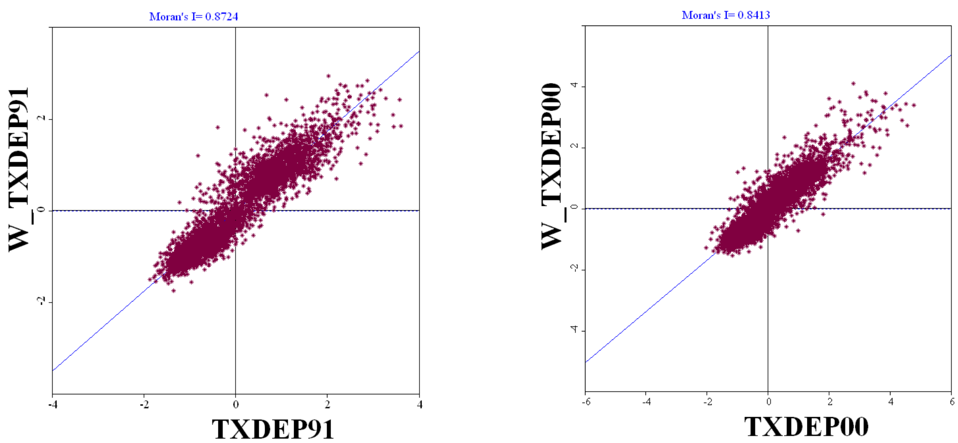
The univariate and bivariate spatial analysis was carried out using the Queen contiguity spatial weights matrix of order 1 (Queen 1). To select the matrix, Queen matrices of order 1 and 4 were compared while for k-nearest matrices, the mean of neighbours (4) was used and the standard deviation (3) was added one at a time, and so the orders of the k-nearest matrices were 4, 7, 10 and 13. The matrices of this type, as they are contiguity ones, were sequentially selected. Appendix 1 shows the Moran's indices for all analyzed variables and for all types of matrices. Note that there is no significant difference between the indices calculated for Queen 1 and k-nearest 4 matrices. In addition, the Spearman rank correlation coefficient calculated for all variables indicated a 100% significant correlation. As Queen 1 and K-nearest 4 matrices were not statistically different, we decided to use the Queen 1 matrix.

The Moran's indices were estimated for all variables and there was no significant difference in the values between the queen and rook matrices (in the latter type, only the regions on the boundary of a row or column are considered to be neighbors) and the values for both types decreased as the correlation rank increased, as expected, since closer regions tend to be more connected with each other. This way, as the queen matrix includes neighbours on the boundary of a diagonal and, therefore, more neighbours than the rook matrix, and as the values for both types did not show any differences, we chose to use the queen I matrix, which yielded higher values than higher ranked matrices.

2.4.1 Univariate Analysis

The univariate analysis indicates a strong positive relationship of spatial autocorrelation with dependency ratio (TXDEP[44]), estimated for years 1991 (TXDEP91) and 2000 (TXDEP00). From the results shown in Figure 1, it is possible to observe that there was a slight decrease in dispersion between 1991 and 2000[45], and the correlation decreased from 0.8724 to 0.8413. The global positive relationship of spatial dependence indicates that MCAs with a high dependency ratio have a high degree of neighborhood and vice versa. Therefore, the autocorrelation pattern indicates that the dependency ratio is characterized by the presence of spatial clusters in Brazil.

Figure 1 - Univariate Moran's I for the dependency ratio in Brazil– 1991 and 2000



Source: Prepared by the author with the use of Geoda Software (2011)

The analysis of LISA statistics for years 1991 and 2000 indicates that the spatial dynamics of the dependency ratio is stable in Brazil for this period, with two clusters[46]: an HH that consists of MCAs located in the northern and northeastern regions, and an LL in the southern regions (except the central-south region and northeast of Paraná), southeast (except north of Minas Gerais) and Midwest (southern half of Goiás). Hence, there is clearly a

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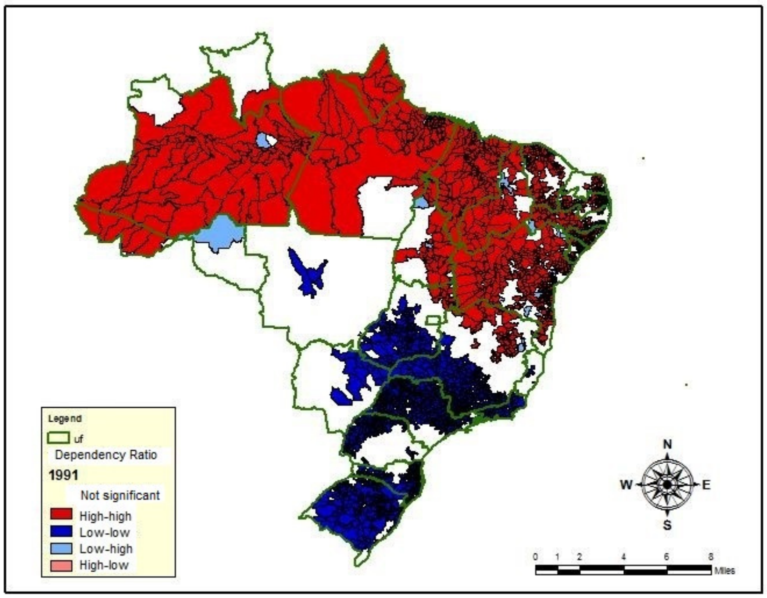
[44] The spatial lag variable is represented by W_TXDEP.

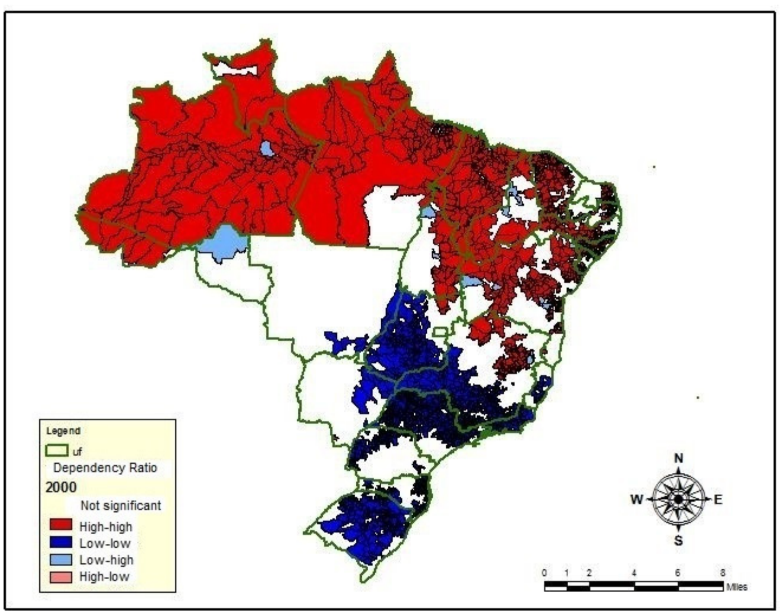
[45] Moran's graphs are on different scales. However, Moran's I shows standardized values of the variables (subtracted from the means and divided by the standard deviation), such that different scales can be associated with different variations in the variables.

[46] Moran's scatterplot contains four quadrants, each of which corresponds to a different type of spatial autocorrelation: positive values of Λ (lower quadrant on the left and upper quadrant on the right) indicate spatial clusters with similar values – High-High (HH) or Low-Low (LL), for instance, a region with high/low values surrounded by neighbors with high/low values, and negative values of Λ indicate clusters with different values – High-Low (HL) or Low-High (LH), regions with high/low values and neighbors with low/high values).

concentration of MCAs with a high dependency ratio in the north and northeastern regions and a concentration of MCAs with a low dependency ratio in the southern and southeastern regions and in some of the midwestern region.

Figure 2 - Dependency ratio clusters in Brazil – 1991 and 2000





Source: Prepared by the author with the use of Geoda and Arcview Softwares (2011)

This configuration indicates that the southern and southeastern regions are more advanced in the demographic change process, as they have a larger concentration of economically active individuals. Nevertheless, this finding can also be associated with migration as the economically active population tends to seek job opportunities in more dynamic regions, where prospects of employment are higher and wages tend to be higher as well.

The migration process, according to Rigotti (2006), initially attracted low-skilled people, particularly in Sao Paulo and Rio de Janeiro. However, it is taking place the return to the regions of origin (RIBEIRO, CARVALHO, 1998). Thus, the return of individuals less qualified (or metropolitan areas of ancient agricultural boundaries) into the country must have played a significant role in the migration process more currently (RIGOTTI , 2006) since the great transformations of the productive structure[47] have a reflection into the organization of the Brazilian space. Thus, the migration process occurs differently depending on the profile of the hand labor of the region and the characterization of productive activity (DINIZ, 1993).

Rigotti (2006) examined the migration process in the period 1986-1981 and 1995-2000, so that the latter period covers part of the analysis of this study. The author shows that the changes of the period were small but significant. The author divided the analysis between migration of people with high (15 or more years of schooling) and low education (04 years or less of schooling). Concerning the years 1995-2000, the first part of the analysis - people with high education - indicated that in the metropolitan area of Rio de Janeiro, the emigrants were destined for the North, while the metropolitan area of São Paulo distributes people to central areas of the Northeast, suggesting that the return migration to the interior may be occurring. Furthermore, the author concludes that in the late '90s, São Paulo started sending qualified emigrants to the interior of the own state rather than dynamic places like the Midwest. This would explain the fact that the Midwest may not be as advanced as the southern and southeastern regions regarding the process of demographic change. The second part of the analysis - people with low education - indicates that the metropolitan region of São Paulo remains the main destination of less qualified population in the Northeast. In addition, many regions containing urban centers of their respective states, across the whole country, are receiving migrants from their surroundings.

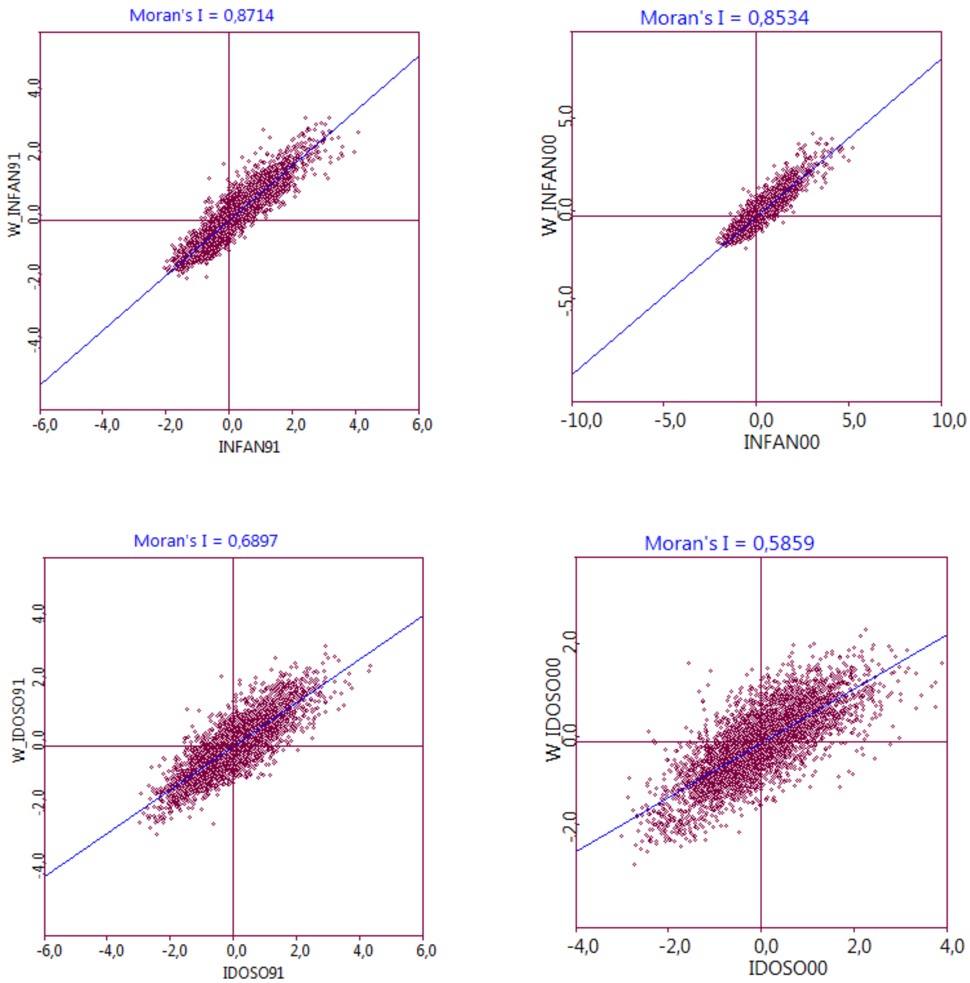
[47] Until 1970 the industry had focused on the production of durable consumer goods and basic industries, which depend on natural resources. Subsequently, there were technological demands, which now require qualification of manpower. Thus, the location of people came to be grounded in educational and research.

Given that the dependency ratio has two components (child population and aged population), the spatial profile of these components is likely different across Brazilian regions. So, we also try to assess the spatial association pattern for each of these components. Moran's indices for these components are shown in Figure 3 and the respective clusters, obtained by the application of LISA, are displayed in Figure 4. The child variable (INFAN) represents the dependency ratio of the child population while the aged variable (IDOSO) represents the dependency ratio of the aged population; the numbers 91 and 00 at the end represent the years 1991 and 2000, respectively and W_INFAN and W_IDOSO indicate the spatial lag of the variables. The Moran's I values in Figure 3 indicate that the global spatial correlation is stronger for the child population than for the aged one and, in addition, the spatial correlation values of the child population (INFAN) – 0.8714 and 0.8534 for 1991 and 2000, respectively–are similar to the dependency ratio value (TXDEP) shown in Figure 1. The spatial correlation for the aged population is lower and varies more often throughout the analyzed period (decreasing from 0.6897 to 0.5859), indicating, again, that the dependency ratio in the analyzed period tends to be more associated with the child component of the population.

The northern and northeastern regions have a high dependency ratio because they still have a lot of children in their age structure. This assumption is confirmed when we analyze the clusters of child population, as shown in Figure4, indicating a high concentration of child population in the northern and northeastern regions and a low concentration in the southern (except in the central-south region and in the northeast of Paraná), southeastern, and midwestern (southern half of Goiás) regions.

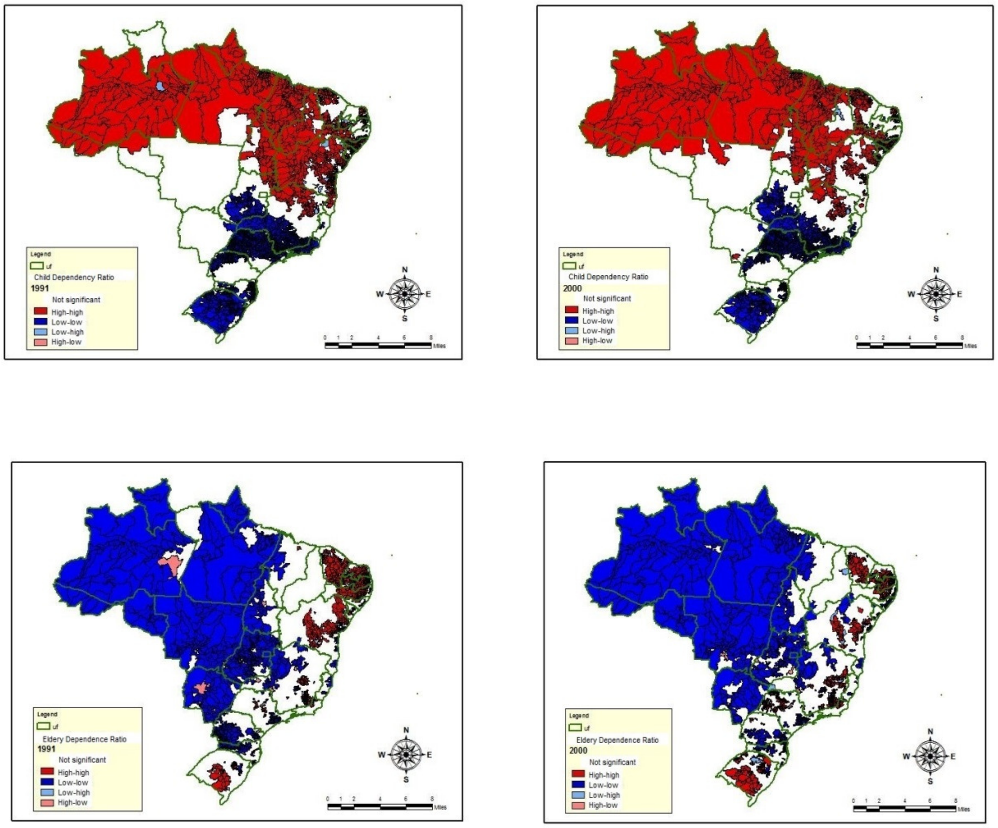
As the demographic change process advances, these maps tend to change, and so LL regions (which have a low dependency ratio) will have an ever-increasing number of aged people while HH regions will have more and more economically active individuals. Looking at the demographic change process, it is interesting to note the evolution of the aged population. Figure 4 shows that there is a low concentration of aged people in the northern and midwestern (except for Goiás) regions. However, the high concentration of aged people is still recent, and it is observed only in the central-south region of Rio Grande do Sul and in the states of Ceará, Rio Grande do Norte and Paraíba.

Figure 3 - Univariate Moran's dependency ratio components in Brazil – 1991 and 2000



Source: Prepared by the author with the use of Geoda Software (2011).

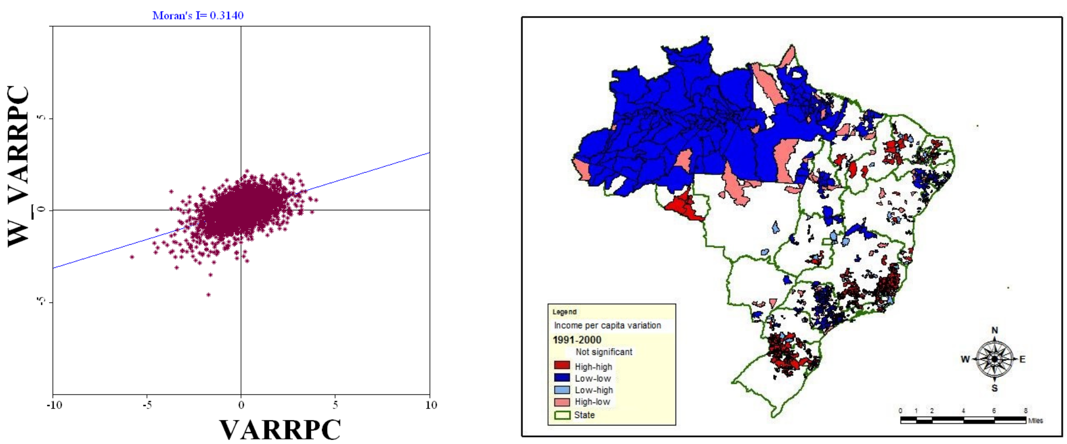
Figure 4 - Dependency ratio components clusters in Brazil – 1991- 2000



Source: Prepared by the author with the use of Geoda and Arcview Softwares (2011).

Taking into consideration a dynamic perspective for the income per capita (Figure5), its variation (VARPC) from 1991 to 2000 had a positive spatial autocorrelation, but this variation was smaller than that of the dependency ratio (Moran's I = 0.3140). The analysis of LISA indicates that the northern region had a low income growth in the analyzed period (LL cluster), and that this growth was larger mainly in the north of Rio Grande do Sul and in the central-eastern part of the southeastern region (two HH clusters). Even though the areas with the largest growth do not represent a single area as was the case of the dependency ratio, there is some similarity to the dependency ratio clusters observed previously, as the cluster with a high dependency ratio in the northern and northeastern regions, which indicates low predominance of the economically active population, had a smaller income growth, especially in the northern region whereas the cluster with a low dependency ratio in the southern and southeastern regions, which indicates large predominance of economically active people, corresponds to areas with higher income growth (except for São Paulo and Mato Grosso do Sul), chiefly in the southern region.

Figure 5 - Univariate Moran's I and income per capita variation clusters in Brazil from 1991 to 2000



Source: Prepared by the author with the use of Geoda Software (2011).

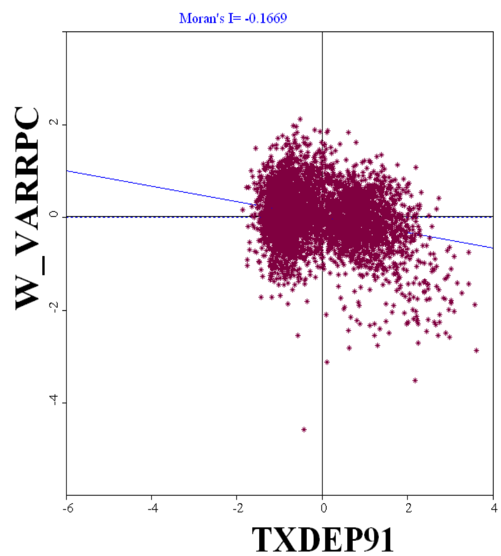
2.4.2 Bivariate Analysis

It is now necessary to determine whether there exists some relationship of spatial dependence between the dependency ratio (TXDEP) and income per capita variation (VARRPC). According to the literature, the relationship between dependency ratio and economic growth tends to be negative, as productivity, associated especially with the labor factor, tends to decrease as the population grows older. Since population aging also reduces the savings rate and implies larger social security expenditures, these factors strengthen the negative effects on growth.

To assess that, we used a bivariate analysis of spatial data between the variation in income per capita from 1991 to 2000 and the 1991 dependency ratio. The Moran's I results (Figure 6) demonstrate that the spatial correlation between these two variables is actually inverse. Although this association is not extremely strong, there is evidence that income per capita growth in the neighborhood of regions with a high dependency ratio tends to be lower than it would be otherwise.

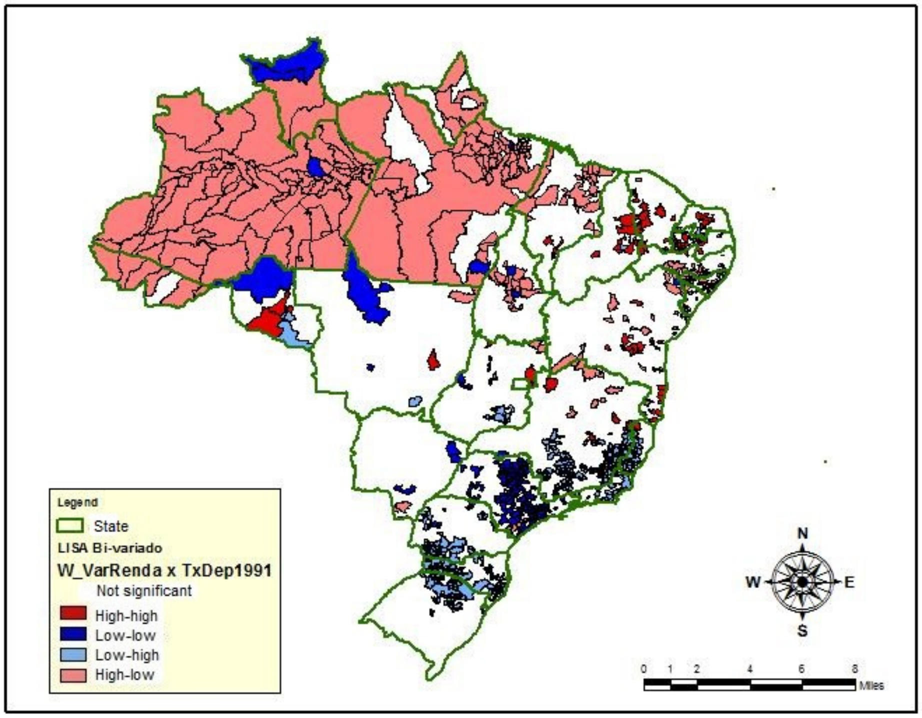
The local bivariate analysis identified HL clusters for the north, i.e., regions with a high dependency ratio are seen in the neighborhood of regions with a low income per capita growth (Figure 7). Two LH clusters were observed in the southern and southeastern regions, and therefore regions with a low dependency ratio are found in the neighborhood of those with a high income growth. Interestingly, several MCAs of São Paulo have a cluster with a low dependency ratio and neighboring regions with a low income growth. This finding may be due to the negative effects associated with spatial clustering.

Figure 6 - Bivariate Moran's I for the dependency ratio and for income per capita variation



Source: Prepared by the authors with the use of Geoda Software (2011).

Figure 7 - Dependency ratio clusters and income per capita variation clusters



Source: Prepared by the author with the use of Geoda Software (2011).

2.4.3 Convergence Analysis

The convergence analysis is divided into conditional income analysis and unconditional analysis of the dependency ratio.

2.4.3.1 Conditional Income Analysis

The conditional income analysis follows the specification of equation 9, whose independent variables are the overall dependency ratio (TXDEP91) – model 1, and the child dependency ratio (INFAN91) and the aged dependency ratio (IDOSO91) – model 2. The independent variables, as well as the income per capita, are computed at baseline (1991). The results of the OLS estimation, spatial lag model and spatial error model can be seen in Tables 1 and 2, respectively.

Table 1 - Conditional income analysis - OLS

Parameters	Coefficients	
	Model1	Model2
α	0.9979*	0.9977*
β	-0.0016	-0.0016
TXDEP91	-0.0021*	
INFAN91		-0.0021*
IDOSO91		-0.0020*
Adjusted R^2	0.2441	0.2440
AIC	-12160.1	-12158.1
Spatial dependence tests		
I-Moran	42.8942*	42.9246*
Robust LM (lag)	9.7916*	9.8147*
Robust LM (error)	466.1724*	465.6229*
Heteroscedasticity tests		
Breusch-Pagan	128.6724*	230.4603*
Koenker-Bassett	63.7944*	114.2361*
White	169.2554*	331.1768*

Source: Prepared by the author with the use of Geoda Software (2013).
*significant at 1%, **significant at 5%, ***significant at 10%.

Table 2 - Conditional income analysis – Spatial lag and spatial error models

Parameters	Coefficients			
	Spatial lag		Spatial error	
	Model1	Model2	Model1	Model2
α	0.5448*	0.5515*	1.2365*	1.2296*
β	-0.0105*	-0.0113*	-0.0315*	-0.0309*
TXDEP91	-0.0015*		-0.0034*	
INFAN91		-0.0015*		-0.0034*
IDOSO91		-0.0017*		-0.0028*
ρ	0.5377*	0.5380*		
Lambda			0.6642*	0.6660*
R^2	0.4350	0.4352	0.4999	0.5005
AIC	-13151.7	-13150.5	-13515.6	-13515.5
Spatial dependence tests				
Likelihood Ratio Test	993.6745*	994.424*	1355.542*	1357.413*
Heteroscedasticity tests				
Breusch-Pagan	19.1494*	79.5709*	21.6274*	66.6469*

Source: Prepared by the author with the use of Geoda Software (2013).
*significant at 1%, **significant at 5%, ***significant at 10%.

Tables 1 and 2 confirm the statistical significance of a long-term income equalization trend (β – convergence) and that demographic change influences this process. The convergence rate was 0.16% for the OLS model, 1.05 to 1.13% for the spatial lag model and 3.09 to 3.15% for the spatial error model. The low convergence rate for the OLS estimation may be associated with the presence of spatial dependence, as indicated by the tests in Table 1 for both spatial lag and spatial error models, showing that the effects of neighborhood should be taken into account in the estimation process in order to obtain an accurate estimate of income convergence rate. In addition, the convergence coefficient for the OLS estimation was not significant.

The spatial error model yielded a higher determination coefficient than that of the spatial lag model, demonstrating that it explains income dynamics better. The positive value of ρ indicates that shocks have a positive spatial autocorrelations. However, the low coefficient value indicates that this analysis only illustrates the income convergence behavior conditional on demographic change, but there are other factors that influence this relationship, such as education, population density, population growth, capital, among other ones suggested by the economic growth literature, which will be dealt with further on. Moreover, the likelihood ratio test in Table 2 indicates that neither the spatial lag model nor the spatial error model eliminates spatial dependence completely, indicating that some other factors influence income convergence and/or that spatial dependence can be better modeled by some other specification, perhaps a combination of spatial lag and spatial error models.

According to the procedure of Florax, Folmer and Rey (2003)[48] *apud* Resende and Silva (2007) explained in the methodology section, the estimation must follow the model with the highest LM test result. In this case, the best specification for the income convergence model conditional on demographic change, using an MCA database, would be the spatial error model. This result is also probably related to the higher determination coefficient and to the fact that the convergence rate is the one that most closely resembles the actual rate.

2.4.3.2 Unconditional analysis of the dependency ratio

The unconditional analysis of the dependency ratio was carried out for the overall dependency ratio, its child component and its old-age component. The estimated equation

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[48] Florax, R. J. G. M., Folmer, H., and Rey, S. J. (2003). Specification searches in spatial econometrics: The relevance of Hendry's methodology. Regional Science and Urban Economics, 33, 557–579.

follows equation 7, but the dependent variable is the dependency ratio growth rate (and the growth rates of the child and old-age dependency ratios for the other models) and the explanatory variables are a constant and the log of the dependency ratio at baseline (and the log of the child and old-age dependency ratios for the other models). The results are displayed in Tables 3 and 4.

Table 3 - Unconditional analysis of the dependency ratio – OLS

Parameters	OLS coefficients		
	Dependency ratio	Child dependency ratio	Aged dependency ratio
α	5.7768*	1.7770*	7.5697*
TXDEP91	-1.8703*		
INFAN91		-1.0610*	
IDOSO91			-2.7127*
Adjusted R^2	0.2695	0.0874	0.2187
AIC	9590.27	10501.7	16814.8
Spatial dependence tests			
Moran-I	42.7016*	46.3473*	40.5844*
Robust LM (lag)	45.7013*	36.2505*	0.0024
Robust LM (error)	400.4723*	206.4296*	238.4499*
Heteroscedasticity tests			
Breusch-Pagan	227.4982*	227.8178*	247.487*
Koenker-Bassett	116.0777*	125.3609*	108.4512*
White	152.874*	166.8176*	187.0261*

Source: Prepared by the author with the use of Geoda Software (2013).
*significant at 1%, **significant at 5%, ***significant at 10%.

Table 4 - Unconditional analysis of the dependency ratio - Spatial lag and spatial error models

Parameters	Coefficients					
	Spatial lag			Spatial error		
	Dependency ratio	Child dependency ratio	Aged dependency ratio	Dependency ratio	Child dependency ratio	Aged dependency ratio
α	3.4493*	1.3938*	4.4402*	7.6700*	4.0162*	7.7439*
TXDEP91	-1.0447*			-2.3243*		
INFAN91		-0.5752*			-1.6016*	
IDOSO91			-1.6915*			-2.7793*
ρ	0.5543*	0.6237*	0.5500*			
Lambda				0.6382*	0.6673*	0.6155*
R^2	0.4577	0.3829	0.4188	0.5018	0.4127	0.4488
AIC	8586.1	9183.65	15815.1	8325.77	9032.28	15664.1
Spatial dependence tests						
Likelihood Ratio Test	1006.168*	1320.051*	1001.729*	1264.494*	1469.42*	1150.649*
Heteroscedasticity tests						
Breusch-Pagan	51.3559*	49.0604*	389.3924*	44.9551*	42.5956*	364.1124*

Source: Prepared by the author with the use of Geoda Software (2013).
*significant at 1%, **significant at 5%, ***significant at 10%.

The conditional convergence analysis of the dependency ratio indicated the presence of convergence of the spatial dependence rate and of its child and old-age components, indicating that demographic change tends to even out in the long run. The spatial dependence test demonstrated that, except for the old-age dependency ratio for the spatial lag model, spatial dependence was significant for all variables.

The determination coefficient for the three types of estimation (OLS, spatial lag and spatial error models) was higher for the overall dependency ratio, then for the old-age component, and finally for the child component. This finding is probably associated with the demographic change process itself, in which the old-age component tends to be more relevant in the long run.

The autoregressive spatial coefficient value was higher for the spatial error model. The Akaike (AIC) criterion was smaller for this type of model in all specifications, thus indicating that the spatial error model is apparently the most appropriate model, even though the likelihood ratio test still indicates the presence of spatial dependence for spatial lag and spatial error models.

2.5 CONCLUSION

Brazil has undergone a peculiar demographic change process, in which the percentage of the child population has been decreasing while that of the economically active population has increased. This demographic transition will imply the aging of the Brazilian population in the future.

In this paper, we sought to assess the spatial pattern of this demographic change process as well as its relationship with income per capita growth from a spatial perspective, using MCAs as territorial unit of analysis. The literature suggests that the population aging process is associated with the lower pace of economic growth due to several factors, such as reduction of labor productivity, reduction of investments, and increase of social security expenditures, with a heavier tax burden for the current economically active individuals.

The univariate ESDA results showed a dichotomous north-south spatial pattern for the dependency ratio. In brief, the MCAs of the northern and northeastern regions belong to a cluster characterized by a high dependency ratio whereas the MCAs of the southern and southeastern regions and some of the central-western region belong to a cluster characterized by a low dependency ratio. Note that this spatial pattern was relatively stable from 1991 to 2000 and that there is a predominance of the child component in the dependency ratio. In the upcoming decades, this pattern may change due to the population aging trend and also to other factors, such as migration.

The univariate ESDA applied to the income per capita growth variable also pointed out a positive spatial correlation, but weaker than that obtained for demographic components. In this case, the MCAs of the northern region and some parts of São Paulo indicated a cluster with low economic growth. One should recall that the variable used in the study represents income ownership rather than income generation, usually measured by GDP.

On the other hand, bivariate ESDA results showed the existence of a spatially inverse relationship between dependency ratio and income per capita growth. Therefore, although this relationship is not very strong, there is some evidence that locations in the neighborhood of regions with a high dependency ratio tend to have a slower income per capita growth rate and vice versa. This finding is consistent with that obtained by Prskawetz and Lindh (2007), especially because the child component predominates over the magnitude of the dependency ratio in Brazil. According to LISA results, most of the MCAs of the northern region fit into a cluster with a high dependency ratio and low income per capita growth. The opposite (low dependency ratio and high growth rate) occurs for some clusters in the three southern states and in Minas Gerais and in Espírito Santo. A cluster with a low dependency ratio and low income per capita growth rate located in São Paulo is noteworthy. The phenomenon may result from saturated growth in these areas due to negative clustering effects.

In an attempt to statistically confirm the relationship between economic growth and the dependency ratio, we conducted a convergence analysis of income conditional on the dependency ratio. The result is in line with ESDA, indicating that there is income convergence when demographic factors are present. Spatial dependence was significant in virtually all models, highlighting the importance of spatial factors in this study. However, the estimated spatial lag and spatial error models were not enough to correct for spatial dependence, suggesting that a mixed model or a more sophisticated estimation method should be used.

In summary, the results of the present paper show evidence that the spatial pattern of the demographic change process in Brazil is asymmetric regionally. This pattern, whose nature reflects a north-south dichotomy, is akin to the income inequality pattern. Given this evidence, in addition to an inverse spatial relationship between dependency ratio and income per capita growth, we observe that demographic characteristics also seem to play an important role in explaining the differences in income level and dynamics in the Brazilian regional context.

To conclude with, we must say that this paper is part of a more comprehensive research effort that seeks to investigate the demographic conditions of income inequality and regional income convergence in Brazil. In this first assay, the paper searched evidence through the use of ESDA. The next step would be to assess the role of these demographic components by estimating a conditional income convergence model using spatial econometrics.

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2.7 APPENDIX

Moran's I for Queen and K-nearest matrices

	TXDEP91	TXDEP00	INFAN91	INFAN00	IDOSO91	IDOSO00
QUEEN1	0.8724	0.8413	0.8714	0.8534	0.6897	0.5859
QUEEN2	0.8229	0.7704	0.8216	0.7864	0.5781	0.4658
QUEEN3	0.7782	0.708	0.7759	0.7265	0.4936	0.374
QUEEN4	0.7432	0.6536	0.738	0.6719	0.4376	0.3087
KNEAREST4	0.8908	0.8503	0.8887	0.8615	0.7133	0.6156
KNEAREST7	0.8785	0.8329	0.8768	0.8444	0.679	0.582
KNEAREST10	0.869	0.8212	0.8664	0.833	0.6568	0.5544
KNEAREST13	0.8618	0.8121	0.8582	0.8236	0.6388	0.5333

Source: Prepared by the author with the use of Geoda Software (2013).

3 ARTICLE 2 - DEMOGRAPHIC CHANGE AND REGIONAL ECONOMIC GROWTH IN BRAZIL

Abstract
The Brazilian economy has had a very fast demographic transition because fertility and mortality rates have significantly decreased over the last decades. Additionally, the spatial pattern of the demographic structure is not homogenous across regions. In this paper we investigate whether demographic change plays a role in the dynamics of regional economic growth in Brazil through the estimation of convergence equations conditioned by demographic variables. The extent to which demographic change affects regional economic growth and its robustness are investigated using different econometric methods. The estimated effect of child and aged dependency ratios on regional economic growth is negative, whereas the working-age population has a positive effect. According to the spatial distribution of per capita income and the dependency ratio, demographic change can contribute to the reduction of regional inequality in Brazil. However, this result also is consistent with less economic growth for the entire country due the ageing of the population.

Keywords: Demographic change. Regional growth. Convergence. Inequality. Spatial dependence.

3.1 INTRODUCTION

The regional structure of the Brazilian economy can be characterized by high and persistent inequality. For instance, the Northeast is the poorest region of Brazil; its per capita income, however, accounted for 48.3% of the national per capita income in 1970 and for 61.5% in 2010. These data suggest the existence of dynamic convergence across Brazilian regions, which seems to be very slow. In fact, Azzoni (2001) showed that the speed of convergence for Brazilians states is 0.68% per year in the case of absolute convergence and 1.29% in the case of conditional convergence. Therefore, total equalization of per capita income across Brazilian states would be achieved only after several decades.

Many other empirical studies have been undertaken to identify the forces acting on regional growth and convergence in Brazil. Some studies show that initial conditions such as physical and human capital, industrialization, and infrastructure do matter for the dynamics of regional growth (BARRETO; ALMEIDA, 2008; CANÊDO-PINHEIRO; BARBOSA FILHO, 2011; COELHO; FIGUEIREDO, 2007; GONDIM; BARRETO; CARVALHO, 2007; MAGALHÃES; MIRANDA, 2009). Geographical aspects such as location, agglomeration, and spatial dependence also seem to be important for the dynamics of convergence across Brazilian regions (SILVEIRA-NETO, 2001; SILVEIRA-NETO, AZZONI, 2006; RESENDE, 2011).

Recently, the literature on endogenous economic growth models has sought to gain a better insight into the relationship between demographic factors and income convergence (FUKUDA; MOROZUMI, 2004; PRETTNER; PRSKAWETZ, 2010). Most studies usually assume that population size and its growth rate are associated with economic growth and do not take into account the population age structure and its changes over time. As fertility and mortality rates have significantly decreased over the last decades but as countries have differences in their demographic transition process, it seems important to take into account demographic factors as another force influencing the economic dynamics across countries. A more detailed specification of demographic factors in growth models, for instance, population age structure, is relevant because the agent's decisions change over the life cycle. The literature assumes that the channels linking demographics with economic growth would be associated with the effect of demographic change on consumption preferences, savings decisions, labor supply and productivity of the workforce, and the need for more public expenditure to support pension systems.

In this paper we investigate how demographic factors can influence the economic dynamics of Brazil from a regional perspective. The empirical literature has ignored the potential role of demographic factors in regional economic growth in Brazil. As it has been in other countries, demographic transition has rapidly evolved in Brazil because the fertility and mortality rates of the population have significantly decreased over the past decades. The ageing of the population is not yet the main characteristic of the Brazilian age structure, but it will certainly be in a few decades. Important differences across Brazilian states can be observed in terms of their demographic structure, but the effects on the regional economic dynamics are not yet known. Therefore, the aim of this paper is to investigate whether demographic change plays a role in the dynamics of regional economic growth in Brazil. The sensitivity of demographic parameters is also evaluated through different specifications for the convergence equation and with the use of different estimation methods.

The paper is organized into six sections, including this introduction and the final remarks. Section 3.2 presents a brief review of the theoretical and empirical literature on economic growth models, highlighting the role of demographic factors. Section 3.3 explores the characteristics of the population age structure and demographic change across Brazilian regions over the past 40 years. Section 3.4 discusses the methodological procedures, and section 5 reports and analyzes the results.

3.2 LITERATURE REVIEW

There are different theoretical perspectives on the issue of income convergence, but the main ones are those of the neoclassical and the endogenous growth models. The classical model proposed by Solow (1956) and Swan (1956) went on to become the landmark study of economic growth, since it served as a source of inspiration for many other models that emerged in the literature, from which new features are incorporated or simply the existing characteristics are modified.

Solow explored the role of technological change in the U.S. economy in the 1909-1949period and concluded that approximately 90% of its growth could be attributed to the technological factor; actually, only the production factors (capital and labor)[49] do not sustain the long-term economic growth rate, indicating that this rate is exogenous in the sense that it is not determined by the model (JONES, 2000). Thus, technology, inserted exogenously into the model, known as the Solow residual, is the responsible factor for the growth of the economy. It is important to emphasize that this result is also found in other models, the so-called endogenous growth models, in which technology is treated endogenously. In this sense, the economic growth model of Robert Solow inspired many other models that have emerged in the literature.

Several other studies evaluate economic growth, searching for an endogenous explanation, such as those carried out by Lucas (1988) and Romer (1990). According to the former author, it is necessary to postulate appropriate variations in the parameters related to technology and preferences. This adjustment reflects the mobility of factors so that it is no longer possible to pay them for their marginal productivities, since the world is not competitive. This seems to be the major distinction between what the neoclassical theory predicts and the pattern of trade observed. Using a similar technique to that used in the models of Arrow (1962), Uzawa (1965), and Romer (1986), Lucas extends the neoclassical model by adding what Schultz (1963) and Becker (1964) called “human capital,” in order to address these aspects. The increase in productivity is explained by economic incentives, such as higher returns for higher levels of education. Thus, an economy with more human capital grows faster, because higher levels of education have incentives in the form of higher returns, having a positive impact on the wages of individuals.

[49] It is assumed that the output function has constant returns to scale, implying that when both production factors are increased together, the product increases proportionally.

The development of endogenous models gave rise to new theories of endogenous economic growth, which differ from the original model of Solow by their use of increasing returns to scale (CLEMENTE; HIGACHI, 2000; MARTIN; SUNLEY, 1998). These theories can be classified into two groups: the first includes the models of Lucas, (1988), Romer (1986), and Rebelo (1991), in which technology is a public good (except for Lucas), whereas the second one, the neoclassical-Schumpeterian models of endogenous growth, includes the models of Romer (1990) and Aghion and Howitt (1993), in which technology is a general good subject to appropriation, introducing the idea of imperfect competition. The model of Rebelo (1991) is an example of linear models, which assume that physical capital, human capital, and research are the basic sources of economic growth, adding these factors in a broad measure of capital, so that the output is a linear function of the capital measure. The neoclassical-Schumpeterian models attribute the key role in explaining economic growth in the long run to innovation. Technological progress is explained by the pursuit of higher profits. Considering imperfect competition, investment in research and development (R&D) allows the creation of a variety of new products with higher quality, ensuring profitability.

The analysis of the relationship between the change in demographic structure and in economic growth is recent in the literature. Previously, the population variable was limited by the extent of its total growth and size, considering the population age structure to be constant. However, several authors, mainly from the 1990s, have studied the relationship between these variables, since the change in demographic structure is a significant variable for explaining economic growth. As to the implications of the process of demographic change for the economic sphere, Miles (1999) mentions its impact on the rate of savings, capital formation, labor supply, interest rate, and real wages. Wong and Carvalho (2006) deem the impact on labor supply to be important, since the active working-age population (25-64 years old) will grow at least until 2045. Nevertheless, this supply of labor can only be explored if the productivity of this population is developed, maintaining the economic, social, and intergenerational balance.

Prettner and Prskawetz (2010) present an extensive review of the theoretical literature on economic growth models that deal with changes in the age structure of the population. Their review shows that the effect of demographic change on economic growth can be positive or negative depending on the framework of each study. Population ageing can have a positive impact on economic growth if the savings of the working-age population increase in order to support future consumption or if R&D investments increase relative to the size of the workforce. However, the impact could be negative if population ageing is conditioned on declines in fertility coupled with a reduction in population growth or if the pension system share is formulated in such a way that the ratio of work force to retirees decreases.

The ambiguity regarding the effect of population ageing on economic growth is also very clear in the overlapping generations model with capital accumulation and uncertain lifetime horizon developed by Fukuda and Morozumi (2004). Their results suggest that a large share of the output is consumed by non-productive factors when the proportion of the elderly population is large, producing a negative impact on economic growth. However, countries with a high aged dependency ratio tend to have a high life expectancy and allow rate of population growth, which contribute to increasing the savings rate of the working-age population and enhancing economic growth. Thus, the effective impact of population ageing on economic growth would not be certainly clear and would depend on the relative combination of these sources. The cross-country panel analyses carried out by Fukuda and Morozumi (2004) found evidence of a positive effect between the aged dependency ratio and economic growth.

Other empirical studies have analyzed the relationship between the components of population and economic growth per worker. According to Prskawetz and Lindh (2007), the child dependency ratio seems to be significantly and negatively related to economic growth. Evaluating the role of demographics for Europe, Kelley and Schmidt (2005) also found that the decline in the child dependency ratio had a strong positive effect on the rate of growth of output per worker during the 1970s and 1980s. The general conclusion from these analyses is that, regardless of the method applied and the set of additional control variables considered, the relationship between the economic growth rate and demographic change seems to be robust.

In Brazil, the empirical literature on economic growth has mainly investigated the existence of convergence across regions and the importance of some factors suggested by the theoretical models, such as physical and human capital, as well as other structural characteristics of each region, such as agglomeration, industrialization, and infrastructure (BARRETO; ALMEIDA, 2008; CANÊDO-PINHEIRO; BARBOSA FILHO, 2011; COELHO; FIGUEIREDO, 2007; GONDIM; BARRETO; CARVALHO, 2007; MAGALHÃES; MIRANDA, 2009). Other studies have explored the importance of geographical aspects, such as spatial dependence on income convergence in Brazil (AZZONI *et al.*, 2000; SILVEIRA-NETO, 2001; SILVEIRA-NETO; AZZONI, 2006; RESENDE, 2011).

Little attention has been devoted to investigating the importance of demographic change as a potential source explaining the economic dynamics across Brazilian regions. A first study carried out by Azzoni, Menezes-Filho, and Menezes (2005) using microeconomic data – household surveys – suggests that demographic structure matters for regional growth, because the speed of income convergence varies considerably across birth cohorts and the demographic structure tends to differ across regions. Menezes, Silveira-Neto, and Azzoni (2011) have also emphasized the effects of demographic factors on regional inequality in Brazil, analyzing the income convergence for age cohorts. According to this study, income convergence would only exist for the older generations. Moreover, such a convergence would be explained mainly by retirement payments, pension payments, and other government transfers, and would not be observed when these transfers are controlled in the analysis.

In the present study, we investigate the role of demographic change in the economic growth of Brazilian states by estimating the income convergence equation that explicitly addresses demographic variables. Thus, this analysis is expected to reveal the extent to which demographic change is effectively correlated with regional growth and inequality in Brazil.

3.3 THE PATTERN OF INEQUALITY AND DEMOGRAPHIC CHANGE IN BRAZIL

In this paper, we look at demographic change as a potential channel to explain regional economic growth in Brazil, a country characterized by strong regional inequalities. Table 5 presents the extent of regional concentration and inequality in Brazil through the share of each region in the national income and the ratio of the average per capita income of each region to the national average per capita income. In 1970, the income in the Northeast region was 14.6% of national income, whereas that of the North reached only 2.9% of the national total. In terms of inequality, whereas the Northeast presented an average per capita income of 48.3% below the national average, the North reached 65.6%; only the Southeast had an income that was substantially above the national average. In 2010, regional inequality changed for the North and the Northeast regions, while income in the Southeast, South, and Central West regions was above the national average.

In terms of demographic structure, Brazil has experienced significant changes over the last decades. The decrease in birth and mortality rates has contributed to boosting demographic transition in Brazil. Figure 8 presents the evolution of the dependency rate[50] and

[50] The dependency ratio calculated by IBGE considers the population under the age of 15 and over the age of 64 relative to the population over the age of 14 and under the age of 65. Consequently, the child and aged

the child and aged components from 1940 to 2050, considering the population projections calculated by the Brazilian Institute of Geography and Statistics (IBGE). The total dependency ratio decreases sharply from 1970 and must remain so until 2020, starting to increase thereafter. The preponderance of child participation in the dependency ratio is very clear, but the ageing of the Brazilian population tends to become more prominent each year and will govern the dependency ratio after 2030. As the working-age population is expected to achieve the biggest participation of population in 2020, the role of demographic bonus in enhancing economic growth seems to have a short period of time to be effective.

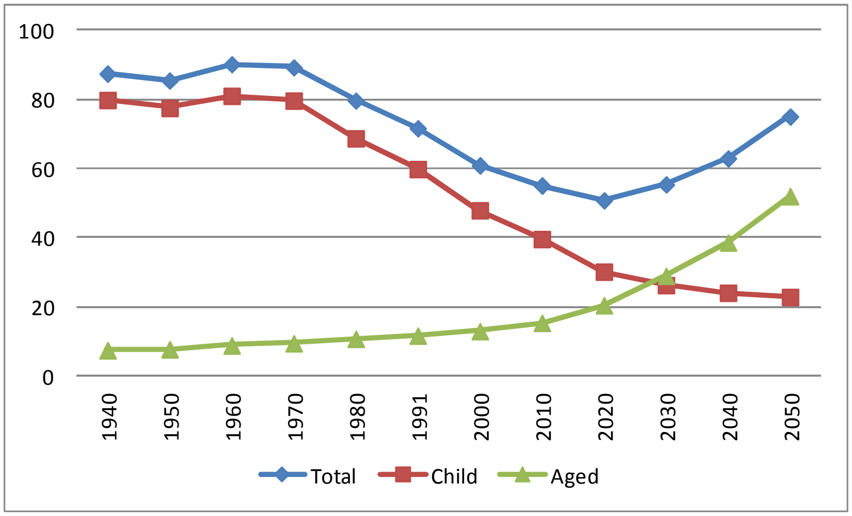
Table 5 - Income and Income per capita for Brazilian Regions

Regions	Income[a]		Population		Income per capita[b]	
	1970	2010	1970	2010	1970	2010
Brazil	100.0	100.0	100.0	100.0	100.0	100.0
North	2.9	4.7	4.4	8.3	65.6	69.2
Northeast	14.6	15.8	30.2	27.8	48.3	61.5
Southeast	62.2	52.7	42.8	42.1	145.5	119.5
South	16.1	17.9	17.7	14.4	90.8	113.1
Central West	4.2	8.9	4.9	7.4	86.1	117.0

Source: elaborated by the author with data from IBGE and IPEA (2012).
[a] Ratio of the income of each region to the national income.
[b] Ratio of the income per capita of each region to the national income per capita.

dependency ratios correspond respectively to the population participation under the age of 15 and over the age of 64.

Figure 8 - Dependency ratio for Brazil, 1940-2050



Source: IBGE, Demographic Census 1940-2000 and Population Projections for Brazil 1980-2050, revised in 2008.

The demographic transition at the regional level has been similar to the national tendency, but the demographic structure and its dynamics are not totally homogenous across Brazilian regions as shown by the data presented in Table 6. The child dependency ratio represents most of the total dependency for each region, but it is more important for the North and the Northeast. The child dependency ratio for these regions has remained systematically above the national ratio while the opposite occurs for the Southeast. In the case of the South and the Central West, the child dependency ratio is initially above the national ratio in 1970 but ends up below the national ratio in 2010. It is worth noting that the current pattern of the regional child dependency ratio somehow replicates in some way the North/Northeast versus South/Southeast polarization also observed in the per capita income inequality, suggesting a negative correlation.

Table 6 - Dependency ratio of population for Brazilian regions, 1970-2010

Regions	1970	1980	1991	2000	2010
Dependency ratio					
Brazil	82.4	73.1	65.4	55.0	45.9
North	96.4	95.4	83.7	69.3	55.7
Northeast	93.7	91.5	80.1	63.5	50.9
Southeast	72.8	62.1	57.1	49.4	42.5
South	83.9	66.9	58.5	50.9	42.7
Central West	88.8	77.4	62.7	51.9	43.5
Child dependency ratio					

Brazil	76.6	66.1	57.5	45.9	35.1
North	92.0	90.0	78.1	63.1	48.6
Northeast	87.5	83.1	71.0	54.0	40.1
Southeast	66.8	55.3	49.0	39.9	30.9
South	78.6	60.5	50.6	41.5	31.2
Central West	85.2	72.7	57.4	45.5	35.1
Aged dependency ratio					
Brazil	5.8	7.0	8.0	9.1	10.8
North	4.4	5.4	5.5	6.2	7.1
Northeast	6.2	8.4	9.1	9.5	10.8
Southeast	6.0	6.8	8.1	9.5	11.5
South	5.4	6.4	7.9	9.4	11.6
Central West	3.7	4.7	5.3	6.5	8.4

Source: elaborated by the author with data from IBGE, Demographic Census 1970-2010 (2012).

In the case of the aged dependency ratio, only the ratios of the Northeast and the Southeast were above the national ratio in 1970. In 2010, however, only the aged dependency ratio of the Southeast remained above the national ratio, and it included also the South. As to the Northeast region, the aged dependency ratio seems to converge towards the national ratio. Although not well defined as in the case of the child dependency ratio, the North/Northeast versus South/Southeast polarization observed in per capita income inequality also has been replicated for the case of the aged dependency ratio. The difference in this case lies in the position of the regions, since the correlation between the aged dependency ratio and per capita income inequality seems to be positive.

These results imply that the demographic transition process tends to occur more quickly for the South and the Southeast. As mentioned before, demographic change can affect the growth dynamics by way of several channels, and demographic change could be another source to explain the dynamics of regional inequality in Brazil. Thus, the relevance of this source is empirically investigated through the estimation of convergence equation models for the Brazilian states, as discussed in the next section.

3.4 METHODOLOGICAL PROCEDURES

The methodological approach used to investigate whether demographic change plays a role in the economic dynamics of Brazilian states follows the usual specification of the convergence equation as a panel data regression presented in Durlauf *et al.* (2005). In the conditional form, β-convergence is evaluated through a regression where the growth rates of per capita income are the dependent variable and the initial values of the income per capita level and other variables representing the structural characteristics of each region are the independent variables. The general dynamic panel data specification for the convergence equation used in this study is represented as follows[51]:

$$g_{i,t} = \beta y_{i,t} + \delta X_{i,t} + \mu_i + \varepsilon_{i,t} \tag{12}$$

where $g_{i,t}$ represents a vector with observations for average per capita income growth rates for each state i in each decade t (i = 1, …, 27; t = 1970s, 1980s, 1990's)[52]. Moreover, $y_{i,t}$ is the initial income per capita, $X_{i,t}$ is a vector of explanatory variables containing those determinants suggested by the growth literature, μ_i are the individual-specific effects, and $\varepsilon_{i,t}$ is the vector of error terms. The individual-specific fixed effect model has the advantage of dealing with the problem of omitted variables associated with fixed effects related to heterogeneity across regions and that are constant over time. As noted by Islam (1995), the fixed effect panel model would be superior to the pooled panel model because the former allows for differences in the aggregated production function across regions.

The first-difference formulation derived from equation (12) can also be adopted to handle the issue of omitted variables, since the term μ_I is eliminated. In this specification, equation (12) is reformulated as follows:

$$\Delta g_{i,t} = \beta \Delta y_{i,t} + \delta \Delta X_{i,t} + \varepsilon_{i,t} - \varepsilon_{i,t-1} \tag{13}$$

Although the problem of omitted variables is not presented, this specification presents endogeneity because the lagged term in the first component is correlated with the lagged error term. The first-differenced generalized method of moments (GMM) developed by Arellano and Bond (1991) would be an alternative procedure to be used, but Bond *et al.* (2001) showed that the lagged first-difference of the explanatory variables can be weak instruments for the explanatory variables in equation (2). As a consequence, the coefficient variance increases asymptotically and the coefficients can be biased in small samples. To reduce these problems, Blundell and Bond (1998) developed the system GMM (SYS-GMM) estimator where the

[51] As can be observed, the dynamic structure comes from the following equivalent formulation of equation (1): $y_{i,t+1} = (1+\beta)\, y_{i,t} + \delta X_{i,t} + \mu_i + \varepsilon_{i,t}$.

[52] The average per capita income growth rates were calculated using a formula equivalent to $(\ln y_{i,t+1} - \ln y_{i,t})/10$. The per capita income data come from the demographic census for the 1970-2000 period, for which data are available for 1991 but not for 1990. Thus, the denominator of that formula is 10 only for 1970-1980, 11 for the 1980-1991, and 9 for 1991-2000.

instruments for the regression in differences (in levels) are the lagged levels (differences) of the explanatory variables.

It is worth noting that there are other potential sources of endogeneity in the context of growth models related to variables such as human capital and demographic factors. The growth dynamic can be influenced by human capital, and human capital accumulation can be influenced by the income dynamics. Additionally, as demographic factors can indirectly affect economic growth, economic growth can also affect the demographic factors in the sense that the working-age population can be attracted to the regions with faster growth dynamics.[53]

These aspects suggest the endogeneity problem cannot be ignored, enhancing the need to use the SYS-GMM approach to estimate the convergence equation.

We are particularly interested in evaluating the contribution of the demographic variables to the economic dynamics of the Brazilian states as well in evaluating their robustness to different estimation methods. We used three different model specifications to estimate the convergence equation. Model 1 is equivalent to the augmented Solow's growth model where the set of explanatory variables $X_{i,t}$ is composed only of population growth, average education as a proxy for human capital, and population density to account for scale effects. Model 2 has the same set of explanatory variables of model 1, with the addition of the child and aged dependency ratios. These two components of the dependence ratio were accounted for separately due their heterogeneous distribution across Brazil. Model 3 has the same set of explanatory variables of model 1, with the addition of the working-age population. These different specifications allow achieving a better comprehension of the effects of demographic transition, because all components of demographic change are explicitly accounted for. The explanatory variables are considered in terms of their initial values in each decade and are summarized in Table 7.

[53] Although the existing theory on demographics do not have a consensus on the demographics to be one of the causes or consequences of economic growth, the technique of GMM-System corrects for endogeneity, so that if demography is also a consequence of economic growth, characterized as a problem of simultaneity, it would be corrected by the technique.

Table 7 - Explanatory variables in the convergence equation

Code	Description
WTCRPC	Spatial lag of the dependent variable
INC	Logarithm of initial per capita income
AEST	Logarithm of average years of schooling
DENS	Logarithm of population density
POG	Logarithm of population growth
CDPR	Child dependency ratio
WAP	Working age population
ADPR	Aged dependency ratio

Notes: Elaborated by the author (2012). All variables are assessed at the beginning of each decade, that is, 1970, 1980, 1991. The data were collected from IPEADATA (Institute of Applied Economic Research) and from the Demographic Census conducted by IBGE. The population growth variable was calculated based on the demographic data and adjusted for depreciation and technological growth, meaning that it is equivalent to $n_{i,t}$+d+g in accordance with the Solow's model.

The panel model of each convergence equation was estimated using the ordinary least squares (OLS)-fixed effects method and the SYS-GMM. A spatial panel model was also estimated using the SYS-GMM. The use of these different techniques is useful in evaluating the robustness of the parameters as well in correcting potential biases associated with endogeneity problems or spatial dependence. Additionally, to avoid the potential problem of instrument proliferation in GMM estimations observed by Roodman (2009a, 2009b), the SYS-GMM approach used in this paper follows the empirical strategy proposed by Roodman (2009b) for collapsing the instruments[54].

It is worth noting that the estimation of the spatial panel equations is important if spatial dependence is presented in the error term, because ignoring it would still yield a biased coefficient variance. A convergence study carried out by Silveira-Neto and Azzoni (2006) on the gross domestic product per capita dynamics across Brazilian states showed that spatial dependence is more relevant for the unconditional than for the conditional convergence equation. Another study, conducted by Resende (2011), showed that the more fragmented the spatial unit in the regression models is, the more important the spatial dependence. Even though the spatial dependence problem seems to be less relevant if the variables associated

[54]We used the collapse sub option for the xtabond2 command in Stata, which combines instruments by adding smaller sets without dropping any lags. As observed by Vieira and Haddad (2011), this procedure implies the creation of one instrument for each variable and each lag distance, rather than one for each time period, variable, and lag distance. The final outcome is obtained by dividing the GMM-style moment conditions into groups and summing up the conditions in each group to form a smaller set of conditions. In the end, we have a set of collapsed instruments, one for each lag distance, with zero indicating any missing values.

with the spatial linkage across regions are computed into the vector of explanatory variables, this issue needs to be assessed when regression models are specified for territorial units.

The spatial dependence problem is evaluated by using the global spatial autocorrelation measure known as Moran's I statistic (ANSELIN, 1988). This statistic is calculated for the cross-sectional errors generated for each time span in the panel, providing information on the spatial autocorrelation effects across the three decades (1970s, 1980s, and 1990s). Moran's I statistic is represented as follows:

$$I = \frac{\sum_i \sum_j w_{i,j}(\varepsilon_i - \bar{\varepsilon})(\varepsilon_j - \bar{\varepsilon})}{\sum_i (\varepsilon_i - \bar{\varepsilon})^2} \quad (14)$$

where ε_i and ε_j are the values of the cross-sectional errors, $\bar{\varepsilon}$ is the mean of the errors, and w_{ij} are elements of the spatial weighting matrix that is row-standardized, that is, the elements w_{ij} in each row total 1. To perform this test, we used the Queen and K-nearest neighbors to calculate w_{ij}. The weighting matrix calculated by the Queen form implies a first-order contiguity matrix that considers all the states bordering one specific state, while the weighting matrix calculated by the K-nearest form assumes a number of neighborhoods specified *a priori*. The statistics were computed for 1 to 5 neighborhoods and allow evaluating the sensitivity of the spatial dependence to different neighboring levels. The matrix with higher significant values is chosen.

3.5 RESULTS

As previously discussed, three different convergence equations were estimated through two different econometric techniques to assess how important demographic change is to Brazilian regional growth. Table 8 reports the results for each convergence equation. As expected, the speed of convergence is negative for all equations, indicating the presence of convergence for the regional economic dynamics in Brazil. However, the level of the speed of convergence is quite different between the OLS-fixed effects method and the SYS-GMM. Considering the results of model 2, for instance, this speed varies from -0.1685 estimated by the OLS-fixed effects method to -0.2811 estimated by the SYS-GMM (no spatial). It seems that the bias associated with the endogeneity problem implies underestimation of the speed of convergence when the OLS-fixed effects method is used.

All models estimated by the OLS-fixed effects method and the SYS-GMM present spatial dependence in the error term at least in one sub-period of the panel, as shown by the Moran's I test[55]. However, the potential bias and inefficiency caused by spatial dependence seem to be very low for all coefficients if we take into account the results obtained from the SYS-GMM estimation with and without correction for spatial dependence. Despite the error term for the 1970s presenting spatial dependence in the SYS-GMM estimation (no spatial), it can be observed that the spatial dependence that was significant for the 1980s and 1990s in the OLS-fixed effects estimation practically disappear. These results suggest that the instruments defined in the SYS-GMM estimation can capture much of the spatial dependence. This could explain the little bias observed in the parameters when the spatial model is estimated using the SYS-GMM. Moreover, the estimation of spatial SYS-GMM for model 2 corrects spatial dependence for all decades and for model 3spatial dependence is still present for the 1970s.

[55] The null hypothesis of Moran`s I test is that there is spatial independence.

Table 8 - Panel Data Results for the convergence equations

Explanatory Variables	OLS - Fixed Effects			SYS-GMM - No Spatial			SYS-GMM - Spatial		
	Model1	Model2	Model3	Model1	Model2	Model3	Model1	Model2	Model3
WTCRPC – Spatial lag							0.0008	0.0056	0.0034
							(0.0049)	(0.0028)***	(0.0019)***
INC – Initial income per capita	-0.1553	-0.1685	-0.1078	-0.2531	-0.2811	-0.2827	-0.2668	-0.2806	-0.2811
	(0.0081)*	(0.0060)*	(0.0080)*	(0.0354)*	(0.0315)*	(0.0336)*	(0.0424)*	(0.0319)*	(03.53)*
POG – Population growth	-0.0210	-0.0014	-0.0399	-0.1610	-0.1090	-0.0991	-0.1474	-0.1054	-0.0848
	(0.0121)***	(0.0115)***	(0.0097)***	(0.0597)**	(0.0596)***	(0.0616)	(0.0658)**	(0.0468)**	(0.0530)
AEST – Education	0.1131	0.0765	0.0644	0.2744	0.1939	0.1549	0.2721	0.1892	0.1403
	(0.0072)*	(0.0086)*	(0.0080)*	(0.0231)*	(0.0598)*	(0.0480)*	(0.0285)*	(0.0537)*	(0.0413)*
DENS – Population density	0.0100	0.0013	0.0089	-0.0181	-0.0151	-0.0229	-0.0019	-0.0153	-0.0232
	(0.0068)	(0.0074)	(0.0012)	(0.0078)**	(0.0127)	(0.0107)**	(0.0216)	(0.0090)	(0.0099)**
CDPR – Child Dependency ratio		-0.1597			-0.1822			-0.1826	
		(0.0249)*			(0.0553)*			(0.0551)*	
ADPR – Aged Dependency ratio		0.4769			-0.8794			-0.8932	
		(0.1652)*			(0.2921)*			(0.2635)*	
WAP – Working Age Population			0.6011			0.7996			0.8563
			(0.0732)*			(0.1956)*			(0.1854)*
Constant	0.5670	0.8324	0.0654	0.2627	0.6109	0.0146	0.2903	0.6188	0.0045
	(0.0773)*	(0.0780)*	(0.0494)*	(0.1226)**	(0.1335)*	(0.1169)	(0.1395)**	(0.1264)*	(0.1209)?
Adjusted R-squared	0.9867	0.9828	0.8387						
Hansen				19.99	20.18***	18.44**	22.31**	21.45	20.20***
Hansen-Diff				4.59	12.81**	9.57***	10.40*	11.57	9.51
Number of Groups				27	27	27	27	27	27
Number of Instruments				21	19	16	16	23	19
Collapsing the number of instruments				no	yes	Yes	yes	yes	yes
Testing for spatial autocorrelation:									
Moran's I for 70's	0.3542	-0.0952	0.7482*	0.7154*	0.4178***	0.6775*	0.3712*	0.1886	0.5862*
Moran's I for 80's	0.5870*	0.7387*	0.0335	0.0514	0.0205	0.1377	0.2262***	-0.0844	0.0963
Moran's I for 90's	0.7026*	0.3787***	-0.0423	0.3389	0.1665	-0.1468	0.3297*	0.0527	-0.1308

Source: elaborated by the author (2012). Note: *significant at 1%, **significant at 5%, ***significant at 10%. For the fixed-effect OLS estimation, correction of the cross-sectional weights was used for the standard errors. For the SYS-GMM estimation, all explanatory variables were considered to be potentially endogenous. For the spatial model (model 3), we used a first-order k-nearest matrix, as it was the one with higher significant values.

The effect of education – a proxy for human capital – on regional economic growth is positive, as predicted by the theoretical literature. However, the importance of education for economic growth is underestimated in the OLS-fixed effect estimation, and it seems overestimated when the demographic variables are not accounted for, when we look only for the results obtained from the SYS-GMM, mainly for model 3 whose specification includes the working-age population. In general, the contribution of education would be associated with the level of education of the working-age population. If this demographic factor is explicitly introduced into the equation, the effect exclusively associated with the share of this demographic group in the population is now identified.

It is important to note that, based on the population census of the IBGE, a variable related to migration was inserted in the database, however, the same was not significant in the estimations. Therefore, it was decided not to keep it in the model. Although the discussion on migration is important, it is beyond the scope of this study.

Considering only the results for the SYS-GMM estimation, the population growth effect is negative for models 1 and 2 and not significant for model 3. It is worth noting that the effect of population growth on economic growth is very controversial in the empirical literature. For instance, Bouayad-Agha and Vedrine (2010) found a negative effect of population growth in the convergence equation using the SYS-GMM for estimating spatial panel models, but they did not take into account demographic factors. Our results show that the effects of population growth and population density are not robust in the dynamics of economic growth in Brazil, because the significance of these variables changes with the introduction of demographic variables into the convergence equation.

Finally, but not least important, we analyze the results found for the demographic change variables. We focus the analysis on the results obtained from the SYS-GMM (no spatial), since the OLS estimation seems very sensitive to the endogeneity problem and the results of the spatial estimation are not quite different. All the demographic variables are statistically significant for each model, a finding that puts in evidence the importance of demographic change for the regional economic dynamic in Brazil.

In model 2, the child and aged dependency ratios are negatively significant. For the regional dynamics in Brazil, these results suggest that the higher the child (aged) dependency ratio is, the lower the economic growth. In addition, the coefficient of the aged dependency ratio is much higher than the one estimated for the child dependency ratio. These differences imply that demographic change could contribute to reducing regional inequality in Brazil given the spatial pattern of child and aged dependency across Brazilian regions. As the child (aged) dependency ratio is higher for the poorest (richest) regions and is rapidly declining (increasing) over the decades, the continuation of such a process could effectively contribute to reducing regional inequality in Brazil.

The negative effect of the child dependency ratio, as discussed in section 2, is consistent with the literature, so that this sign is consistent with what was expected. For the aged dependency ratio, the sign is being investigated in the literature, and, according to Fukuda and Morozumi (2004), the effect can be positive or negative. Vasconcelos, Alves, and Silveira Filho (2008) found an ambiguous effect for old generations in the Brazilian economic growth, but they attribute this result to the correlation of life expectation and income. As we could control for this correlation using the SYS-GMM, we believe we have contributed to solve this ambiguity, at least for Brazil or countries with similar characteristics.

The negative impact of the aged dependency ratio, as discussed in section 2, probably means that older generations in Brazil are very dependent on the productive segment of the population, or the savings rate is not high enough to support future consumption, or the pension system in Brazil is formulated in such a way that it will not be able to support older generations, or the investment in R&D is very low, or a combination of these factors (FUKUDA; MOROZUMI, 2004; PRETTNER; PRSKAWETZ, 2010).

On the other hand, model 3 shows a positive effect of the working-age population on regional economic growth. As expected, this implies that the demographic bonus can enhance economic growth, but in a regional perspective, as we have high disparities related to income and demographic variables and as we have nowadays more people in the productive age, this process would reinforce the inequality among Brazilian regions according to the spatial distribution of the income and dependency ratio in Brazil (Tables 5 and 6). The projections of the population by age structure in Brazil show that the growth forces associated with the demographic bonus would be present until 2020, and after that the composition of population would tend to move towards an ageing economy. The results obtained in this study show that, differently from what happens to the working-age population, the aged dependency ratio has a negative effect in economic growth, so, it implies that the States that are being benefited today from the demographic bonus will feel the negative impact of aged dependency ratio first, so that, considering everything else held constant, demographic change can contribute to the reduction of regional inequality in Brazil but would imply less economic growth for the whole country.

3.6 FINAL REMARKS

Economic growth can be influenced by demographic change, as the economic behavior of people changes over their life cycle. In this paper, we addressed the importance of demographic change to the dynamics of regional economic growth in Brazil, a country characterized by high and persistent regional inequality. Most of empirical studies on regional growth in Brazil usually investigate the existence of convergence and the role of some factors postulated by endogenous growth models, such as physical and human capital. Some studies explore other factors, such as agglomeration, spatial effects, and urbanization, but little attention has been devoted to gaining a better insight into the demographic sources of regional inequality in Brazil.

Following recent developments in the theoretical and empirical literature on economic growth, in which demographic change is explicitly modeled, we estimate convergence equations to evaluate how demographic change is related to the dynamics of economic growth across Brazilian states. The results suggest that the OLS fixed-effect estimation for the convergence equation provides a highly biased coefficient, underestimating the speed of convergence for the regional economic dynamics in Brazil. When the consistent estimation obtained from the SYS-GMM is taken into account, the results show that child and aged dependency ratios have a negative and statistically significant effect on regional growth, whereas the working-age population has a positive impact. Additionally, the coefficient of the aged dependency ratio is much higher compared with that estimated for the child dependency ratio, implying that demographic change could contribute to the reduction of regional inequality in Brazil given the spatial pattern of child and aged dependency across Brazilian regions. The SYS-GMM was able to capture much of the spatial dependence on the residuals, although the spatial version of model 2 estimated by the SYS-GMM completely corrects the problem of spatial dependence.

In spite of the potential contribution of demographic change to the reduction of regional inequality, the results also suggest that economic growth for the whole country could be impaired in the future because of the ageing process implied by the evolution of demographic change in Brazil. Then, as suggested by the growth literature, one important strategy to mitigate or postpone the potential negative impact of demographic change would be to reinforce policies for increasing human capital and innovation in order to enhance productivity and growth.

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4 ARTICLE 3 – DEMOGRAPHICS AND HOUSEHOLD CONSUMPTION IN RIO GRANDE DO SUL

Abstract
Consumption behavior by age is still a puzzle for the international and national literature. In theory, consumption should decrease with age, but this does not hold for all sectors in Rio Grande do Sul, Brazil. Using econometric techniques to control for complex samples, in addition to demographic variables, consumption models by sector were estimated based on data from the 2003 Household Budget Survey. As a result, machinery and tractors, electric and electronic equipment, transport equipment, other industries, financial institutions, household and business services, property rental, and government and private non-market services are sectors in which age has a positive effect on consumption, what we could call an unlike retirement consumption puzzle. Moreover, overall consumption proved to be stable, which apparently makes sense, since there are sectors in which consumption decreases with age.

Keywords: Consumption Behavior by Age. Retirement Consumption Puzzle. Household Budget Survey.

4.1 INTRODUCTION

The slowdown in population growth in more developed regions also affects Brazil and other developing countries, but its onset occurred later. According to United Nations data, Brazil increased its participation in the world population from 1950 to 2009; however, the reverse process is expected to take place between now and 2050, with negative population growth rates for Brazil after 2039, predicted by the Brazilian Institute of Geography and Statistics (IBGE).

Population aging is a consequence of low fertility and mortality rates and higher life expectancy. Thus, there is a reduction in the proportion of children in the population and a consequent increase in the proportion of people in older age groups. In Brazil, the State of Rio Grande do Sul currently has 10,830,295 inhabitants, and in 2010, it had the highest percentage of aged individuals and the lowest percentage of children, thus representing the Brazilian state in which the process of demographic change is more pronounced. The Foundation of Economics and Statistics predicts that the rates of population growth in this state will probably be negative between 2025 and 2030, with the rates for Brazil as a whole lagging far behind. However, it is worth noting that Brazil and Rio Grande do Sul are still at the stage where the economically active population (EAP) is the most representative among the age groups.

Regarding the implications of the process of demographic change for the economy, Miles (1999) mentions the negative impact on the savings rate, since in populations with a predominance of young people or people over 65 years, the savings rate tends to decrease, a result that is consistent with the life cycle hypothesis (MODIGLIANI, 1970). Demographic change also has negative effects on capital formation, because lower savings lead to less investment (AZARIADIS, 2006; MILES, 1999; ALVES, 2008).

Wong and Carvalho (2006) consider the important impact of demographics on labor supply, since the mature economically active Brazilian population[56] (EAP) is expected to grow at least until 2045. However, this supply of workers can only be exploited if their productivity can be developed while maintaining the balance between economic, social and intergenerational aspects, giving special attention to education. Still, as the aging process advances and the EAP begins to decrease, the impact on labor supply should be reversed, being negative. A smaller supply of workers also contributes to the reduction of unemployment, explaining its decline in current periods of low economic growth.

In addition to the improvements in quality of education, population aging demands more health and social security resources, resulting in an increase in government spending on older individuals (WONG; CARVALHO, 2006). Turra's (2001) estimations of the revenue to expenditure ratio for Brazil show a considerable decline for the period 2000 to 2050, thus confirming this trend. As a result, the government's fiscal deficit is likely to increase, making it necessary to take precautionary measures to offset this public demand.

Besides government spending, another important issue associated with population aging is that the structure of household consumption may change. As the aged population increases, there must be a change in the structure of household consumption and, according to the results obtained by Lefèbvre (2006), some sectors will eventually be prioritized (housing, health, leisure, etc.) over others (food, clothing, transportation, etc.). Consequently, adjustments must occur in the labor market, directing labor force to sectors with a higher demand and, therefore, supply must also change. Therefore, the focus of this study is to examine how the demographic structure affects household consumption in the state of Rio Grande do Sul.

[56] For mature EAP it was considered people from age of 25 to 64 years old. If it would be only EAP it would be people from 15 to 64 years.

The objective of the study is to identify the effects of age on household consumption for different types of products using econometric techniques, such that an economic equation is estimated for each product. The paper is organized as follows. Section 4.2 presents the literature review. Section 4.3 analyzes the data. Section 4.4 describes the methodology used. Section 4.5 shows the results obtained. Finally, Section 4.6 concludes.

4.2 LITERATURE REVIEW

The first consumption theory in the economic theory, from the Keynesian standpoint, dealt with consumption, which was defined as a direct function of disposable income, in which a percentage applied to that income corresponds to the marginal propensity to consume. In addition to objective factors such as variations in real wages, changes in fiscal policy, changes in present and future income expectations, Keynes (1982) also argues that there are subjective factors that lead individuals to stop spending their income as a precautionary measure, security, time value of money (interest), among others.

The empirical results of the Keynesian consumption function showed that it could be improved, giving rise to the life cycle theory, developed by Franco Modigliani, Richard Brumberg and Albert Ando in the 1950s. This theory postulates that consumption is constant over time, and that individuals save while they receive labor income in order to spend it during their old age, when they no longer receive income from work. Thus, periods of higher income represent savings and periods of lower income or of no income at all represent dissavings, allowing consumption to be constant throughout life. This is the main factor that tells the life cycle theory and the Keynesian consumption theory apart, since while the latter considers only the current income, the former considers the lifelong income (MORAES; FAMÁ; KAYO, 1998).

The permanent income theory of consumption was developed by Milton Friedman in 1957. In this theory, the permanent income determines consumption, i.e., the share of current income individuals believe to be persistent over time. Thus, the permanent income can be defined as the average between present income and income from the previous period (DORNBUSCH; FISCHER, 1982). Just as the life cycle theory, this theory seeks to show that the marginal propensity to consume is different in the short and in the long run. Thus, the life cycle and permanent income theories can be treated as complementary, in that the former emphasizes the motivation to save and the latter shows how individuals calculate their expected future income (MORAES; FAMÁ; KAYO, 1998).

Lefèbvre (2006) shows that many studies address the issue of consumption at older ages and that consumption is reduced significantly in retirement, resulting in the so-called "retirement-consumption puzzle" (HAMMERMESH, 1984; FAIR; DOMINGUEZ, 1991; BANKS; BLUNDELL; TANNER, 1998; BERNHEIM; SKINNER; WEINBERG, 2001; HURD; ROHWEDDER, 2003). The explanation for this phenomenon would be that the marginal utility of consumption, and not consumption itself, would be smoothed over time, so that changes in family size, number of workers (economically active individuals), mortality or population aging may adjust the marginal utility consumption and cause consumption to fall at advanced ages. Furthermore, the reduction in consumption could also be explained by the lack of correct income forecast by households and by the substitution effect between consumption and increased leisure time (HURD; ROHWEDDER, 2003; SMITH, 2004).

Even those studies that used other variables as instruments for expected retirement, as that of Haider and Stephens Jr (2007), in which subjective expectations of retirement were utilized as instruments, also confirmed the fall in consumption when individuals retire on schedule; however, this decrease was found to be lower than that shown by studies in which age was used as an instrument. Thus, the retirement-consumption puzzle is evidenced in many ways, and the literature also seeks to investigate this issue.

This study seeks to assess not only the consumption at advanced ages, but also to capture the differences in consumption behavior for different household structures, formed by children, working-age individuals, or old people. However, as population aging is underway in Brazil, we seek to know specifically what sectors are impacted positively and negatively in households where the elderly represent a significant variable.

4.3 DATA

The 2002-2003 Household Budget Survey (POF) data for Rio Grande do Sul include 1,850 households, which correspond to 5,870 people. Expansion factors are applied to this sample to represent the state. Households in Rio Grande do Sul are mainly composed of adults and children (45.62% of the total). Households composed only of adults account for a relatively high percentage (34.54%), showing that population aging has increased in the state and that not having children has become increasingly common. If we add the households with adults and aged individuals and those with only aged people, we get a total of 15.94%.

Table 9 - Household Composition – Rio Grande do Sul – 2003

General Composition	% total	Typical Composition	% total
Adults and children	45.62%	2 Adults and 1 child	14.05%
Adults	34.54%	2 Adults	13.68%
Adults, child and elderly	3.73%	2 Adults, 1 child and 1 elderly	0.59%
Adults and elderly	8.86%	2 Adults and 1 elderly	3.84%
Elderly	7.08%	1 Elderly	4.65%
Children and elderly	0.16%	1 Child and 1 elderly	0.11%

Source: Prepared by the author from the 2002-2003 POF microdata (2013).

A typical household in Rio Grande do Sul between the years 2002 and 2003 includes 2 adults and 1 child (14.05% of the cases), followed closely by 2 adults (13.68%). Note that households with only one elderly person - 4.65% - are more typical than those with 2 adults and 1 elderly (3.84%). Although that is the most traditional household composition in Rio Grande do Sul, several studies underscore the gradual disappearance of family as a social institution (SANTOS, 2009; CERRONI *et al*., 1971; BEBEL *et al*., 1980).

Population aging, women's better education and, consequently, women's more active role in the labor market, coupled with Maria da Penha Law (BRASIL, 2006), have contributed to changes in household composition. In particular, this law ensures women's right to a decent life, protecting them against domestic violence and allowing for their development in society. New family arrangements indicate the emergence of women as household heads, prompting the Brazilian Institute of Geography and Statistics (IBGE) to alter this concept in order to include women, who are then designated as "reference person" (IBGE, 2000 Census). Thus, the demographic trend of household composition is characterized by the decline in fertility rates, the large number of single mothers, the growth of single-parent families, the larger number of women as household heads, the decrease in the number of marriages and the increase in the number of separations and divorces (GOLDANI, 1994; SANTOS, 2009).

4.4 METHODOLOGY

This study uses Household Budget Survey (POF) data from 2002 to 2003 collected by the IBGE. In order to analyze the consumption of different goods by age group, the data on household and individuals were cross-matched based on number of household, sequence, and check digit, common in both databases. According to the IBGE (2004b), a household is a house structured separately (limited by walls or fences and covered by a roof) with independent access and made up of one or more rooms. The sequence variable, according to the description of POF variables, provides a sequential number for each of the sectors (which correspond to the geographical basis sectors of the 2000 Census) included in the sample, while the check digit variable identifies the sequential number assigned to the sector of the sample. The consumer unit variable should also be described, as there can be more than one per household, which is characterized by a resident or group of residents who share the same power supply or share the living expenses.

For IBGE, according to the same publication cited in the previous paragraph, the term "household" is represented by the consumer unit and meets international recommendations, denoting "people linked by kinship ties, dependence or domestic standards of living, without explicit reference to consumption or expenditure" (IBGE 2004b, p. 10). There are cases in which households had more than one consumer unit, and, in these cases, the demographic data (number of children, elderly and working-age people by age group) of each consumer unit were used for the demographic structure of the household. This simplification was necessary because the adjustment would otherwise be too time-consuming, as combining the household and people databases was not an easy task.

The amount of household residents variable allowed opening the household database and entering the age of all residents through the creation of new variables (number of economically active persons, number of children, number of elderly), so that if the household has four residents, it has four lines in the corresponding People database, with the age of each resident. Additionally, variables for economically active people were created in order to analyze which age groups under this category contribute more remarkably to consumption. Data such as sex, education, income, credit access, among others, were also included.

The 2002-2003 POF, conducted between July 2002 and June 2003, investigates the expenses of families with different types of consumer goods, as well as the socioeconomic characteristics of households (income, education, etc.) and personal attributes of residents (e.g., sex, age and access to credit). Expenses have a record of 10,428 items, containing information on the amount spent on each good (annualized or deflated), on how the good was purchased (cash payment, installment payment, exchange, own production), and other relevant information. For expenditure data, a translator of the 2002-2003 POF products was used for the 45 sectors of economic activity contained in the input-output matrix of Rio Grande do Sul - Base year 2003 - and this translator was subsequently reduced to 20 sectors, as shown by the results on table 11. Since an econometric consumption equation is estimated for each sector, using the same explanatory variables in each one of them, we decided to cluster only those sectors that were statistically significant, and by comparing them with the results obtained by Lefèbvre (2006), we thought it was important to break down the household and business services for healthcare expenditures.

Once we defined the sectors for which we intend to estimate the corresponding consumption functions, both the estimation model and method for each consumption function defined in this work were based on the studies of Lefèbvre (2006) and Farinha (2008), also taking into account the variables obtained from the database constructed with 2002-2003 POF data. Equation 15 represents the consumption function model for each sector defined in Table 9.

$$lnC_i = lnY_i + S_i + NI_i + NA_i + \sum_{k=1}^{5} NWAk_i + u_i \qquad (15)$$

The lnC_i variable is the dependent variable and represents the logarithm of the amount spent on consumption by household i. Consumer spending data were those recorded on the book of expenses, expenses incurred within a 90-day period, expenses incurred within a 12-month period, individual expenses, other expenses, expenditures with domestic services and expenditures with vehicles. The first explanatory variable lnY_i represents the logarithm of income of the consumer unit (family), i.e., the sum of the gross monetary income of all residents in the consumer unit, obtained from work, transfers, other types of income and from the positive balance of financial transactions, plus the share related to the non-monetary income of the consumer unit. Importantly, some studies, such as that of Farinha (2008), use the wealth variable rather than the income variable. Wealth is defined by Farinha as assets with appreciation in the market, i.e., real estate assets and risky financial assets (stocks and other securities). Although this variable is an important component of many theories of consumption (e.g., the permanent income theory of consumption), we do not have this variable in Brazilian research studies, and thus we opted to use the variable available from the POF database: income of the consumer unit.

The variable S_i represents the household head's education level. The other variables are the demographic variables, which were obtained from the combination of the household and people databases. Thus, NI_i is the number of children, NA_i is the number of aged people and $NWAk_i$ represents the number of economically active people for each of the age groups:

Table 10 - Specification of age groups for the variable $NWAk_i$

K	Age group (years)
1	15-24
2	25-34
3	35-44
4	45-54
5	55-64

Source: Developed by the author (2013).

Compared to the study of Lefèbvre (2006), the present study represents an improvement in terms of database, since that study included only data on household heads, whereas we included demographic data on household members.

As we are dealing with a complex sample, it is appropriate to include the various features of the sampling plans. Routines have been recently added to statistical software programs to deal with complex samples. Stata does it through the svy command[57], with which we can control for conglomerate variable, for sample weight and for the stratum, providing accurate estimates (SILVA *et al.*, 2002; BATTISTI, 2008). Stratum represent populations divided into mutually exclusive subsets, which are then estimated by combining the samples obtained from each stratum. In the POF, a conglomerate plan was adopted, with geographical and statistical stratification (from the variable that characterizes the socioeconomic strata) of the primary sample units (PSUs), which correspond to the sectors in the 2000 Demographic Census. The sectors were selected by systematic sampling, in which probability was proportional to the numbers of households in each sector. In relation to the sample design, the allocation of the sectors selected in each stratum was proportional to the total number of permanent private households in the stratum, conditional on the existence of at least two sample sectors in each stratum.

Besides the stratum, the svy command needs to determine the sample weight and the conglomerate variable. The expansion of the sample takes into account the sample weight, in which each household belonging to the Household Budget Survey sample is a certain number

[57] The svy: regress command differs slightly from the regress command, in the sense that the variance is multiplied by $\{n/(n-1)\}$ in the first command and multiplied by $\{N-1/N-k\}\{n/(n-1)\}$ in the second one, where *N* is the number of observations, *k* is the number of regressors and n is the number of PSU (conglomerate variable). So, the svy command assumes that $N \gg k$, and that $\{N-1/N-k\}$ is close to 1, otherwise, Stata advises you not to use the svy command. As a result, the command generates slightly different standard errors (STATA, 2013).

of permanent households of the population (universe) from which this sample was selected. Hence, each household in the sample is assigned a sample weight or expansion factor that, when attributed to the characteristics investigated by the POF, allows obtaining estimates of the quantities of interest. This conglomerate variable is usually defined as the primary sample unit (PSU) and each conglomerate, formed by N_i secondary sample units. As only the secondary sample units were available, and as we combined the household and people databases, taking the household as reference and as the household and the selection of sectors is made proportionally to the number of households, we considered them as the conglomerate variable.

Vieira (2001) and Battisti (2008) suggest that the adoption of a simple random sample instead of a complex one can be inefficient when the population is not homogeneous and when subgroups differ in size. The adoption of a complex sample also is important to estimate the variance of standard errors, allowing us to determine the accuracy of the estimates. Normally, the estimators are linearly weighted, as in the case of svy. Thus, we adapted the svy estimator defined in the Stata software to the ordinary least squares (OLS) linear regression model.

4.5 RESULTS

The models were estimated for the sectors contained in Appendix 1, on the right-hand side[58], and also for total consumption. The models were estimated by the Stata software and by data analysis methods applied to the complex sample. In total, 20 models were estimated, according to equation 1 defined in the previous section, allowing us to capture the effect of income, age, education, and sex.

The estimations were made using the svy command for the complex sample, as explained in the previous section. We first applied the ordinary least squares (OLS) method and ran some tests to verify the validity of the estimations. The F test rejected the null hypothesis that all coefficients are statistically equal to zero for all sectors. The svy command controls for heterocedasticity, and, as we are dealing with cross-sectional data, we do not have to worry about autocorrelation. However, it is necessary to check if we do not have any endogeneity problem.

[58] Except for the trade sector (sector 12), as the available observations were not enough.

Table 11 - Regression results per sector

	1	2	3	4	5	6	7	8	9	10
Sector	Agriculture	Metallurgical industries	Machinery and tractors	Electric and electronic equipment	Transport equipment	Wood and furniture	Chemical and petrochemical industry	Clothing and footwear	Food	Industrial public utilities
Constant	3.3118*	-2.2771	0.5611	3.3567*	-0.2175	3.3533	2.9071*	1.3731*	3.9714*	2.8291*
Log W	0.1063*	1.0366*	0.578*	0.1365**	0.8994*	0.1724	0.3361*	0.4872*	0.0989*	0.383*
Elementary education	-0.052	-0.0394	-0.8802	0.2164	0.3916	-0.0283	0.0244	-0.1059	-0.1255*	-0.0165
Schoolling	-0.0473	-0.8973	-0.6642	0.3026	0.4758	-0.3045	0.0259	0.0545	-0.1378	0.0184
High school education	0.0025	-0.4592	-0.1652	0.7059	0.683	-0.3194	0.1948	-0.0901	-0.0827	-0.1711
No. of children	-0.046**	0.0268	-0.173**	-0.1448*	-0.2415*	-0.1342***	-0.1012*	-0.1092*	-0.1126*	-0.0379
Age15-24	-0.074*	-0.2195*	-0.5048*	-0.0936	-0.127	-0.3984*	-0.1009*	-0.1193*	-0.1116*	-0.0161
Age25-34	-0.1833*	-0.4137*	-0.3759**	-0.1423	-0.1258	0.0015	-0.0275	-0.1793*	-0.1499*	-0.0284
Age35-44	-0.1767*	-0.3078*	-0.2016	-0.2263**	-0.2014	0.0045	0.0145	-0.2078*	-0.1321*	0.0386
Age45-54	-0.1745*	-0.4259*	-0.305	-0.3014*	-0.2298	0.0601	-0.0232	-0.2093*	-0.1282*	-0.0143
Age55-64	-0.1364*	-0.4466*	-0.1852	0.0568	-0.2698***	0.2454	-0.0134	-0.1766*	-0.0594**	0.0268
No. of Elderly	-0.1386*	-0.3611*	0.0963	0.128	0.0542	-0.0657	-0.0464	-0.192*	-0.0502**	-0.0135
Sex	-0.0741**	-0.1503	0.779*	0.696	0.3115	0.4451	0.2225*	-0.0806***	0.0689*	-0.1248*
R^2	0.0522	0.0971	0.3132	0.0764	0.2388	0.0845	0.1162	0.1545	0.0684	0.0862
F test	16.19	4.7	13.46	7.15	19.36	3.27	26.49	64.75	39.54	24.17
No. of obs	12.748	721	165	869	796	380	3.035	13.021	25.157	3.098
Population Size	1,281,646	1,281,646	294,311	1,546,043	1,425,342	669,734	5,427,690	23,344,553	44,946,893	5,574,507
No. of Strata	19	19	11	19	19	18	19	19	19	19
No. of PSUs	310	217	92	239	211	158	318	316	318	312
Adjusted Wald Test	2.21	7.91*	1.03	1.47	0.02	1.59	0.03	8.14*	0.52	6.76*
Method Estimation	OLS	IV	OLS	OLS	OLS	OLS	OLS	IV	OLS	IV
Sargan test	-	1.9467	-	-	-	-	-	3.9063	-	0.6196

Source: Developed by the author (2013).

Note: * significant at 1%, ** significant at 5%, *** significant at 10%.

Table 12 - Regression results per sector cont'd

Sector	11 Building	13 Transport	14 Communications	15 Other industries	16 Financial Institutions	17 Household and business services	18 Property rental	19 Government	20 Private non-market services	Total
Constant	3.4885*	0.0412***	4.3055*	1.7023*	1.8982*	1.8765*	4.6424*	2.9073*	0.0303	1.763*
Log W	0.2097**	-0.0049*	0.2154*	0.4016*	0.3636*	0.387*	0.3805*	0.3356*	0.7099*	0.4523*
Elementary education	0.4119	0.0134	-0.0541	-0.035	0.2401	0.1601***	0.1883*	-0.1135	-0.1051	-0.1407*
Schooling	0.8987*	0.0223	0.0127	0.0026	0.375	0.3093*	0.117	0.0094	-0.0579	-0.1397*
High school education	0.4559	-0.0165	0.1045	-0.0879	0.502	0.4897*	0.0368	0.0367	-0.1107	-0.1981*
No. of children	-0.1194***	0.1314*	-0.1561*	-0.1321*	-0.0668***	-0.1251*	-0.0809*	-0.1918*	-0.0503	-0.0856*
Age15-24	-0.1524	0.1451*	-0.1657*	-0.1865*	-0.2683*	-0.2025*	-0.1135*	-0.1099*	-0.1505*	-0.1512*
Age25-34	-0.0163	0.1657*	-0.1734*	-0.1713*	-0.2489*	-0.2017*	-0.1843*	-0.2031*	-0.2135*	-0.1893*
Age35-44	-0.0157	0.171*	-0.1456*	-0.1752*	-0.1668*	-0.2244*	-0.007	-0.2265*	-0.2213*	-0.1964*
Age45-54	-0.0956	0.1601*	-0.1366*	-0.1877*	-0.1176***	-0.2079*	0.0018	-0.2527*	-0.2396*	-0.2128*
Age55-64	0.0604	0.1527*	-0.0642	-0.0619**	-0.0662	-0.1468*	0.0318	-0.2257*	-0.2266*	-0.1562*
No. of Elderly	0.0028	0.1243*	-0.1051**	-0.0387	0.0854	-0.1234*	0.0537	-0.1459**	-0.1223*	-0.1582*
Sex	0.1865	0.0224*	-0.0959	0.0226	-0.0198	0.0251	-0.0996***	-0.2034**	-0.0657	-0.0134
R^2	0.0641	0.8927	0.1069	0.1085	0.1027	0.1352	0.1422	0.1369	0.1422	0.1254
F test	2.46	149.75	29.45	65.59	25.14	53.41	21.9	22.85	52.3	158.13
No. of obs	456	2,299	2,095	18,840	2,814	10,966	2,459	2,441	6,602	108,962
Population Size	824,695	4,116,842	3,863,446	33,826,254	5,077,591	19,707,913	4,392,119	4,374,869	11,818,811	173,794,905
No. of Strata	19	19	19	19	19	19	19	19	19	19
No. of PSUs	184	301	281	320	265	317	320	277	315	321
Adjusted Wald Test	0.65	0.02	0.21	3.91**	0.05	0.61	0.18	0.34	10.33*	1.2
Method Estimation	OLS	OLS	OLS	IV	OLS	OLS	OLS	OLS	IV	OLS
Sargan Test	-	-	-	13.188	-	-	-	-	39.612	-

Source: Developed by the author (2013).
Note: * significant at 1%, ** significant at 5%, *** significant at 10%.

The income variable, regarded as an explanatory variable of consumption, can also be explained by the consumption, since the higher the income, the lower the consumption, characterizing a form of endogeneity - reverse causality (FARINHA, 2008; CAMERON; TRIVEDI, 2009; WOOLDRIDGE, 2003). Thus, it is important to check whether the income is not an endogenous variable to ensure that the estimators are consistent. To perform this test, Stata gives some options (estat endogenous, estat first stage and estat overid), although they are not accepted with the *svy* command (STATA, 2013). We used the adjusted Wald test, which consists in regressing the supposed endogenous variable with additional instruments that should be correlated with it and not with the error term, thus saving the residuals of this equation. Then, we included the residuals as an explanatory variable and checked whether this variable was significant. By typing test and the name of the Stata variable, we got the adjusted Wald test, obtaining a significant *F* statistic for the null hypothesis that the OLS estimation is consistent. So, if the statistic is significant, it indicates that an endogeneity problem exists (CONG, 1999).

The adjusted Wald test results indicated that sectors 2 (metallurgical industries), 8 (Clothing and footwear), 10 (Industrial public utilities)[59], 15 (Other industries) and 20 (private non-market services)[60] have an endogenous income variable. Therefore, they were estimated by instrumental variables. The set of instruments included year of study, age of the reference person and, for sectors 10 and 20, also a combination of these instruments, as only the first instruments were not enough to control for endogeneity according to the Sargan test, supporting the null hypothesis that the set of instruments is valid. The results indicate that the instruments used are valid both for the number of observations and for the total population – the latter was much higher than the former as we controlled for the complex sample.[61]

Because we controlled for the complex sample, we can assure that our estimates are accurate even that our R2 is small. We also compared our results with the literature and we found this value to be acceptable as we are dealing with cross-sectional data, whereas other studies found an R2 on the order of 0.4 for panel data (FARINHA, 2008). Other studies also show that a small R2 is not a problem and obtained an even smaller value for the OLS estimation with panel data (SOUZA *et al.*, 2012; MOURA *et al.*, 2011).

[59] Production and distribution of gas, of electricity, of steam and hot water, collection, treatment and distribution of water.

[60] Domestic services, activities of business and employers organizations, professional organizations, union organization, religious and political organization.

[61] For simplification, we showed only the statistic for the number of observations.

Except for transport (sector 13), income has a positive effect on consumption, being consistent with the Keynesian theory. Income seems to have a greater impact on metallurgical industries (sector 2) and on transport equipment (sector 5), so that a 1% increase in income pushes up consumption by 1.04 and 0.9%, respectively. On the other hand, for transport (sector 13), the effect of income is practically null, indicating that income probably does not affect the demand for transport, as people can get around in many ways – they can either walk or get a ride – and companies usually pay for transportation; so people do not usually have to pay for it. For the other sectors, the impact varies between zero and 0.7%.

In most sectors, education proved to be an important determinant of consumption in the sense that the higher the level of education, the higher the consumption, however, this variable was not significant in most cases. In some sectors such as agriculture (sector 1), machinery and tractors (sector 3), food (sector 9), communications (sector 14) and government (sector 19)[62], this relation is also valid, although the impact can be negative for some levels of education (e.g., elementary education); however, this negative impact decreases for higher educational levels. For the wood and furniture sector (sector 6) the impact of education is an exception, indicating that the higher the educational level, the less people spend on wood and furniture. Also, for sectors 8 (clothing and footwear), 10 (industrial public utilities) and 15 (other industries), all of them estimated with instrumental variables, schooling proved to have a higher impact on consumption.

Sex is also an important variable when analyzing consumption in different sectors. We built this variable as a dummy variable, assigning value 1 if the reference person (formerly designated as household head) was a man (as 72.2% of household heads were men) and 0 if the person was either a woman, a pregnant woman or a lactating woman. The results indicate that being male has a positive effect, especially on sectors such as machinery and tractors, electric and electronic equipment, transport equipment, wood and furniture, chemical and petrochemical industry, food, building, transport, other industries and household and business services. Other sectors have a negative influence on males; in other words, women have a positive effect, for instance, on clothing and footwear, communications, and private non-market services.

The effect of age on consumption is an important contribution to the retirement consumption puzzle. The theory postulates that there should be a large drop in consumption

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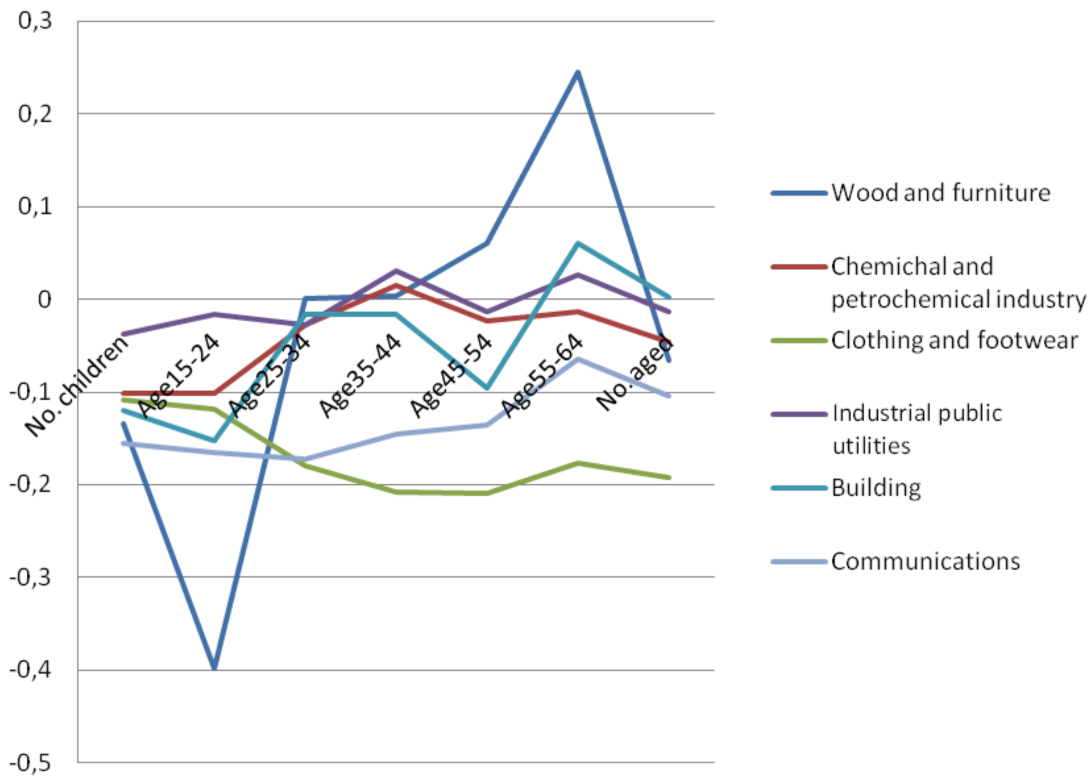
[62] General public administration, Regulation of social and cultural activities, Regulation of economic activities, Activities in support of public administration, foreign relations, defense, justice, Public order and safety, civil defense, social security, Social services with accommodation, Social services without accommodation, Organizations and institutions extraterritorial

as people get older. The results indicate that this holds for the wood and furniture, chemical and petrochemical industry, clothing and footwear, industrial public utilities, building, and communication sectors. In some sectors, we could not observe a rise or drop, but we use this classification if consumption decreases, as is the case of clothing and footwear. The industrial public utilities sector may hinder our understanding as we may think it is related to public expenditure, but as it is associated with the production and distribution of water and electricity, it is reasonable to regard that consumption is constant in the economically active population and that it falls slightly later in life.

Graph 3 - Sectors in which consumption decreases with age



Source: Elaborated by the author (2013).

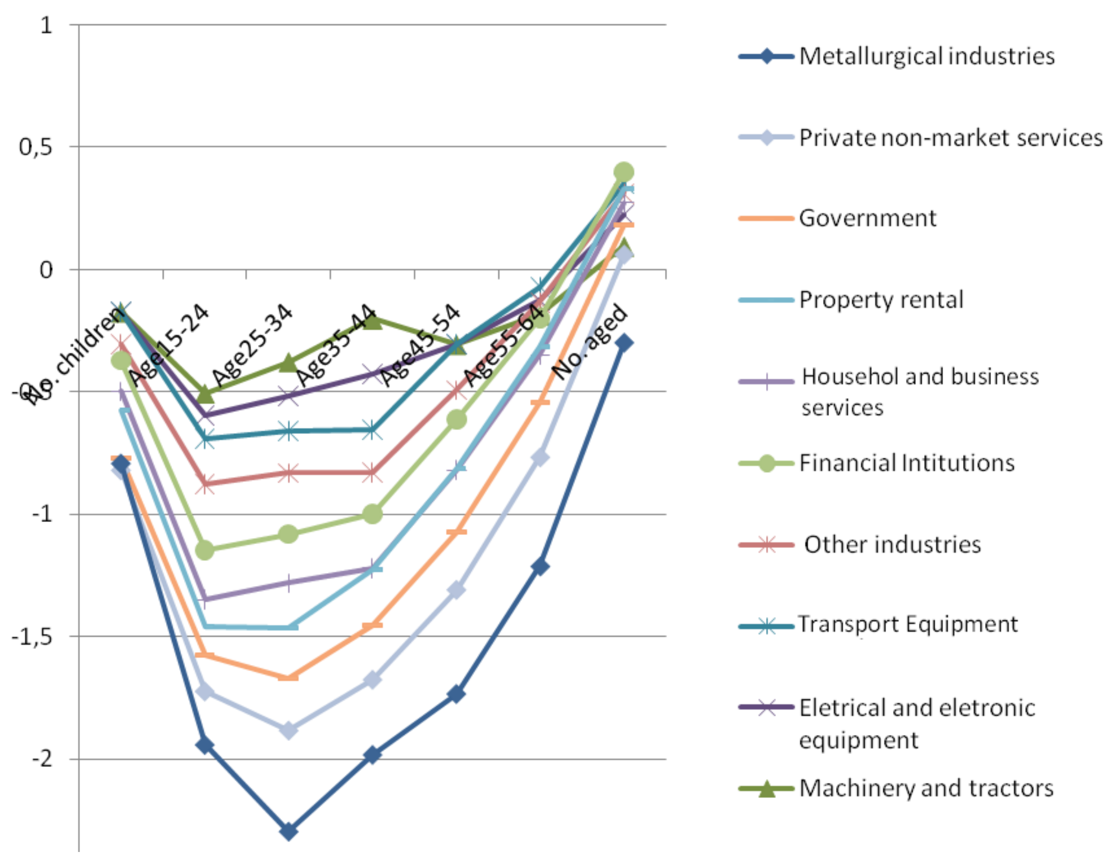
It is also interesting to note from Graph 3 that consumption peaks between the ages of 35 and 44 years for industrial public utilities[63] and for the chemical and petrochemical industry, and between 55 and 64 years for wood and furniture, building, and communications. For clothing and footwear, we identified two peaks: at 15 to 24 years and also at 55 to 64

[63] In this sector, there is also a peak between the ages of 55 and 64 years.

years. The first peak is considered to be very reasonable, as our bodies are in the process of changing and also because people start to have a social life at these ages.

The number of aged people (defined as older than 65 years) in the household has a positive effect on consumption, compared with the age-group below it (age 55 to 64 years), for metallurgical industries, machinery and tractors, electric and electronic equipment, transport equipment, other industries, financial institutions, household and business services, property rental, government, and private non-market services. However, this variable was not significant in many sectors. For these sectors, consumption rises with age, so we could say that there is an unlike retirement consumption puzzle. Graph 4 shows the sectors in which consumption rises with age in the state of Rio Grande do Sul based on 2002-2003 data.

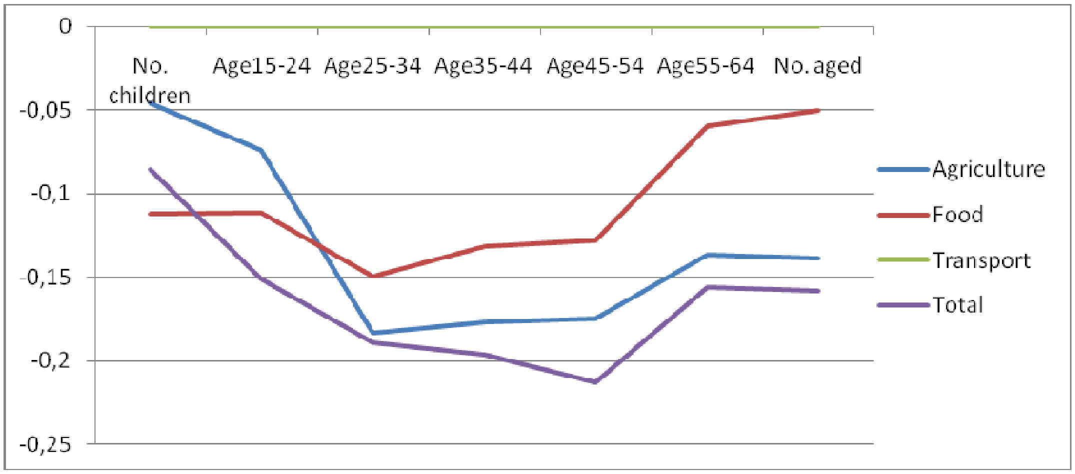
Graph 4 - Sectors in which consumption rises with age



Source: Elaborated by the author (2013).

Graph 5 shows that transport, food, and agriculture are sectors that show constant consumption at older ages. Also, aggregate total consumption does not seem to change as people get older. Perhaps, this can be explained by the fact that consumption decreases with age in some sectors, as predicted by the literature, but increases in some others, as shown on graphs 3 and 4, respectivelly.

Graph 5 – Sectors with constant consumption at older ages



Source: Elaborated by the author (2013).

4.6 CONCLUSION

Demography is a factor that has a major impact on consumption. The traditional Keynesian Theory uses current income to explain consumption. Other theories, such as the life cycle theory and the permanent income theory of consumption, analyze consumption over time. While the former theory concludes that consumption is constant over time and that there are periods of savings (higher income) and dissavings (lower income), the latter theory determines consumption over time. By adding demographic variables, we analyzed the "retirement-consumption puzzle," according to which consumption decreases significantly in retirement.

We used the 2003 Household Budget Survey (POF) for the state of Rio Grande do Sul and matched the household and people databases in order to include the demographic variables. The data indicated that households in Rio Grande do Sul are composed mainly of adults and children (45.63%), and that such composition usually includes 2 adults and 1 child. While the most traditional household structure in Rio Grande do Sul is composed of adults and children, several studies highlight that family as a social institution is gradually disappearing. Because other types of household structures in Rio Grande do Sul include adults and aged people or only aged people, and since it is not common anymore to have a lot of children, it may be concluded that the aging population in the state has been increasing.

As population aging is underway in Brazil, we analyzed its positive and negative impacts on the main sectors in households where the elderly represent a significant variable. Particularly, we classified the sectors by analyzing whether consumption in the group aged 55 to 64 years rises or falls compared to the number of aged people. The estimations were made using ordinary least squares (OLS) and instrumental variables (IV), controlling for the complex sample.

Our results indicate that the retirement consumption puzzle is true for the wood and furniture, chemical and petrochemical industry, clothing and footwear, industrial public utilities, building, and communication sectors. However, for metallurgical industries, machinery and tractors, electric and electronic equipment, transport equipment, other industries, financial institutions, household and business services, property rental, government, and private non-market services, consumption rises with age. Therefore, we could say that there is an unlike retirement consumption puzzle.

These results are important because they indicate the sectors that tend to grow in Rio Grande do Sul as people get older, assuming everything else held constant. Also, they indicate sectors with a constant consumption at older ages (transport, food, and agriculture. Also, aggregate total consumption does not seem to change in Rio Grande do Sul as people get older. Perhaps, this can be explained by the fact that consumption decreases with age in some sectors, as predicted by the literature, but increases in some others. So, these results may contribute to the retirement consumption puzzle theory, as they do not hold for all sectors, and what we call the unlike retirement consumption puzzle is certainly another contribution of this paper.

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5 CONCLUSÃO

A transição demográfica é um fenômeno que acontece com todos os países, e não é diferente com o Brasil. O que muda em cada país é se ao final desse processo ele consegue ou não aproveitar os benefícios que ocorrem durante a fase em que mais pessoas estão em idade ativa, o chamado bônus demográfico. O ônus é certo que todos países terão após passado esse período, pois diminuem as pessoas que geram renda. Além de menos renda gerada, cada vez temos mais pessoas que precisam de uma aposentadoria, aumentando os gastos do governo com seguridade social. A solução para essa situação é saber aproveitar o jovem trabalhador dando a ele uma educação de qualidade. São também necessários investimentos urbanos para uma nova realidade, desenvolver um mercado voltado para o que pessoas idosas consomem. Para saber qual o correto investimento de mercado é necessário traçar um perfil de consumo da população por faixa etária. A estas soluções também é fundamental que existam leis que permitam que as soluções propostas se tornem reais.

Essa tese investigou a relação empírica entre demografia e economia utilizando diferentes e complementares abordagens. Os ensaios foram pensados em uma análise gradual de ideias e de técnicas utilizadas, de forma que o primeiro ensaio teve um recorte geográfico maior – de abrangência nacional – mas uma técnica relativamente mais simples de ser implementada: AEDE (Análise Exploratória de Dados Espaciais). Foram analisados os municípios brasileiros divididos em Áreas Mínimas Comparáveis (AMC) para os anos de 1991 e de 2000. O segundo ensaio utilizou um recorte geográfico menor – Estados brasileiros - de 1970 a 2000, formando dados em painel. A técnica utilizada foi de econometria espacial com GMM-*System*, considerada uma das mais avançadas hoje em dia. O terceiro e último ensaio é ainda mais restrito em termos de abrangência geográfica – dados para o Rio Grande do Sul – mas possui um grande diferencial na construção da base de dados, unindo as bases de pessoas e de domicílios da Pesquisa de Orçamentos Familiares (POF). Ele investigou a influencia da demografia sobre o consumo em 20 setores da economia, permitindo identificar setores que são mais ou menos influenciados por pessoas idosas.

A análise da taxa de dependência, no primeiro ensaio, indicou que as regiões sul e sudeste estão mais avançadas no processo de mudança demográfica, indicando que existe uma concentração de AMC com baixo valor para a taxa de dependência, isto é, a AMC possui baixa taxa de dependência e a área AMC vizinha também (BB). Esse resultado pressupõe que a população em idade ativa possui uma proporção maior na população em relação à soma das populações dependentes (infantil e idosa). Por outro lado, as regiões norte e nordeste apresentaram uma alta taxa de dependência, a qual pode ser explicada pela elevada concentração de população infantil. Com o avanço do processo de mudança demográfica esses resultados tendem a se inverter, uma vez que os idosos vão passar a ter mais peso nas regiões sul e sudeste, sugerindo que a taxa de dependência venha a ser positiva, e a população em idade ativa deve ser maior nas regiões norte e nordeste. A configuração final para todas as regiões quando o processo de mudança demográfica estiver finalizado deverá, portanto, ser de alta taxa de dependência explicada pela maior proporção de idosos. Contudo, esse processo ainda é incipiente uma vez que a estatística *Local Indicator of Spatial Association* (LISA) indicou que os clusters de população idosa podem ser verificados apenas na região centro-sul do Rio Grande do Sul e nos Estados do Ceará, Rio Grande do Norte e Paraíba.

A análise bivariada pela estatística I de Moran mostrou uma relação inversa entre a variação da renda e taxa de dependência infantil e idosa, tanto pela estatística I de Moran. Já a estatística LISA identificou clusters do tipo AB para o Norte, isto é, regiões de alta taxa de dependência são vizinhas de regiões de baixo crescimento da renda per capita, e do tipo BA para as regiões sul e sudeste, de forma que regiões de baixa taxa de dependência são vizinhas de regiões de alto crescimento da renda. Resultados curiosos apareceram, por exemplo, para clusters em São Paulo, cujo tipo foi de baixa taxa de dependência associada a baixa renda, podendo decorrer de resultados negativos associados à aglomeração espacial.

A análise de convergência para a renda confirmou a significância estatística de um processo de tendência de equalização da renda no longo prazo (β – convergência) e que a mudança demográfica possui influência nesse processo. A baixa taxa de convergência para a estimação OLS pode estar associada a presença de dependência espacial, indicando que deve-se considerar os efeitos de vizinhança no processo de estimação para obter uma estimativa correta da velocidade de convergência da renda. Conforme o procedimento de Florax, Folmer e Rey (2003) [64] *apud* Resende e Silva (2007) explicado no primeiro ensaio, o modelo de estimação deve seguir aquele que tiver o maior valor do teste para o teste do multiplicador de lagrange (LM). Neste caso, a melhor especificação para o modelo de convergência de renda condicionado pela mudança demográfica, considerando uma base de dados de AMC, seria o modelo erro espacial. Provavelmente esse resultado também está relacionado ao maior coeficiente de determinação e a velocidade de convergência seja a que mais se aproxima da real. Além disso, o teste de razão de verossimilhança (*likelihood ratio test*) indicou que tanto

[64] Florax, R. J. G. M.; Folmer, H.; Rey, R. J. Specification searches in spatial econometrics: the relevance of Hendry's methodology. **Regional Science and Urban Economics**, v. 33, p. 557-579, 2003.

os modelos lag quanto erro espacial não eliminam totalmente a dependência espacial, indicando que ou realmente existem outros fatores que influenciam a convergência de renda e/ou a dependência espacial pode ser melhor modelada por alguma outra especificação, talvez uma combinação entre as modelagens de *lag* e erro espacial.

A análise não condicional para a taxa de dependência indicou a presença de convergência da taxa de dependência espacial e das suas componentes infantil e idosa, indicando que existe uma tendência de equalização no longo prazo da mudança demográfica. O teste de dependência espacial indicou que, com exceção da taxa de dependência idosa para o modelo *lag* espacial, a dependência espacial mostrou-se significativa para todas as variáveis. O coeficiente de determinação para os três tipos de estimação (Mínimos Quadrados Ordinários - MQO*,* *lag* espacial e erro espacial) mostrou-se maior para a taxa de dependência total, depois para o componente idoso e por fim para o componente infantil. Esse resultado provavelmente está associado ao próprio processo de mudança demográfica, no qual o componente idoso tende a ter maior relevância no longo prazo. Tanto pelo critério de Akaike quanto pelo valor do coeficiente espacial autorregressivo o modelo erro espacial parece ser o mais indicado, embora o teste de razão de verossimilhança (*likelihood ratio test*) indique ainda a presença de dependência espacial tanto para os modelos *lag* quanto erro espacial, assim como indicou a análise de convergência condicional para a renda.

O ensaio dois analisou a convergência da renda de uma maneira mais profunda que o primeiro ensaio, condicionando tanto à renda do período inicial tanto a variáveis demográficas (taxa de crescimento populacional e taxas de dependência) quanto a socioeconômicas (capital humano). A equação de convergência da renda (equação 1) foi diferenciada para retirar o problema de variáveis omitidas, contudo, a equação resultante (equação 2) apresentou endogeneidade em razão do componente defasado da renda no período inicial ser correlacionado com o componente defasado do erro. Optou-se por utilizar o método de Gmm-*System* espacial e não espacial em razão do método desenvolvido por Arellano e Bond (1991) – First-Differenced Gmm – utilizar instrumentos que podem ser considerados fracos (BOND *et al*., 2001) para a estimação da equação 2, uma vez que os coeficientes podem ser viesados em pequenas amostras. Assim, Blundell e Bond (1998) desenvolveram o método Gmm-*System* no qual os instrumentos para a regressão em diferença (nível) são valores defasados (diferenças) das variáveis explicativas.

Os resultados foram estimados por MQO-Efeitos Fixos e Gmm-*System*, sendo este último estimado também de forma espacial. O uso de diferentes técnicas de estimação é importante para avaliar a robustez dos parâmetros bem como a presença de dependência espacial, uma vez que este artigo também incluiu modelos espaciais para Gmm-*System*. As estimações indicaram que a velocidade de convergência mostrou-se negativa para todos os modelos e métodos, indicando a presença de convergência da renda no Brasil, conforme era o esperado. Contudo, o grau de velocidade mostrou-se maior, em módulo, para a estimação por Gmm-*System*, indicando provável viés de endogeneidade na estimação por MQO.

Em relação à dependência espacial, o teste I de Moran indicou que todos os modelos estimados por MQO e GMM-*System* apresentaram dependência espacial para ao menos 1 período da análise. Contudo, o viés e a ineficiência causados pela dependência espacial parecem diminuir significativamente para a estimação por GMM-*System* (não espacial), uma vez que apenas a década de 70 apresentou dependência espacial. Ademais a estimação do modelo 2 (que contém as variáveis de taxa de dependência infantil e idosa) na forma espacial por GMM-*System* corrigiu totalmente a dependência espacial.

A variável educação, que representa o capital humano, mostrou ter um efeito positivo, apesar de subestimada pela estimação por MQO. Interessante que, na estimação por GMM-*System*, essa variável mostrou ser superestimada no modelo em que não havia variáveis populacionais, de forma que a variável captura parte do efeito demográfico quando este não está presente na equação.

As variáveis de mudança demográfica mostraram-se significativas para todos os modelos estimados, colocando em evidência a importância da mudança demográfica para a dinâmica de crescimento regional no Brasil. As taxas de dependência infantil e de idosos mostraram ser negativamente significativas, sugerindo um impacto negativo sobre o crescimento econômico (comprovando também pela equação de crescimento a relação negativa entre taxa de dependência e crescimento econômico que já havia sido comprovada pela Análise Exploratória de Dados Espaciais (AEDE), sendo que o coeficiente da taxa de dependência de idosos é muito maior (em módulo) do que a taxa para crianças. Essas diferenças sugerem que a mudança demográfica pode contribuir para diminuir a desigualdade regional no Brasil, uma vez que quanto maior a taxa de dependência infantil (de idosos), mais pobre (rica) a região, e uma vez que esse processo vem se acelerando pode reduzir a desigualdade regional, contudo o país como um todo teria um crescimento menor. Ademais, a literatura destaca uma ambiguidade para o sinal da taxa de dependência de idosos na equação de crescimento econômico para o Brasil, a qual esperamos ter solucionado, ao menos para países com características similares ao Brasil, uma vez que conseguimos controlar a correlação entre expectativa de vida e renda usando GMM-*System.* O sinal negativo da taxa de dependência de idosos pode estar relacionado com o fato de as gerações de pessoas idosas ser bastante dependente da geração de pessoas em idade produtiva, ou da poupança não ser suficiente para suportar o consumo na aposentadoria, ou do sistema de aposentadoria no Brasil ser formulado de maneira a não suportar gerações mais velhas, ou pelo fato de o investimento em pesquisa em desenvolvimento ser muito baixo, ou uma combinação desses fatores (PRETTNER; PRSKAWETZ, 2010; FUKUDA; MOROZUMI, 2004).

A população em idade ativa mostrou impactar positivamente o crescimento econômico no Brasil, confirmando mais uma vez os resultados obtidos pela AEDE no primeiro ensaio. Esse resultado implica que o bônus demográfico existe no Brasil e pode melhorar o crescimento econômico, contudo a desigualdade deve ser acentuada e devemos implementar reformas para evitar o impacto negativo estimado da taxa de dependência da população idosa. O atual sistema de previdência do tipo de repartição, que é o mais comum entre os países, é posto em cheque em razão da queda do crescimento demográfico e o inevitável déficit, uma vez que a totalidade dos ingressos é destinada aos gastos corrente e a expectativa de vida é crescente para o Brasil (MORAES; FAMÁ; CAIO, 1998). Logo, se já existe um déficit na previdência hoje[65], período em que temos mais pessoas em idade ativa, o que podemos esperar do atual sistema se a população caminha para o envelhecimento populacional, situação na qual teremos mais dependentes e menos pessoas em idade ativa, isto é, contribuindo para a previdência. Dentro deste contexto, o consumo com saúde deve se elevar, e o sistema de saúde público, ainda precário, com falta de equipamentos e de médicos, exige uma mudança nesse aspecto. Outro aspecto é que as pessoas devem ficar mais tempo no mercado de trabalho, e talvez seja mais urgente investir em educação, uma vez que, quanto mais velha a pessoa, mais difícil a aprendizagem. A situação do mercado de trabalho requer primeiramente investimentos em educação para que o mercado de trabalho possa ser mais produtivo, contribuindo mais e de forma positiva para o crescimento econômico. Mas, ainda assim, o mercado de trabalho requer outros tipos de incentivos que permitam uma maior empregabilidade da população, como, por exemplo, redução de impostos sobre os empregados.

O terceiro ensaio avaliou o impacto da mudança demográfica sobre o consumo no Estado do Rio Grande do Sul. Foram utilizados dados da POF (Pesquisa de Orçamentos Familiares) referentes ao ano base 2002-2003, unindo as bases de domicílios e de pessoas. Diferentes teorias avaliam fatores que explicam o consumo, que podem ser a renda corrente (teoria Keynesiana), a renda permanente (teoria do ciclo de vida) ou a aposentadoria (quebra-

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[65] O déficit estimado em 2012 foi de R$ 42,3 bilhões segundo dados do Ministério da Previdência.

cabeça do consumo na aposentadoria). Esta última teoria, particularmente, afirma que o consumo diminui significativamente na aposentadoria.

A análise estatística dos dados indicou que a família típica do Rio Grande do Sul é composta por adultos e crianças, e que, neste cenário, a maior parte das famílias possui 2 adultos e 1 criança. Também foram identificadas famílias compostas por adultos e idosos ou só por idosos, indicando ser essa uma tendência para o Estado, uma vez que se vivencia o processo de envelhecimento populacional.

Foram testados modelos de consumo para 20 setores da economia do Rio Grande do Sul utilizando, além da renda, dados relativos à composição etária da família, com o objetivo de verificar se o consumo aumenta, diminui, ou permanece constante quando idosos estão presentes. Particularmente, foi observado o comportamento do consumo na última faixa-etária de pessoas em idade ativa (55 a 64 anos) comparado com o consumo de pessoas idosas. As estimações foram feitas por MQO e por Variáveis Instrumentais (VI), sendo este último método aplicado para os modelos onde endogeneidade se mostrou presente (indústria metalúrgica, vestuário e calçados, serviços industriais de utilidade pública, outras indústrias e serviços privados não mercantis).

As estimações foram feitas utilizando-se a correção para amostra de dados complexos que pode ser implementada pelo software Stata através do comando *svy*. Como resultado, temos destaque para os setores máquinas e tratores, material elétrico e eletrônico, material de transportes, outras indústrias, instituições financeiras, serviços prestados às famílias e às empresas, aluguel de imóveis, administração pública e serviços privados não-mercantis, que possuem um efeito positivo do envelhecimento populacional no consumo, o que podemos chamar de quebra-cabeça ao contrário do consumo na aposentadoria. Ademais, o consumo total indicou ser estável, o que parece fazer sentido, uma vez que existem também setores cujo consumo diminui com a idade.

A tese apresentou algumas limitações, que seguem de sugestão para posteriores trabalhos. No artigo 1, limitou-se a trabalhar com dados do Censo Demográfico de até 2000, sendo que até a data da defesa inexistiam dados do Censo de 2010 para Áreas Mínimas Comparáveis. No artigo 3, a análise ficou limitada ao Estado do Rio Grande do Sul e ao ano de 2002-2003, de forma que seria interessante ampliá-la no tempo e no espaço. Uma das principais limitações refere-se à análise do componente migração, que foi muito superficial, sem poder dar a merecida atenção. Além disso, a análise também ficou limitada a equilíbrio parcial. A agenda de pesquisa na autora e dos orientadores está sendo reformulada para incluir essas limitações.

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